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KALMAR

Workshop manual

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A Foreword

About the Workshop Manual

General

Thank you for choosing Cargotec as your machine supplier. We hope that we'll meet your expectations.

Conditions

The instructions are based on the use of generally available standard tools. All lifting devices, for example, slings, straps, ratchet blocks, etc., must meet governing national standards and regulations for lifting devices.

Cargotec will not accept any responsibility for modifications performed without permission from Cargotec or if other lifting devices, tools or work methods are used other than those described in this manual.

Storage

NOTE

The Workshop Manual should be accessible to the service personnel.

About the machine version

The information in this publication corresponds to the machine's design and appearance at the time of delivery from Cargotec. Due to customizations, there may be variations and/or deviations.

Cargotec reserves the right to modify specifications and equipment without prior notice. All information and data in this manual are valid at the time of publication.

Copyright

Cargotec Sweden AB

Duplication of the content in this manual, in whole or in part, is strictly prohibited without written permission from Cargotec Sweden AB.

Duplication by any means such as copying, printing, etc., is prohibited.

⚠ DANGER

External equipment may only be used if it is approved by Cargotec.

Risk of fatal accidents and property damage!

Only used equipment approved by Cargotec.

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Reading instructions

Warning information

Warnings inform on potential dangers which can, if the warnings are not heeded, result in personal injury or product damage.

⚠ DANGER

Situation that may result in serious personal injury, possible death, if the instruction is not followed.

⚠ WARNING

Situation that may result in serious personal injury if the instruction is not followed.

⚠ CAUTION

Situation that may result in damage to the product if the instruction is not followed.

Important information

Important information marked with NOTE facilitates the work process, operation/handling or increases understanding of the information.

NOTE

Information that is important without being safety related.

Read operator's manual



000262

Read the operator's manual

The symbol to the left is used in certain cases on the machine and refers to important information in the operator's manual.

Read maintenance manual



001128

Read the maintenance manual

The symbol to the left is used in certain cases on the machine and refers to important information in the maintenance manual.

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Workshop manual contents

The Workshop Manual contains information to facilitate maintenance (part replacement) and is a supplement to the Maintenance Manual. The supplier documentation for engine, transmission and drive axle also supplements the Workshop Manual. If possible, the Workshop Manual provides reference to supplier documentation instead of printing the same information twice. Methods for preventive maintenance and certain checks are found in the Maintenance Manual; no references are given. Use the function groups to locate the information in the Maintenance Manual.

The Workshop Manual is divided into the following sections:

A	Foreword	General information about the workshop manual's purpose, contents and reading instructions as well as survey for feedback of views and any inaccuracies.
B	Safety	Keep in mind for your safety.
C	Preventive maintenance	Reference to maintenance manual: Preventive maintenance.
0	Complete machine	Technical description, comprehensive function descriptions and a description of the function of components included in the machine, divided into function groups. The components used for each function are described under each subfunction. Consequently, common components are described in several places, but in general under the first function to use the component. Together with the general description is a detailed description of what is unique about the specific subfunction. The next subfunction to use the same component only has a description what is unique for the new function. Work instructions for corrective maintenance (replacement of components).
1	Engine	
2	Transmission	
3	Driveline/axle	
4	Brakes	
5	Steering	
6	Suspension	
7	Load handling	
8	Control system	
9	Frame, body, cab and accessories	
10	Common hydraulics	
11	Common electrics	
12	Common pneumatics	
D	Error codes	Error code information and instructions for reading error code information.
E	Schematics	Wiring and hydraulic diagrams
F	Technical data	Technical data, conversion tables, information for conversion of units.
G	Terminology and index	General terminology and abbreviations, explanation of terms and abbreviations that can appear in the sections, index for headings in the sections.

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Function group structure

The information in the manual is divided in a structure of functions at different levels, based on the machine's design and use, called function groups.

The upper level (called main group) determines area, e.g., group 7 Load handling. The second level (called two-digit) determines function, e.g., 7.2 Lifting and lowering. The third and fourth levels are used to break down functions in smaller parts (components).

The main group and two-position group level structure for the function groups is used for all Cargotec machines, e.g. 4.3 Power-assisted brake system. Machine-specific function group adaptations are done and the third and fourth group level, e.g. 4.3.9 Wheel brake and 4.3.9.1 Disc assembly. Function groups (headings) are only included in the documentation of a machine if the machine has that function or component. Thus, there may be gaps in function group numbering (e.g. the three-position heading level 4.8.7 Oil cooler is included for some machines but not for others).

The function groups are intended to be used as search terms to find different types of information between different sections and manuals. The information in a function group is divided in smaller sections according to the type of content, e.g., description or change.

The maintenance manual and Workshop manual contain different information. The maintenance manual contains only the information needed for preventive maintenance and simpler troubleshooting. The Workshop manual contains more in-depth information and repair instructions.

References between sections in the same manual are indicated with section and group number, e.g., "see section *4 Brakes*, group *4.3.9 Wheel brake* ". References within a section are indicated with a page number, e.g., "see *Sensor fuel level, description page 24* ".

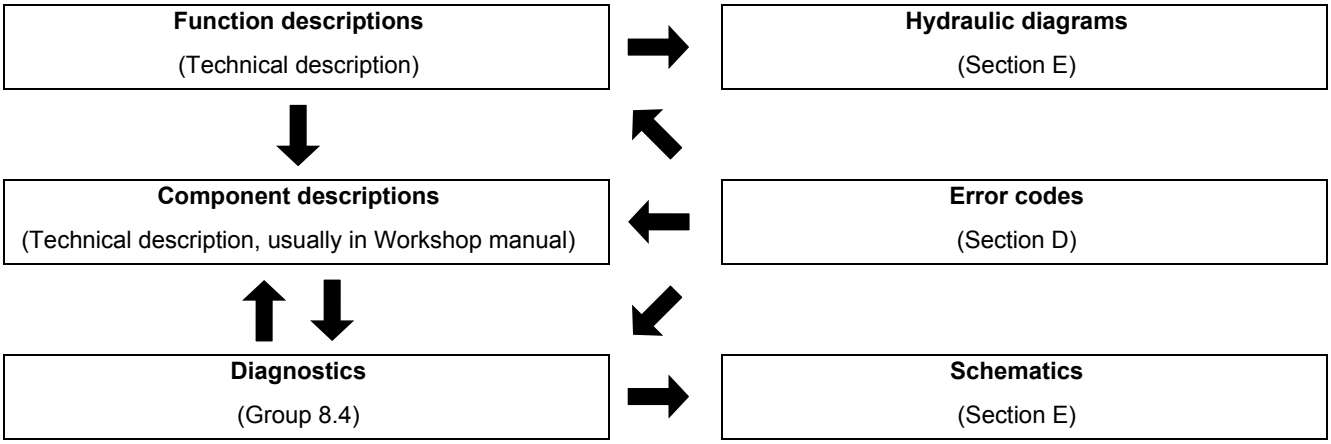
There are no references between the Maintenance Manual and Workshop Manual. If more information on a function group is required, search under the same function group in the other manual. For more in-depth information on where different types of information are located and what references are made, see *References between different information types page 7*.

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References between different information types

The maintenance manual and workshop manual are mainly divided into function groups, see *Workshop manual contents page 5*. Certain parts are broken out as separate parts to increase usability, e.g., "Technical data".

The basic rule of searching for information is to use function groups to find different types of information regarding the function or component in question. As a complement to this, there are references according to the below.



- From Function description to Component description, to enable fast finding of more information about the different components that create a function.
- From Function description to Hydraulic diagram, to enable fast finding of the right hydraulic diagram for the function in question.
- From Component description or Function description to Diagnostics, to enable fast finding of the right diagnostic menu that can be used to check the component (only applies to electrical components).
- From Diagnostics to Schematics. to enable fast finding of the right circuit diagram for further troubleshooting.
- From Diagnostics to Component description or Function description. To enable fast finding of more information about the component's appearance and position when troubleshooting.
- From Error codes to Diagnostics, to enable fast finding of the right diagnostic menu to troubleshoot component or function in question.
- From Error codes to Function description or Component description, to enable fast finding of more information about components or function.

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Product alternatives and optional equipment

The information in the manual is divided in modules. For product alternatives and optional equipment, handling of the modules differs depending on if it is the one or the other that is described, see below.

Special equipment is not described in the manual. If you’re uncertain about what equipment the machine should have, use the machine card to decide which information applies, see *Machine card page 9*.

Product alternative

Product alternatives are such options that exclude certain standard equipment (e.g., engine alternative).

Equivalent information for different product alternatives are described consecutively in separate segments within the same function group. To indicate that there are different alternatives, "Product alternative" is added to the heading together with a simple description of the alternative, e.g. "(Product alternative Climate control system ECC)". In addition, the alternative that is an option is marked with the symbol for optional equipment.



000264

Symbol indicating optional equipment

Optional equipment

Optional equipment are options that can be added to the standard equipment to obtain additional or improved functions.

Information for optional equipment is described in separate sections with standard equipment as the starting point. The description of the optional equipment describes how the standard function is affected by the option as well as which components are added.

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Machine card

NOTE

If the machine has been modified after delivery the information on the machine card may be lacking or incorrect.

IMPORTANT

Changes made on the machine must be reported to Cargotec so that the machine card can be updated. A new updated machine card is sent on the request of the customer.

The machine card indicates of which drawings the machine consists, in many cases these can be associated options and product alternatives. For more information about handling of product alternatives and optional equipment, see *Product alternatives and optional equipment page 8*. The machine card is delivered with the parts catalogue.

The machine card is divided in the same functions groups as the parts catalogue, maintenance and Workshop manual. For practical reasons, the machine card uses only the first and second level in the function group register. The function groups are written in groups of four characters, e.g. group 0107 matches group 1.7 Cooling system in the manual.

For more information about how the machine card is used for ordering spare parts, see the parts catalogue's foreword.

If the information on the machine card does not help, contact Cargotec Sweden AB.

NOTE

All documents that accompany the machine are non-registered documents and there will be no notification of changes.

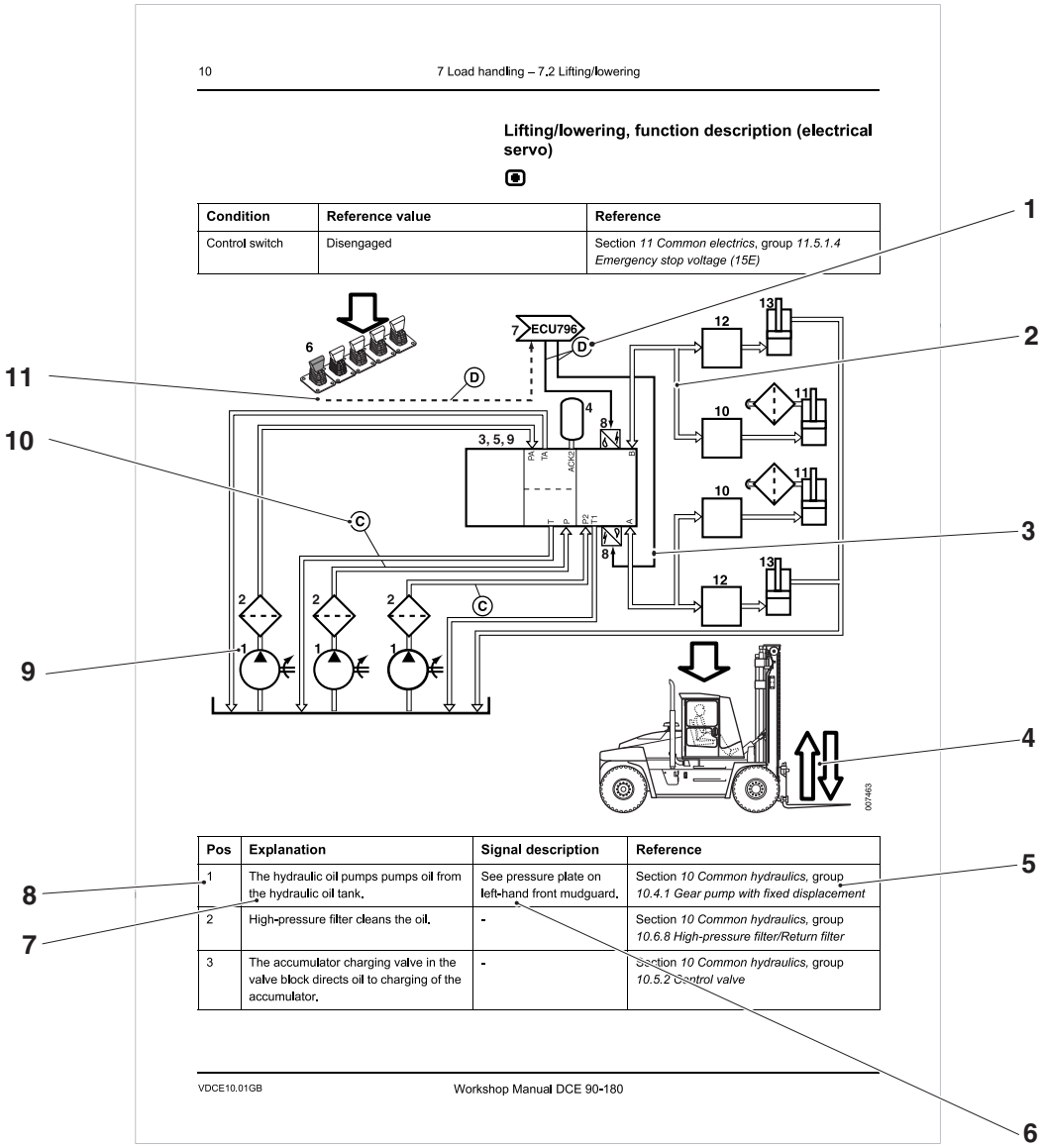
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Function descriptions

Function descriptions are schematic overviews that describe how a function works as well as which components and signals work together.

Function descriptions describe the function in a logical flow from input signal to desired output signal. Most functions require that preset conditions are fulfilled for the function to be activated. In these cases, the conditions are listed above the illustration.

Function descriptions use symbols to illustrate components such as valves, sensors, etc.

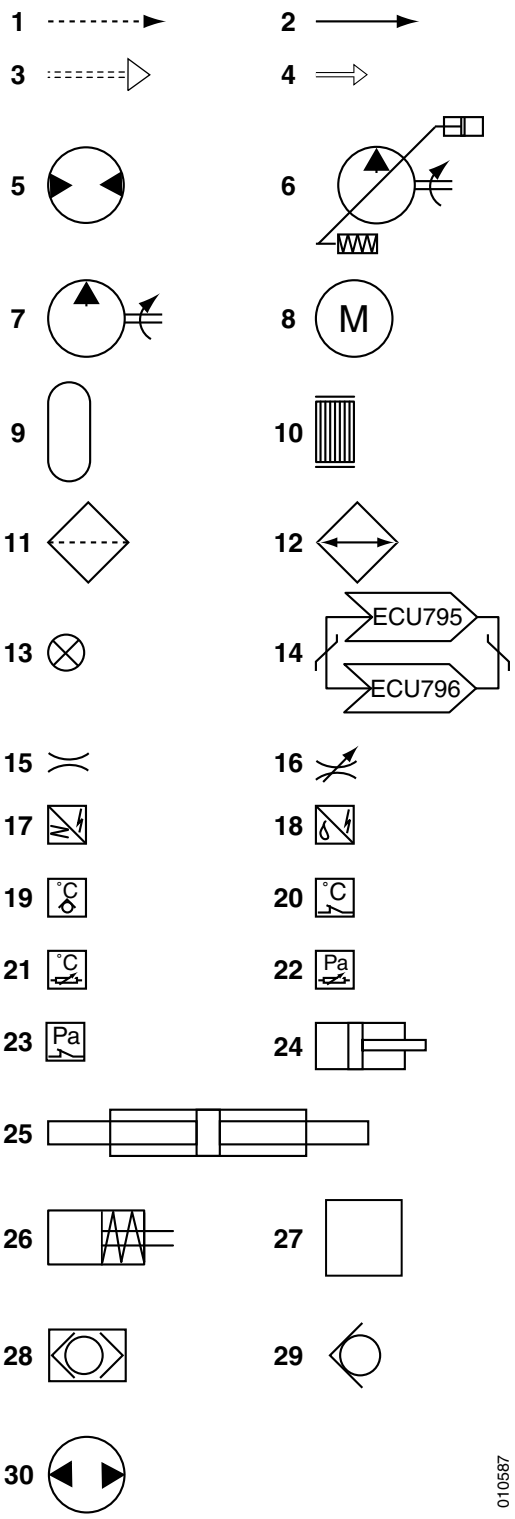


Example of function description

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1. Flag diagnostic, indicates that signal can be checked with diagnostics, see *group “8.4 Diagnostics”*
2. Hydraulic force (solid double line)
3. Electric power (solid single line)
4. Illustration of function, (lift and lower)
5. Reference to description of component
6. Signal description, reference value for signal out from component
7. Description of component's function
8. Position number, reference to position in illustration
9. Position number in illustration, reference to row in table
10. Flag pressure check connection (Check point), indicates that there is pressure check connection for checking pressure signal
11. Elektric control signal (dashed single line)

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Symbol explanation function descriptions

The following symbols are used in function descriptions, the symbols are based on standard symbols used in wiring and hydraulic diagrams.

1. Electric control signal
2. Electric force
3. Hydraulic control signal
4. Hydraulic force
5. Hydraulic motor
6. Hydraulic oil pump with variable displacement
7. Hydraulic oil pump with fixed displacement
8. Electrical motor
9. Accumulator
10. Disc brake
11. Filter
12. Radiator
13. Bulb
14. Control system, two control units with CAN-bus
15. Restrictor
16. Adjustable restrictor
17. Inductive position sensor
18. Electrically controlled servo valve
19. Thermal by-pass valve
20. Temperature-controlled switch
21. Temperature sensor
22. Pressure sensor
23. Pressure-controlled switch
24. Hydraulic cylinder
25. Double-acting hydraulic cylinder
26. Spring brake cylinder
27. Valve block
28. Spool valve
29. Non-return valve
30. Hydraulic oil pump (transmission)

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About the documentation

Documentation sections

The documentation to the machine comprises the following sections:

Operator's manual

The Operator's manual is supplied with the machine in the cab.

Documentation kit

Maintenance manual and spare parts catalogue with machine card are supplied with the machine as a separate documentation kit.

Supplementary documentation

There are Supplementary documentation that can be ordered for the machine.

- Workshop manual.
- Supplier documentation for engine, transmission, drive axle, etc.

Ordering of documentation

Documentation is available for order from Cargotec dealers.

Always specify the publication number when ordering.

See the machine card for publication number.

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Feedback

Form for copying

Cargotec's ambition is that you who work with maintenance of Cargotec machines shall have access to correct information.

Your feedback is important to be able to improve the information.

Copy this form, write down your views and send it to us. Thank you for your participation!

To:	**Cargotec Sweden AB** **SE-341 81 Ljungby, Sweden.** **SWEDEN** **Fax: +46 372 263 90**
From:	Company / Sender: ..... Telephone: ..... E-mail: ..... Date: ..... - ..... - .....
Manual-information	Name / Publication number: ..... Section / page number: .....
Suggestions, views, remarks, etc.	....

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Safety

General safety information

Safety concerns everyone!

The safety information concerns everyone who works with the machine! Persons who do not follow the safety instructions given in this manual must make absolutely sure that the work is performed without risks of personal injury and without risk of damage to machine or machine property!

Remember to:

- follow the instructions in this manual
- be trained for the work in question
- follow local laws, safety rules and regulations
- use the correct equipment and tools for the job
- wear the correct clothes
- use common sense and work carefully. Do not take any risks!

Cargotec has in this publication documented and warned for situations and risks that may occur in connection with using as well as service/ repairs of the machine during normal circumstances.

That' s why it's important that all who work with the machine, or repair/ service the machine read and follow the information in the manuals.

A near accident is a warning!

A near-accident is an unexpected event where neither persons, machine or property are injured or damaged. However, a near-accident indicates that there is an injury risk and actions must be taken to avoid the risk of injuries.

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Safety instructions

General

Read, consider and follow the safety instructions below before starting to work in the machine:

- *Service position page 4*
- *Hydraulic system, depressurizing page 6*
- *Oils page 6*
- *Fuel system page 7*
- *Clothing, etc. page 8*
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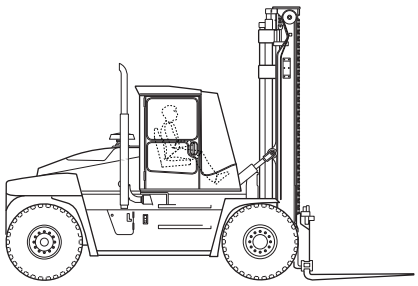
Service position

General

Service position is used for service, maintenance and other situations when the machine needs to be secured.

Service position means:

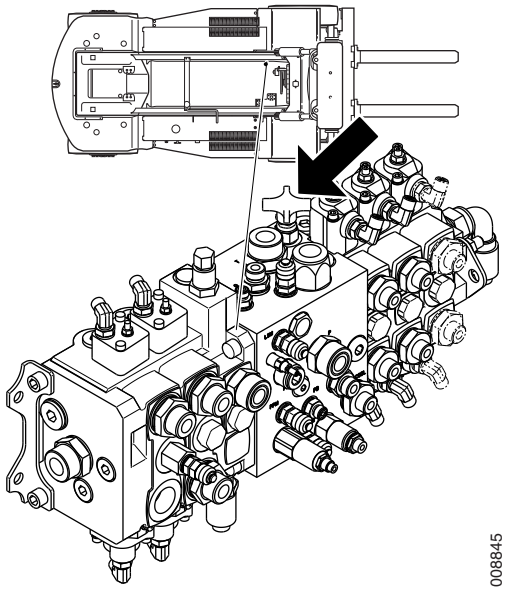
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Machine with forks and lifting carriage in totally lowered position

- Machine parked, that is, parking brake applied.
- Forks and lifting carriage in totally lowered position.
- Engine off.
- Main electric power off (with battery disconnector).

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Accumulator drain valve's control

Hydraulic system, depressurizing

1 Machine in service position.

2 Depressurize the hydraulic system by opening the accumulator drain valve on the valve block.

⚠ DANGER

Fatal danger!

Working with a pressurized hydraulic system endangers your life.

Depressurize the hydraulic system. Open the accumulator drain valve on the valve block.

3 Verify that the accumulator pressure has been released, measure with a pressure gauge on the pressure check connection by the accumulator charging valve (see section *10 Common hydraulics,* group *10.5.2 Main valve*).

NOTE

Keep the drain valve open as long as work is in progress.

Oils

The following safety instructions shall be followed for work when handling oils.

⚠ WARNING

Warm and pressurized oil.

Always depressurize the hydraulic system before starting to work in the system. The system is pressurized and its oil could cause injury.

Avoid skin contact with the oil, use protective gloves. Warm oil can cause burn injuries, rashes and irritation! The oil may also be corrosive to mucous membranes in, e.g., the eyes, skin and throat.

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IMPORTANT

Always clean the area around components and connections before they are loosened. Dirt in oil systems causes increased wear, resulting in subsequent material damages.

Always take action to avoid spills. In places where drain containers cannot be used, use a pump or hose for safe handling.

Always check that plugs seal tight before collection containers are moved.

Handle all oil as environmentally hazardous waste. Oils freely released cause damage to the environment and may also cause fires. Waste oils/fluids shall always be handled by an authorized company.

Fuel system

The following safety instructions shall be followed for work when handling fuel.

DANGER

Pay attention to the risk of fire when working on the fuel system.

Work on the fuel system shall be avoided when the engine is warm since fuel can spill on hot surfaces and may ignite.

Ensure that naked flames, sparks or red-hot/glowing objects have been extinguished before starting work on or in the vicinity of the fuel system.

Do not smoke in the vicinity of the machine when work on the fuel system is in progress.

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⚠ WARNING

The engine's fuel system operates at very high pressure. The pressure is so high that the jet can injure the skin, resulting in severe injuries.

Risk of personal injuries.

Use protective gloves and protective goggles. If a component is to be disconnected, hold a rag over the connection as protection and to collect fuel.

⚠ CAUTION

Always clean the area around components and connections before they are loosened. Dirt in the fuel may cause malfunctions and engine stop in undesirable situations as well as increase wear, resulting in subsequent material damages.

IMPORTANT

Always take action to avoid spills. In places where drain containers cannot be used, use a pump or hose for safe handling.

Always check that plugs and connections seal tight before moving collection containers.

Handle the fuel as environmentally hazardous waste. Fuel freely released causes damage to the environment and may also cause fires. Fuel shall always be handled by an authorized company.

Clothing, etc.

Clothes should be in good condition. Remove loosely hanging clothing (tie, scarf, etc.). Do not wear clothes with wide sleeves, wide trouser legs, etc.

Remove jewellery as it may conduct electricity and get caught in moving parts.

Long hair should be adequately gathered since it can easily get caught in moving parts. Be careful when working with welding or an open flame since hair easily catches on fire.

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Several mechanics on the same machine

WARNING

If several mechanics are working on the same vehicle, extra care must be taken so that accidental movements do not injure any other person. Communicate so that everyone knows where everyone is, and what they are doing.

Risks

Work with wheels or axle suspension, mountings, etc. may result in components on the other side moving and causing damage/injury.

Movements performed from the operator's station, e.g., movement of lifting equipment, may cause severe personal injuries.

Safety precautions

- Make sure that the machine's lifting equipment is completely lowered or secured in another way.
- Move battery disconnector to position zero, remove the key.
- Be aware of the risks when several persons work around the vehicle.
- Make your co-workers aware of what you’re working with.
- Do not work with drive wheels on both sides of the machine at the same time.

Working under machine

Working under cab

There must be no loose objects in a cab when tipped.

The cab must always be tipped to its end position and secured with a stopping device.

If the work requires that the cab not be tipped to its end position or if working on the cab suspension, the cab must always be secured with a stopping device.

On machines with raisable cab, the cab must be secured in the raised position with the lock for this purpose.

Work under chassis

A lifted/raised vehicle may under no circumstances be supported or lifted by components that belong to the suspension or steering. Always support under the frame or drive axle.

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Risks

Mechanical or hydraulic tools and lifting devices can fall over or accidentally be lowered due to malfunctions or incorrect use.

Safety precautions

Use axle stands and supports that stand securely.

Lifting tools should be inspected and type approved for use.

Lifting heavy components

⚠ WARNING

Careless handling of heavy components can lead to serious personal injury and material damage.

Use type approved lifting tools or other devices to move heavy components. Make sure that the device is stable and intact.

Risks

Unsuitable lift slings, straps, etc. may break or slip.

The centre of gravity (balance point) of the component can change during the course of the work, and the component may then make unexpected movements which may cause severe personal injuries and material damage.

A component lifted with lifting equipment can start to turn if the equilibrium is upset.

A component lifted using an overhead crane may start to swing back and forth, which can cause severe crushing injuries or material damage.

Safety precautions

Lifting with lifting device. Use lifting tool or other tools, especially when there are such adapted for certain work. See workshop manual for methods.

If lifting must be performed without lifting device:

- Lift near the body.
- Keep your back vertical. Raise and lower with legs and arms, do not bend your back. Do not rotate your body while lifting. Ask for assistance in advance.
- Wear gloves. They're good protection against minor crushing injuries and cuts to fingers.
- Always use protective shoes.

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Vibrations

In case of long-term use of vibrating tools, for example, impact nut runners or grinders, injuries may be sustained as vibrations can be transmitted from tools to hands. Especially when fingers are cold.

Safety precautions

Use heavy gloves to protect against cold and somewhat against vibrations.

Switch between work duties to give the body time to rest.

Vary work position and grip so that the body is not stressed in only one position by the vibrations.

Noise

Noise louder than 85 dB (A) that lasts for longer than 8 hours is considered harmful to hearing. (Limit values may vary between different countries.) High tones (high frequencies) are more damaging than low tones at the same sound level. Impact noise can also be hazardous, e.g. hammer blows.

Risks

At noise levels higher than the limits hearing damage can occur. In more severe cases, hearing damage can become permanent.

Safety precautions

Use hearing protection. Make sure that it is tested and protects against the noise level in question.

Limit noise with noise-absorbing dividers, for example, noise-absorbing materials in roof and on walls.

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Solvents

Fluids that (as opposed to water) dissolve grease, paint, lacquer, wax, oil, adhesive, rubber, etc. are called organic solvents. Examples: White (petroleum) spirits, gasoline, thinner, alcohols, diesel, xylene, trichloroethylene, toluene. Many solvents are flammable and constitute a fire hazard.

Risks

Products containing solvents produce vapours that can cause dizziness, headaches and nausea.They may also irritate mucous membranes in the throat and respiratory tracts.

If the solvent ends up directly on the skin it may dry out and crack. Risk of skin allergies increases. Solvents may also cause injury if they penetrate through the skin and are absorbed by the blood.

If the body is continuously exposed to solvents, the nervous system may be damaged. Symptoms include sleep disorders, depressions, nervousness, poor memory or general tiredness and fatigue. Continuous inhalation of gasoline and diesel fumes is suspected to cause cancer.

Safety precautions

Avoid inhaling solvent fumes by providing good ventilation, or wearing a fresh-air mask or respiratory device with a suitable filter for the toxic gases.

Never leave a solvent container without tight-sealing lid.

Use solvents with a low content of aromatic substances. It reduces the risk of injury.

Avoid skin contact.

Use protective gloves.

Make sure that work clothes are solvent-resistant.

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Fire and explosion risks

DANGER

The operator's safety may not be jeopardised in case of fire.

If possible, take the following actions at the slightest sign of fire:

1. **Stop the machine and turn the start key to stop position.**
2. **Leave the cab.**
3. **Turn off the system voltage with the battery disconnector.**
4. **Call the fire department.**
5. **Try to put out the fire.**

   If this is not possible, leave the machine and the danger area.

DANGER

Smoke from a fire may be very toxic.

Smoke anaesthetises, suffocates, and can kill people! Even small quantities of smoke can cause damage to the lungs and respiratory organs.

Avoid breathing in fumes, do not stand in the smoke. Use breathing apparatus for fire fighting and work with burnt material.

DANGER

Tires are flammable and can cause fires with explosive events.

Fatal danger!

Always take protection if tires caught fire.

Examples of flammable and explosive substances are oils, gasoline, diesel fuel oil, organic solvents (lacquer, plastics, cleaning agents), rustproofing agents, welding gas, gas for heating (acetylene), high concentration of dust particles consisting of combustible materials. Rubber tires are flammable and cause explosive fires.

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Risks

Examples of cause of ignition is welding, cutting, smoking, sparks when working with grinders, contact between hot machine parts and flammable materials, heat development in rag drenched with oil or paint (linseed oil) and oxygen. Oxygen cylinders, lines and valves shall be kept free from oil and grease.

Fumes from, e.g., gasoline are heavier than air and may "run" down into a sloping plane, or down in a grease pit, where welding flames, grinding sparks or cigarette glow may cause an explosion. Evaporated gasoline explodes very forcefully.

Special cases

Diesel fuel oil with added gasoline has a lower ignition point. Risk of explosion already at room temperature. The explosion risk for warmed diesel fuel oil is higher than for gasoline.

When changing oil in the engine, hydraulic system and transmission, keep in mind that the oil may be hot and can cause burn injuries.

Welding on or near machine. If diesel and or other oils have leaked out and been absorbed by rags, absorbent agents, paper or other porous material, glowing welding sparks can cause ignition and explosive fires.

When a battery is charged, the battery fluid is divided into oxygen and hydrogen gas. This mixture is very explosive. The risk of explosion is especially high when using a booster battery or quick-charger, as this increases the risk of sparks.

On today’s machines there is a lot of electronic equipment. When welding, the control units must be disconnected and the electric power must be turned off with the battery disconnector. Powerful welding currents may otherwise short-circuit the electronics, destroy expensive equipment or cause an explosion or fire.

Never weld on painted surfaces (remove paint, by blasting at least 10 cm around the welding or cutting point). Use gloves, breathing protection and protective glasses. Also, welding work may not be done near plastic or rubber materials without first protecting them from the heat. Paints, plastics, and rubber develop a number of substances that may be hazardous to health when heated. Be careful with machines that have been exposed to intense heat or fire.

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Safety actions

⚠ DANGER

Remains of fuel, oils, grease, and other flammable materials on the engine or in the engine compartment are fire hazards.

Risk of fire!

Remove combustible material residue from the engine compartment as soon it is discovered, be especially careful on hot surfaces such as exhaust systems, manifolds or turbos. If oil, fuel or coolant leakage is detected, establish the cause and rectify the fault before starting the engine.

- Make a habit of visually inspecting the engine and engine compartment before starting the engine and after operation, when the engine has stopped. This helps to quickly detect if anything abnormal has happened or is about to happen. Look particularly closely for oil, fuel or coolant leakage, loose bolts, worn or poorly tightened drive belts, loose connections, damaged hoses and electrical cables. The inspection only takes a few minutes and can prevent serious faults and costly repairs.
- Store hazardous substance in approved and sealed container.
- Make sure that there is no ignition source near flammable or explosive substances.
- Make sure that ventilation is adequate or there is an air extraction unit when handling flammable substances.

Fluid or gas under pressure

High-pressure lines can be damaged during work, and fluid or gas can stream out.

There may be high pressure in a line even if the pump has stopped. Therefore, gas or fluid can leak out when the connection to the hose is loosened.

A gas cylinder subjected to careless handling can explode, for example, if it falls onto a hard surface. Gas can stream out through damaged valves.

Risks

Risk of damage/injuries in connection with work on:

- Hydraulic systems (e.g., working hydraulics and brake system).
- Fuel system.
- Tyre repairs.
- Air conditioning.

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Safety precautions

- Use safety glasses and protective gloves.
- Never work on a pressurized system.
- Never adjust a pressure limiting valve to a higher pressure than recommended by the manufacturer.
- A hydraulic hose that swells, for example, at a connection, is about to rupture. Replace it as soon as possible! Check connections thoroughly.
- Use fluid when checking for leaks.
- Never blow clothes clean with compressed air.
- Discarded pressure accumulator shall first be depressurized and then punctured before it is discarded (to avoid risk of explosion). Carefully, drill a hole with 3 mm diameter after depressurizing.
- Never use your hands directly to detect a leak. A fine high-pressure stream from a hydraulic hose can easily penetrate a hand and causes very severe injuries.

Coolant

The coolant in the machine’s cooling system consists of water, anti-corrosion compound and (when needed) anti-freeze fluid, for example, ethylene glycol.

Coolant must not be drained into the sewer system or directly onto the ground.

Risks

The cooling system operates at high pressure when the engine is warm. Hot coolant can jet out and cause scalding in case of a leak or when the expansion tank cap (filler cap) is opened.

Ingesting ethylene glycol and anti-corrosion compound is dangerous and hazardous to health.

Safety precautions

- Use protective gloves and safety glasses if there is a risk of splashing or spraying.
- Open the filler cap first, to release the excess pressure. Open carefully.Hot steam and coolant can stream out.
- If possible, avoid working on the cooling system when the coolant is hot.

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Refrigerant

Refrigerant is used in the machine's air conditioning system.

Work on the air conditioning system must be performed by accredited/authorized and trained personnel according to national legislation and local regulations.

Risks

The air conditioning operates at high pressure. Escaping refrigerant can cause frostbite.

Refrigerant that is heated (e.g., when repairing leaking climate/AC system), generates gases that are very dangerous to inhale.

Consult your importer for additional instructions.

Safety precautions

- Use special instructions and equipment for refrigerant according to the manual when working on the air conditioning system. Special certification and authorization is often required of the person who may do the work. (Note national legislation and local regulations!)
- Use protective gloves and safety glasses if there's a risk of leaks.
- Make sure that heat-producing sources or objects are not close by (cigarette glow, welding flame).

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Air pollution

Air pollution is the impurities in the air around us and which are regarded as hazardous to health. Certain pollution is more prominent in certain environments.

The following health-hazardous air pollution is especially prominent in workshops:

- **Carbon monoxide (fumes)** is present in exhaust fumes. Odourless and therefore especially dangerous.
- **Nitrogen oxides (nitrous gases)** are present in exhaust fumes.
- **Welding smoke** especially hazardous to health when welding on oily surfaces, galvanized or lacquered materials.
- **Oil mist** for example, when applying anti-corrosion agent.
- **Grinding dust and gases** generated when grinding and heating plastics, lacquer, anti-corrosion agents, lubricants, paint, etc.
- **Isocyanates** are present in certain paints, fillers, adhesives and foam plastics used on machines.

Risks

Sulfuric acid mist is corrosive and injures the respiratory tracts. (Generated when heating certain plastics and paints.)

Isocyanates can be released in the form of steam, dust (or may be present in aerosols) when cutting, grinding or welding. Can irritate mucous membranes producing symptoms similar to asthma and impairing lung function. Even brief exposure to high concentrations can give problems with persistent high sensitivity.

Safety precautions

- Make sure of adequate ventilation with fresh air when welding, battery charging and other work when hazardous gases are generated.
- Use suitable protective gloves and breathing protection when there is a risk of oil mist. Make sure that the protection is oil-proof.
- Apply oil-resistant protective lotion to unprotected skin.
- Make sure that an eye-wash station is in the immediate vicinity when working with corrosive substances.
- Avoid unnecessary operation of the machine inside the workshop. Connect an air extractor to the exhaust pipe so that the exhaust fumes are removed from the workshop.

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Tensioned springs

Examples of tensioned springs:

1. Torque springs in pedals for example.
2. Return spring (cup springs) in parking brake cylinder.
3. Lock rings
4. Gas springs

Risks

If a tensioned spring releases, it is shot out by the spring force and can also take adjoining parts with it.

Small springs can cause eye injuries.

Parking brake springs are tensioned with high force and can cause very severe accidents if they are accidentally released in an uncontrolled manner.

Gas springs and gas-charged shock absorbers are tensioned with high force and can cause very severe accidents if they are accidentally released in an uncontrolled manner.

Safety precautions

- Use safety glasses.
- Lock rings should be of a suitable type and in good condition.
- Follow the instructions in this and other manual when performing maintenance and changing parts and components.
- Always use recommended tools.

Electric motors

Safety precautions

Always turn off the battery disconnector when working on electric motors.

Always block the machine’s wheels, make sure that the parking brake is activated and that the gear selector is in neutral position before starting any work on the machine.

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Rotating components and tools

Examples of rotating components and tools:

- Cooling fan
- Drive belts
- Propeller shafts
- Drills
- Grinders

Risks

Rotating components, for example, fans or shafts, can cause severe injuries if touched.

Drills, lathes, grinders or other machines with rotating parts can cause severe accidents if clothes or hair get caught and are wound up in the machine.

Safety precautions

- Do not use gloves when working with a drill.
- Remove loose, hanging clothing, scarf or tie.
- Never use clothing with wide sleeves or trouser legs.
- Make sure that clothing is intact and in good condition.
- Long hair should be gathered up in a hair-net or similar.
- Remove large or loose hanging jewellery from hands, arms and neck.

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Tyre and rim system

DANGER

Tires shall be regarded as pressure reservoirs. If handled incorrectly, they constitute a fatal danger

Parts can be thrown with explosive force and may cause severe injuries.

Never repair damaged tyres, rims or lock rings. Tyre changes shall be performed by authorised personnel.

Risks

Dismantling wheels: Tyres, rims or lock rings can be thrown.

Inflating of wheels: Tires, rims or lock rings may be ejected.

Safety precautions

- Deflate the tyre before starting to work on the wheel.
- Check that tyres, rims and lock rings aren't damaged. Never repair damaged rims or lock rings.
- Wheels shall be inflated on the machine or in a protective device, designed and dimensioned so that it can handle or dissipate a shock wave from a tire explosion as well as catch the ejected parts.
- Use protective screen and safety glasses.

Lifting equipment

When working on the machine in general, and with the machine's lifting equipment in particular, the greatest caution must be exercised with respect to securing the mast and carriage.

Always make a habit of lowering the carriage to its lowest position before working on the machine.

Risks

Risk of crushing if the machine's lifting equipment is not lowered or secured.

Risk of crushing is extra high when depressurizing the hydraulic system, see *Hydraulic system, depressurizing page 6*.

Safety precautions

Do not start work until the carriage is completely lowered. If the nature of the work requires a raised carriage, this must be secured.

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Spare parts

WARNING

For safety reasons, the following spare parts may only be replaced by genuine spare parts:

- **Brake valve**
- **Drive axle**
- **Valve for mini-wheel/joystick control**
- **Steering valve (orbitrol)**
- **Steering valve incl. priority valve**
- **Steering axle**
- **Steering cylinder**
- **Rim**
- **Lift boom**
- **Boom nose extension**
- **Lift cylinder**
- **Valve block lift**
- **Extension cylinder**
- **Valve block extension**
- **Rotation motor unit**
- **Tilt cylinder**
- **Twistlocks, lift shoe**
- **Control breaker (for hydraulic function)**
- **Emergency switch**
- **Frame**
- **Accumulator**
- **Main valve load handling**
- **Accumulator charging valve**
- **All control units**

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Non-ionised radiation

WARNING

Extra equipment such as two-way radio, RMI, telephone, etc. may emit non-ionised radiation.

Risk of interference with active or non-active medical products.

Use a two-way radio, RMI, telephone, etc., when no persons with active or non-active medical products are nearby.

NOTE

When persons with active or non-active medical products are not nearby, then telephone and two-way radio may be used in the cab.

Equipment should not be used when operating or load handling since this reduces your concentration as operator.

Cargotec does not assume any responsibility for equipment not installed by Cargotec or according to installation instructions approved by Cargotec.

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Environment

General

Ever-increasing industrialisation of our world is having a significant impact on our global environment. Nature, animals and man are subjected daily to risks in connection with various forms of chemical handling.

There are still no environmentally safe chemicals, such as oils and coolants, available on the market. Therefore, all who handle, perform service on or repair machines must use the tools, assisting devices and methods necessary to protect the environment in an environmentally sound manner.

By following the simple rules below, you will contribute to protecting our environment.

Recycling

Well-thought out recycling of the machine is the cornerstone of ending its life cycle and being able to reuse materials in new products. According to calculations by Cargotec, the machine can be recycled to more than 90% by weight.

Environmentally hazardous waste

Components such as batteries, plastics and other items that may constitute environmentally hazardous waste must be handled and taken care of in an environmentally safe and sound manner.

Discarded batteries contain substances hazardous to personal health and the environment. Therefore, handle batteries in an environmentally safe manner and according to national regulations.

Oils and fluids

Oils freely discharged cause environmental damage and can also be a fire hazard. Therefore, when emptying and draining oils or fuel, take appropriate action to prevent unnecessary spills.

Waste oils and fluids must always be taken care of by an authorized disposal company.

Pay close attention to oil leaks and other fluid leaks! Take immediate action to seal the leaks.

Air conditioning system

The refrigerant in the air conditioning system for the cab adds to the greenhouse effect and may never be intentionally released into open air. Special training is required for all service work on the air conditioning system. Many countries require special certification by an authority for such work.

Working in a contaminated area

The machine shall be equipped for work within a contaminated area (environmental contamination or health-hazardous area) before work is started. Also, special local regulations apply to such handling and to service work on such a machine.

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Declarations

The machine does not contain asbestos.

The machines contains lead in batteries and in electric cabling. In certain models, there are lead castings as counterweight.

If the machine is equipped with air conditioning, then refrigerant of the type R134a is used, in an amount between 1-3 kg.

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C Preventive maintenance

Preventive maintenance

See *Maintenance manual DCE 90-180*, section *C Preventive maintenance*.

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Complete machine

Complete machine, description

Kalmar DCF 90-180 is a fork-lift truck. The machine has a lifting capacity of 9–18 tonnes depending on the version.

The engine is a six-cylinder, four-stroke diesel engine with direct injection.

The transmission is hydromechanical with gears in constant mesh. It has three forward gears and three reverse gears. Engine power is transferred by means of a torque converter.

The power transmission consists of a propeller shaft and a rigid drive axle with hub reduction. It is front wheel drive.

The service brakes are wet multiple disc brakes which are attached to the drive wheel hub. The parking brakes are disc brakes and operate on the drive axle input shaft.

Steering operates on the rear wheel with a double action hydraulic cylinder. The steering axle is hung on the frame with pendulum suspension.

The wheels are mounted on the hubs with nuts and washers. Twin wheels are mounted on the drive axle, while the steering axle has single wheels. The wheel rims are detachable.

Load handling consists of components and functions for handling the load. The load is lifted with forks secured at a carriage on a mast. Load handling is divided into the following functions: lifting/lowering, tilt, side shift, spreading, levelling and load carrier.

- Lifting/lowering is the function that lifts and lowers the fork carriage.
- Side shift is for repositioning the forks in parallel at the same distance from each other laterally along the carriage.
- Spreading is for adjusting the width between the forks on the carriage.
- Tilt is for angling the load in the longitudinal direction of the machine by means of the mast.
- Levelling is for angling the load in the lateral direction of the machine.
- The load carrier is for holding or gripping the load.

The control systems are functions for warning the operator of dangerous situations and faults. The control system has diagnostic resources that simplify troubleshooting.

The frame carries the machine. Within the frame the engine, transmission, drive axle, steering axle etc. are secured. On the side of the frame are tanks for fuel and hydraulic oil. The cab is located centrally and can be tipped laterally.

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Troubleshooting, general work instructions

When troubleshooting, it's important that the work is structured and logical. The point of the troubleshooting described in the workshop manual is to exclude components as error source so that the real error source can be pin-pointed. A proposal for structured work method is described below.

When troubleshooting, it's important to understand how the machine functions, certain malfunctions can be pin-pointed directly using function descriptions. In the sections *0–12* there are descriptions of the machine's different functions.

Troubleshooting procedure

1 Check that there is battery voltage available.
   - Battery disconnect switch, must be in position 1.
   - Battery voltage, should be 22–28.5 V .
   - Fuses, check that they are intact.

2 Check that all oil and fluid levels are normal.
   - Fuel
   - Engine oil
   - Transmission oil
   - Hydraulic oil
   - Coolant
   - Washer fluid

3 Check if there are error codes.

4 If there are error codes, use the error code lists as a guide. See *Troubleshooting with error code, example page 5*.

   In the error code lists there are recommended actions for every error code. Error code lists are found in section *D Error codes*.

5 If there is no error code, or problem remains, use the function description for function in question in section *0–12*.

   In the function description there's information about which components are involved in the function and how these components work together. In certain cases, there's information about which conditions apply to enable activation of the function. Measuring points are marked with flags (C for pressure check connections, D for diagnostic menu).

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Troubleshooting without an error code, example

1 Choose suitable section *0–12* to find the function and sub-function that have caused the symptom.

2 Read function description for the function in question to get an overall understanding of which components are affected and how these interact.

3 Use the function description and check the signals for the function in question to find where in the function chain that signal or reaction is incorrect.

4 The fault is probably between the two units where the signal is failing. Start by checking the component that should send the signal.

5 If the component that is to send the signal seems to be correct, check transmission of the signal (electric wiring or hydraulic hoses).

For electric cabling, see *Troubleshooting cable harness page 7*.

For hydraulic hoses, see *Troubleshooting hydraulic hoses page 8*.

6 If the leads or hoses between the components seem in order, then check the component that receives the signal.

Troubleshooting with error code, example

Error codes are strong indicators of malfunctions detected by the control system. Many error codes are connected to electrical malfunctions but there are also error codes that interpret associations between one or several signals that indicate a non-electrical malfunction. It's important to not draw conclusions too fast based on an error code.

1 Read out error code from the display, e.g., error code 357.

2 Use the error code lists and search information about the error code, see "Example of error code information in error code list" below.

Error code lists are found in section *D Error codes*.

For detailed instruction on reading out error code, see section *D Error codes*.

3 Follow instructions in field "Action".

4 Use diagnostic menus and circuit diagrams to determine if the input signal to the control unit is correct, see section *8 Control system*, group *8.4 Diagnostics* as well as section *E Schematics*.

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5 Use Last alarms to see which alarm is saved, see section *8 Control system*, group *8.4.5 Last alarms*.

6 Use the function group to find more information if needed.

In section *0–12* there is function description, the function's included components and their position as well as, in certain cases, work instructions for how components are checked, cleaned or adjusted.

7 If possible eliminate component fault by testing the component individually.

Electric components can sometimes be checked with resistance measurements using a multimeter.

Hydraulic components are often checked by measuring pressure (then described in the function group). Sometimes valves can be activated mechanically to determine if the malfunction is electric or hydraulic.

8 If the component's measuring values are correct, continue by troubleshooting electric cabling and hydraulic hoses.

For electric cabling, see *Troubleshooting cable harness page 7*.

For hydraulic hoses, see *Troubleshooting hydraulic hoses page 8*.

9 If the cable is not defective then connect the lead to the control unit.

NOTE

The main electric power shall be turned off with the battery disconnector!

10 Disconnect the cable harness from the component in question.

11 Turn on the main electric power with the battery disconnector.

12 Turn the ignition key to the operating position.

13 Check that voltage reaches the component.

Table 1. Example of error code information in error code list

Error code	**Description**	**Limi**tation	**Action**
357	Brake system, accumulator pressure low. Brake pressure low for 10 s. The pressure can be low for 60 s at start-up.	Reduction of engine speed.	Stop machine. Check accumulator.

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Troubleshooting cable harness

NOTE

Perform troubleshooting for all cables in the same way to avoid damage to control units, components or measuring equipment.

1 Study the circuit diagram in question, check where the suspected cable is connected and if, and if so where, it is spliced.

2 Turn off the main electric power with the battery disconnector.

3 Unplug the connector at the control unit or component in question.

⚠ CAUTION

Wipe and re-grease the connectors.

Risk of corrosion on contact surfaces.

Clean all connectors loosened during trouble shooting using electronic cleaner 923836.0826 and re-grease them with connector grease 923836.0552.

4 Check if there is open circuit.

NOTE

Some components cannot be checked without power supply to the component. In such an event, proceed to point 5.

a. Measure resistance between connections for the component in the connector at the control unit or component.

b. The resistance must correspond with the component. Otherwise there may be an open circuit or short circuit in cable harness and/or component.

5 Check if there is short circuit to frame:

a. Unplug the connector both at the control unit and component in question.

b. Measure the resistance of one lead at a time. Measure between the lead and a frame-connected part of the machine.

c. The multimeter should show endless resistance.

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Troubleshooting hydraulic hoses

WARNING

Oil under high pressure!

Always depressurize hydraulic system before starting to work on the system. The hydraulic system is pressurised and its oil can cause personal injury.

Avoid skin contact with the oil, use protective gloves. Warm oil can cause burn injuries, rashes and irritation! The oil may also be corrosive to mucous membranes in, e.g., the eyes, skin and throat.

1 Depressurize the hydraulic system, see section *B Safety*.

2 Study the relevant hydraulic diagram, check between whichever components the suspect hose is connected and correspondingly where it is spliced.

3 Locate the hose on the machine.

Start at one component and follow the hose to the next component.

4 Inspect the entire hose and splicing points with respect to chafing damage, pinching damage and leaks.

Change damaged hoses. When removing a hydraulic hose, change of O-ring is always recommended on the hoses that have these (ORFS).

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1 Engine

Engine, general

The engine provides power for propulsion and working hydraulics. The following engine alternatives are available:

- Volvo TAD650VE (147 kW).
- Volvo TAD660VE (147 kW).
- Volvo TAD750VE (181 kW).
- Volvo TAD760VE (181 kW).
- Caterpillar C6.6 (136 kW).
- Cummins QSB6.7 (164 kW).
- Cummins QSB6.7 (129 kW).

In case of differences between engine alternatives is this written out in brackets in headlines or under pictures, to make clear what is described.

The various Volvo and Cummins engines are the same to a great extent, instructions that are common are designated (engine alternative Volvo or Cummins). Instructions that are unique have the whole engine designation written out, for example “(engine alternative Volvo TAD650VE.

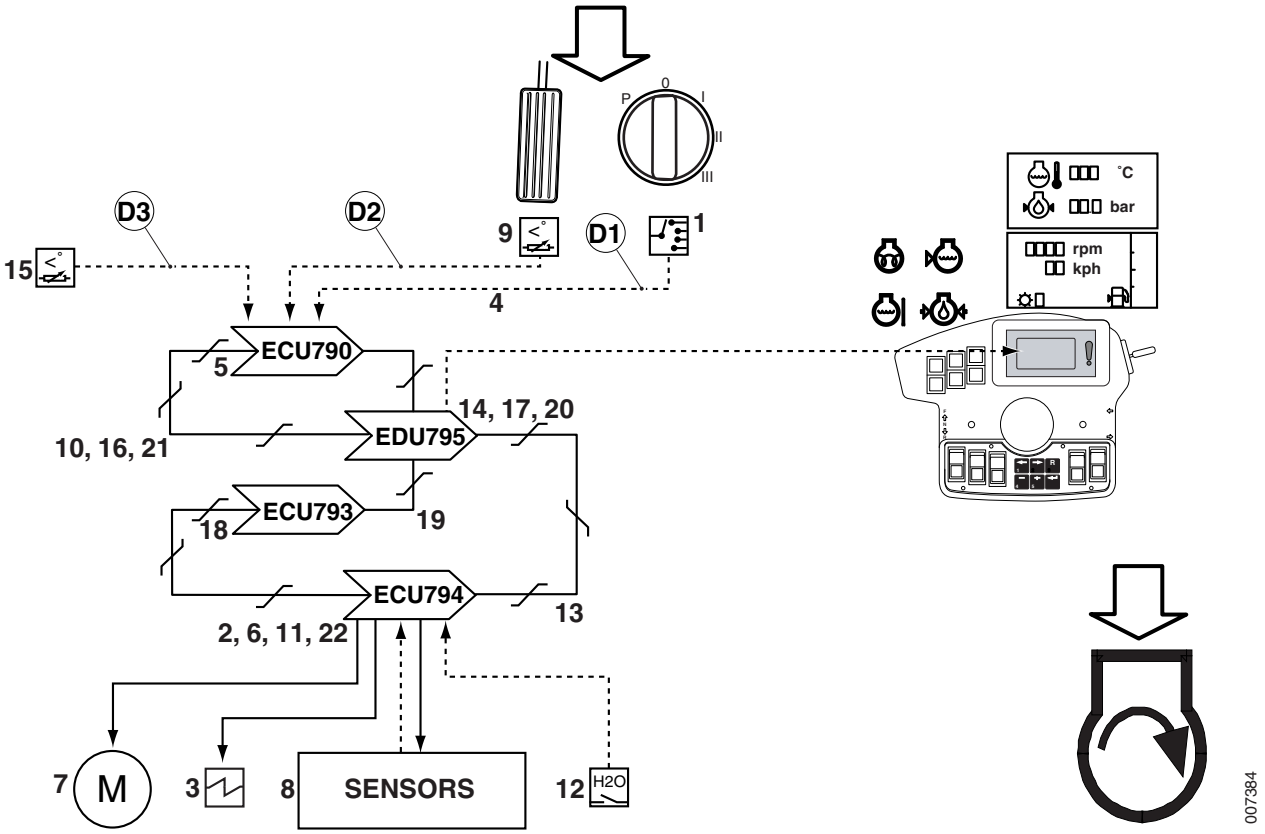
Component supplier documentation

The workshop manual only describes components and job descriptions related to installation in the machine. Please refer to the component supplier documentation for descriptions and instructions of the engine components and systems.

References to component supplier documentation are only provided in exceptional cases. If information about a component is not found, the component supplier documentation should be used.

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Engine, function description (engine alternative Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE)



Pos	Explanation	Signal description	Reference
1	The ignition sends voltage signal to all Control units (ECU) when the start key is turned to position 1 and preheats the primary air if needed.	U = 24 V	See Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.*
2	If preheating has been activated with start key, then control unit engine (ECU794) feeds voltage to the preheating coil via a preheat relay.	U = 24 V	See Section *11 Common electrics*, group *11.5.3 Control unit engine*
3	The preheating coil warms the primary air to the engine.	-	
4	The ignition sends voltage signal to Control unit cab (ECU790) when the start key is turned to start position.	U = 24 V	See Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.* D1: Diagnostic menu, see Section *8 Control system* group *8.4.1.1 View inputs, menu 2*, ECU790 input K1:17.

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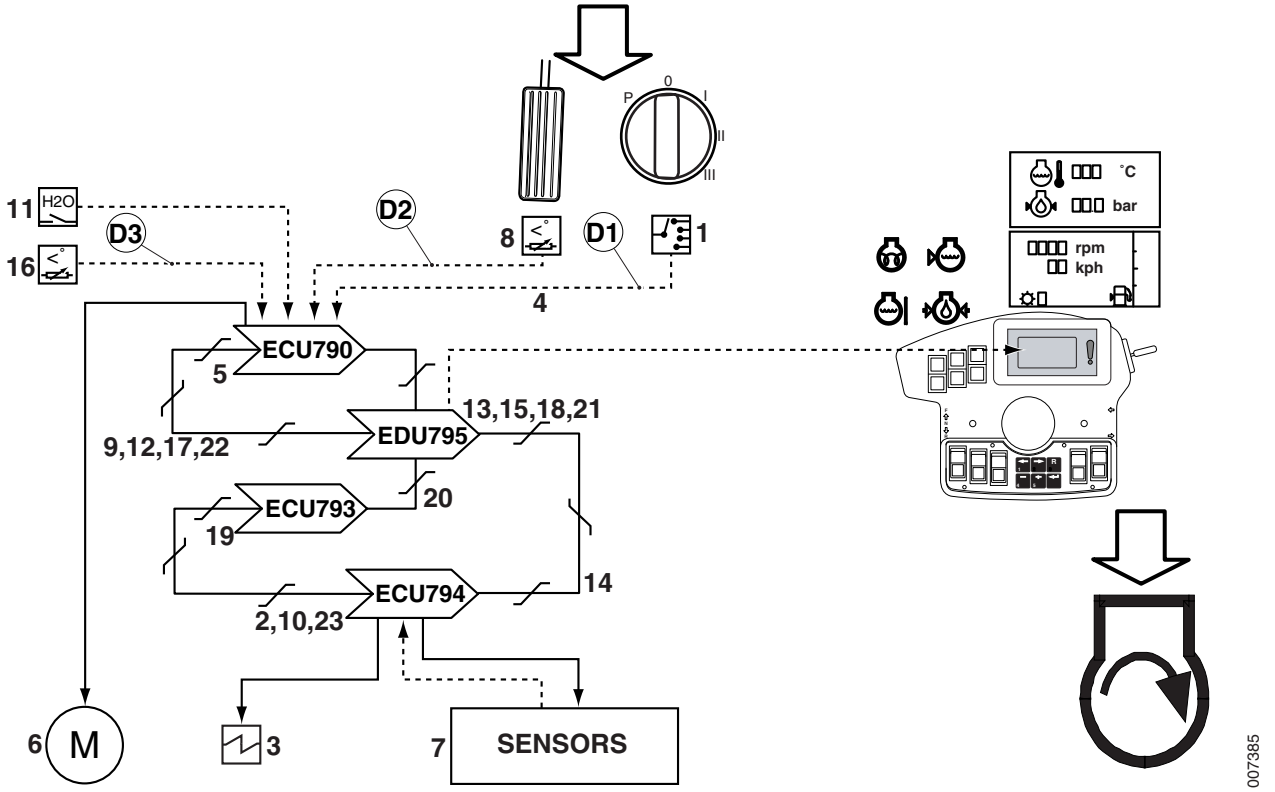
Pos	Explanation	Signal description	Reference
5	Control unit general (ECU790) sends start signal on the CAN-bus.	-	See Section *11 Common electrics*, group *11.6 Communication*
6	Control unit engine (ECU794) controls the Starter motor.	U = 24 V	
7	The starter motor cranks the engine.	-	
8	The engine's sensors send signals to Control unit engine (ECU794) which controls the injectors so that the engine starts.	-	See Section *11 Common electrics*, group *11.5.3 Control unit engine*
9	Throttle pedal sends voltage signal proportional to downward pressing to Control unit general (ECU790).	U = 0,2–4,8 V Lower voltage than 0.5 V and higher voltage than 4.5 V is used to detect malfunction in cable harnesses and controls.	See Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.* D2: Diagnostic menu, see Section *8 Control system* group *8.4.1.1 View inputs, menu 4*, ECU790 input K1:26.
10	Control unit general (ECU790) sends message with rpm request on CAN-bus Control unit engine (ECU794).	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.5.3 Control unit general* See Section *11 Common electrics*, group *11.6 Communication*
11	Control unit engine (ECU794) increases engine rpm.	-	See Section *11 Common electrics*, group *11.5.3 Control unit engine*
12	Make-contact coolant level sends voltage signal to Control unit engine (ECU794) if coolant level is low in expansion tank.	U = 5 V	*Switch normally open (NO), coolant level description page 61*
13	Control unit engine (ECU794) sends engine data and warning messages on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
14	Control unit terminal (EDU795) shows engine data via display figures.	-	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.*
15	Sensor fuel level (B757) sends voltage signal proportional to fuel level in tank to Control unit general (ECU790). An alarm is shown in the display if fuel level is below 15% for more than 40 seconds.	R = 4–73 ohm	*Sensor, fuel level, description page 38* D3: Diagnostic menu, see Section *8 Control system*, group *8.4.1.1 View inputs, menu 3, ECU790 K2:08*
16	Control unit general (ECU790) sends fuel level on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
17	Control unit terminal (EDU795) shows fuel level in operating menu for engine and transmission.	-	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.*

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Pos	Explanation	Signal description	Reference
18	**Speed limitation** Sensor output shaft (B758) sends pulses with frequency proportional to rpm on output shaft to the Control unit transmission (ECU793).	-	See *Supplier documentation transmission*
19	Control unit transmission (ECU793) sends speed on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
20	Control unit terminal (EDU795) shows the machine's speed.	-	See Section *11 Common electrics*, group *11.5.3 Control unit terminal*
21	If the rpm on the output shaft is so high that it matches the limit for the machine's speed limitation, then Control unit general (ECU790) sends reduce engine rpm on the CAN-bus.	-	See Section *11 Common electrics*, group *11.6 Communication*
22	Control unit engine (ECU794) restricts engine rpm.	-	See Section *11 Common electrics*, group *11.5.3 Control unit engine*

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Engine, function description (engine alternative Cummins QSB6.7 and Caterpillar C6.6)



Pos	Explanation	Signal description	Reference
1	The ignition sends voltage signal to all Control units (ECU) when the start key is turned to position 1 and preheats the primary air if needed.	U = 24 V	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.*
2	If preheating has been activated with start key, then control unit engine (ECU794) feeds voltage to the pre-heating coil via a preheat relay.	U = 24 V	See Section *11 Common electrics*, group *11.5.3 Control unit engine*
3	The preheating coil warms the primary air to the engine.	-	
4	The ignition sends voltage signal to Control unit general (ECU790) when the start key is turned to start position.	U = 24 V	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.* D1: Diagnostic menu, see Section *8 Control system*, group *8.4.1.1 View inputs, menu 2*, ECU790 input K1:17.
5	Control unit general (ECU790) controls the starter motor through start relays.	U = 24 V	

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Pos	Explanation	Signal description	Reference
6	The starter motor cranks the engine.	-	
7	The engine's sensors send signals to Control unit engine (ECU794) which controls the injectors so that the engine starts.	-	See Section *11 Common electrics*, group *11.5.3 Control unit engine*
8	Throttle pedal sends voltage signal proportional to downward pressing to Control unit general (ECU790).	U = 0,5–4,5 V Lower voltage than 0.2 V and higher voltage than 4.8 V is used to detect malfunction in cable harnesses and controls.	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation*. D2: Diagnostic menu, see Section *8 Control system*, group *8.4.1.1 View inputs, menu 4*, ECU790 input K1:26.
9	Control unit general (ECU790) sends message with rpm request on CAN-bus via display unit (EDU795) to Control unit engine (ECU794).	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.5.3 Control unit general* See Section *11 Common electrics*, group *11.6 Communication*
10	Control unit engine (ECU794) increases engine rpm.	-	See Section *11 Common electrics*, group *11.5.3 Control unit engine*
11	Make-contact coolant level sends voltage signal to Control unit general (ECU790) if coolant level is low in expansion tank.	U = 5 V	*Switch normally open (NO), coolant level description page 61* D3: Diagnostic menu, see Section *8 Control system*, group *8.4.1.1 View inputs, menu 7, ECU790 K1:38*
12	Control unit general (ECU790) sends low coolant level on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
13	Control unit terminal (EDU795) shows low coolant level as alarm in display.	-	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation*.
14	Control unit engine (ECU794) sends engine data and warning messages on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
15	Control unit terminal (EDU795) shows engine data via display figures.	-	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation*.
16	Sensor fuel level (B757) sends voltage signal proportional to fuel level in tank to Control unit general (ECU790). An alarm is shown in the display if fuel level is below 15% for more than 40 seconds.	R = 4–73 ohm	*Sensor, fuel level, description page 38* D4: Diagnostic menu, see Section *8 Control system*, group *8.4.1.1 View inputs, menu 3, ECU790 K2:08*
17	Control unit general (ECU790) sends fuel level on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*

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Pos	Explanation	Signal description	Reference
18	Control unit terminal (EDU795) shows fuel level in operating menu for engine and transmission.	-	Section *9 Frame, body, cab and accessories*, group *9.1 Controls and instrumentation.*
19	**Speed limitation** Sensor output shaft (B758) sends pulses with frequency proportional to rpm on output shaft to Control unit transmission (ECU793).	-	See *Supplier documentation transmission*
20	Control unit transmission (ECU793) sends speed on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
21	Control unit terminal (EDU795) shows the machine's speed.	-	See Section *11 Common electrics*, group *11.5.3 Control unit terminal*
22	If the rpm on the output shaft is so high that it matches the limit for the machine's speed limitation, then Control unit general (ECU790) sends reduce engine rpm on the CAN-bus.	-	See Section *11 Common electrics*, group *11.6 Communication*
23	Control unit engine (ECU794) restricts engine rpm.	-	See Section *11 Common electrics*, group *11.5.3 Control unit engine*

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Engine, replacement (engine alternative Volvo TAD750VE/ TAD760VE and TAD650VE/ TAD660VE with transmission Dana)

⚠ DANGER

The engine is very heavy.

Risk of pinch injury!

NOTE

Depending on workshop equipment and other circumstances, an alternative method for replacing engine is to lift the entire installation (engine, cooler and gearbox with detached hydraulic pumps) out of the machine, and replace the engine on the ground.

NOTE

Read the safety instructions for oil and for cooling system before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Remove the hood engine compartment, please refer to Section *9 Frame, body, cab and accessories*, group *9.13.2 Hood engine compartment*.



3 Remove the partition wall between the engine compartment and the cab.

The partition wall is secured with four screws.

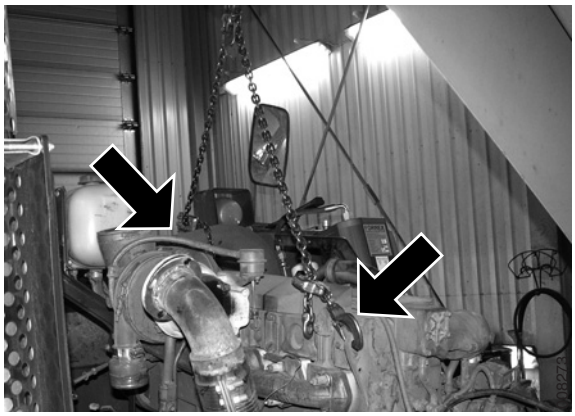
The air cleaner is mounted on the partition wall.

Air cleaner:

- Release the hose connection from the turbo and undo the hose clamp that holds the inlet hose to the left-hand front engine mounting.

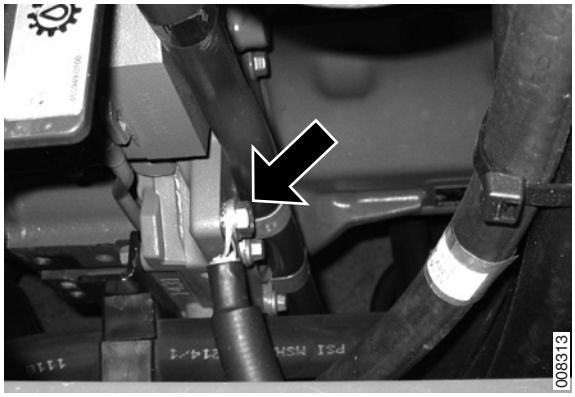
  Protect the air inlet to the engine and the hose with a seal, e.g. a plastic bag.

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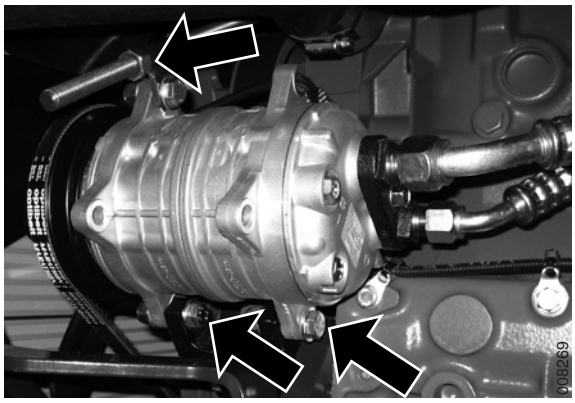
4 Connect lifting equipment to the diesel engine.

5 Undo cables and hoses as necessary before the engine and transmission pump are separated, for example:



Earth strap

- Earth strap for engine, remove the screw from the engine on the machines left-hand side.



AC-compressor

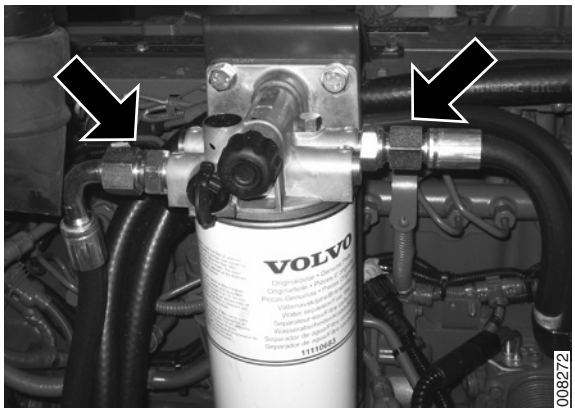
- AC compressor, remove screws and drive belt. Fold the compressor away without undoing the hoses.



Connector, engine cables

- Engine cables, undo the engine cable connector by releasing the screw and pressing the plastic lock on the underside, fold the connector to one side.

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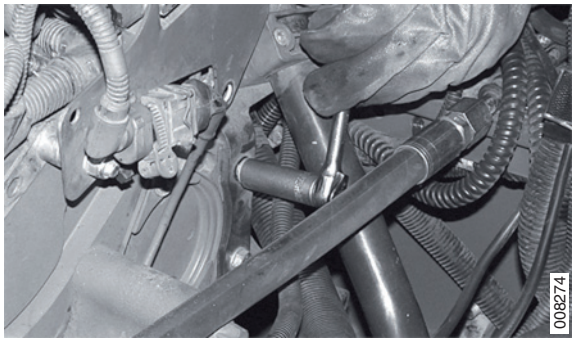


Fuel hoses on fuel filter

NOTE

Empty and collect all fluids before the hoses are undone.

- Fuel hoses, undo and remove the hoses from the primary fuel filter and fuel tank. Plug all connections and hoses immediately to prevent impurities entering fuel or hydraulic system.



Bracket for the gearbox dipstick

- Dipstick for the gearbox, remove the bracket for the dipstick from the engine on the machines left-hand side.



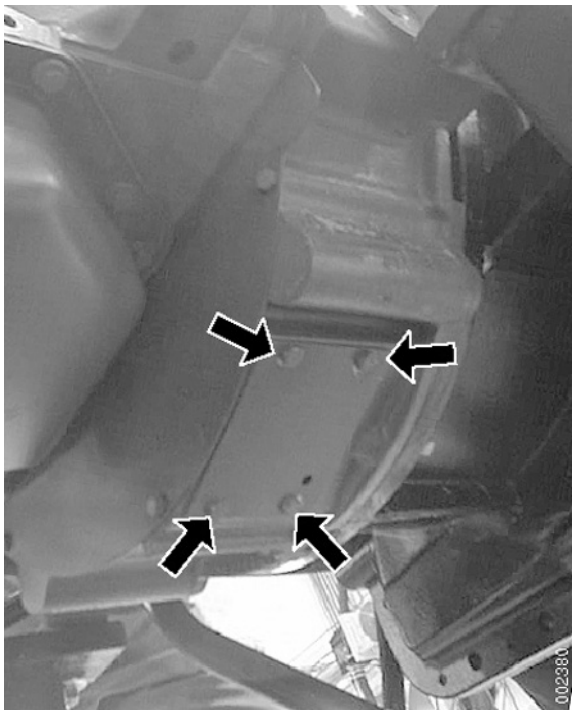
Bracket for the silencer

- Undo the silencer to make it possible to get at the nuts on the flexible plate.

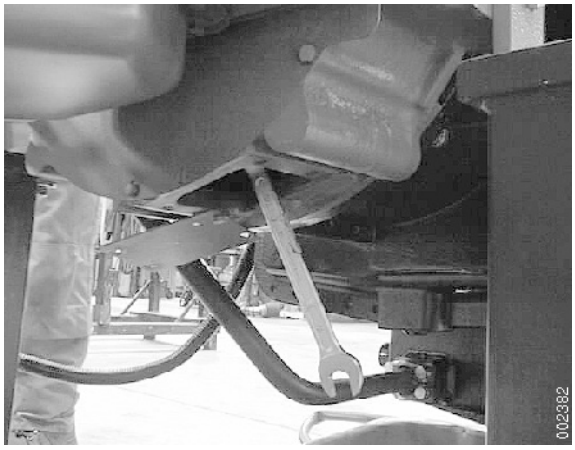
6 Remove the radiator, please refer to *Radiator, replacement page 50*.

7 Use a jack or equivalent to secure the gearbox.

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8 Remove the screws for the cover plate under the flywheel.



9 Remove the nuts for the flexible plate through the hole under the cover plate.

NOTE

Turn the engine for each nut to be removed from the flex plate.

10 Take up the slack in the hoisting equipment.

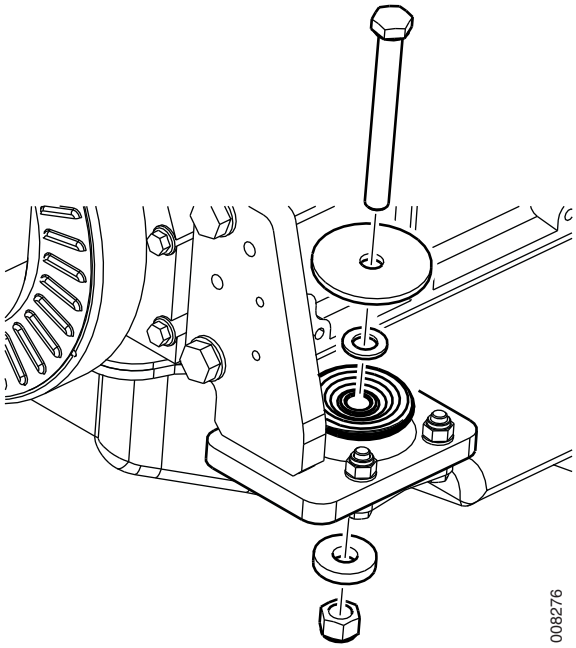
NOTE

Do not raise the engine.



11 Remove the screws between engine and gearbox.

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12 Remove the screws in the engine brackets.

13 Withdraw the engine rearwards to separate it from the gearbox.

NOTE

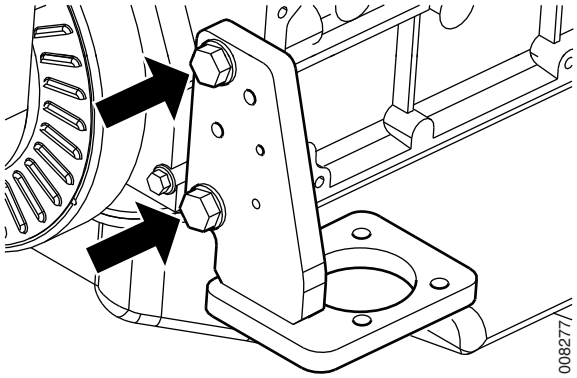
If the flexible plates are damaged during an engine replacement, they must also be replaced.

NOTE

Beware of balance before the engine is lifted.

14 Lift the engine away.

Assembly



15 Move the engine mountings from the removed diesel engine to the new one. Torque the screws on the front engine mountings to **189 Nm.**

16 Move other components from the old diesel engine to the new one, as necessary.

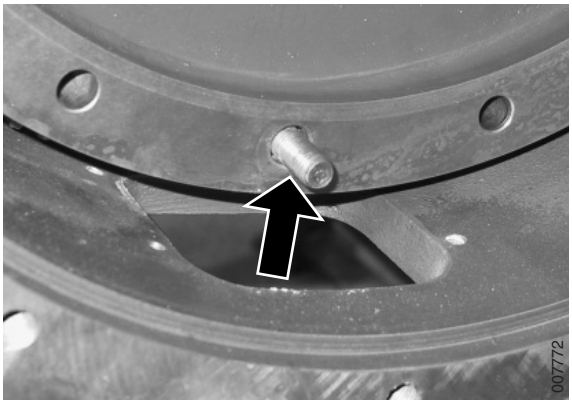


17 Put two studs into the flywheel housing as a guide when the engine is installed.

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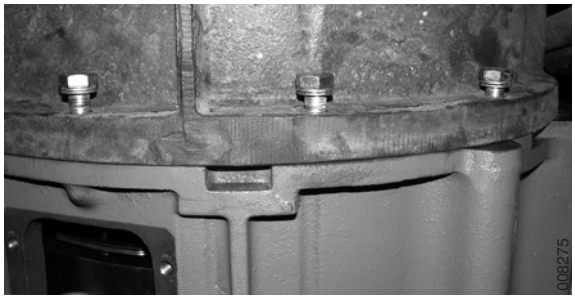


18 Grease the torque converter connection, both on the Diesel engine and on the transmission.

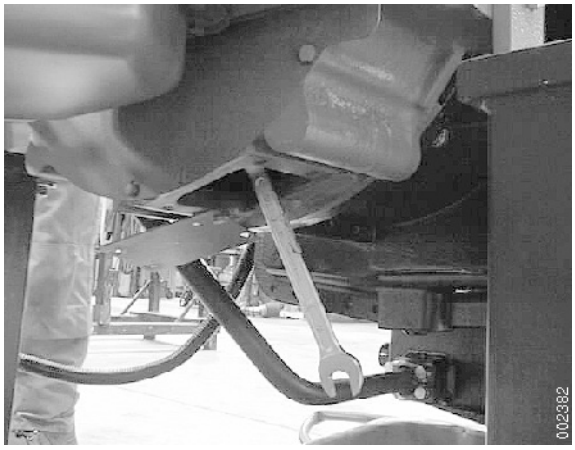


19 Align a stud on the flywheel so that it is centred on a hole in the flywheel housing

20 Lift the new diesel engine into place. Make sure that the studs on the flywheel come into correct alignment and do not damage the flexible plate.



21 Install the screws which fix the gearbox and engine, but do not tighten the screws fully. Leave about a millimetre between the engine and gearbox, to facilitate installation of the nuts for the flexible plate/flywheel.



22 Install the nuts which hold the flexible plate to the flywheel in two stages. Do not tighten the nuts in the first stage.

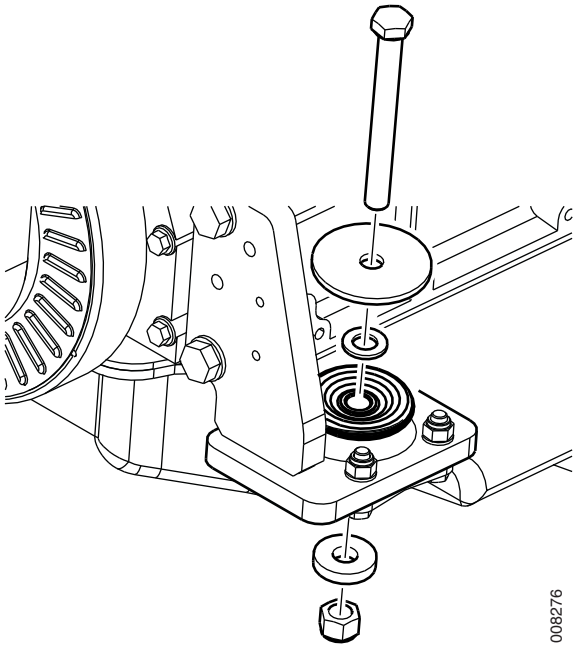
NOTE

The diesel engine must be undone from the engine mountings and from the gearbox to remove a dropped nut. Secure the nut in the socket during installation.

23 Tighten the screws which fix the gearbox and engine.

24 Rotate the flywheel a further rotation and tighten the nuts which hold the flexible plate to the flywheel.

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25 Line up and screw down the engine mountings on the rubber dampers. Torque the screws to **135 Nm.**

26 Fit the cover plate under the flywheel.

27 Undo the lifting equipment from the diesel engine.

28 Remove the jack from underneath the gearbox.

29 Attach relevant hoses and cables to the engine. Check fluid levels and top up as necessary.

30 Put back the radiator, partition wall, silencer and other equipment. Installation is in reverse order.

31 Test drive.

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Engine, replacement (engine alternative Volvo TAD650VE/ TAD660VE with transmission ZF)

⚠ DANGER

The engine is very heavy.

Risk of pinch injury!

NOTE

Depending on workshop equipment and other circumstances, an alternative method for replacing engine is to lift the entire installation (engine, cooler and gearbox with detached hydraulic pumps) out of the machine, and replace the engine on the ground.

NOTE

Read the safety instructions for oil and for cooling system before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Remove the hood engine compartment, please refer to Section *9 Frame, body, cab and accessories*, group *9.13.2 Hood engine compartment*.



3 Remove the partition wall between the engine compartment and the cab.

The partition wall is secured with four screws.

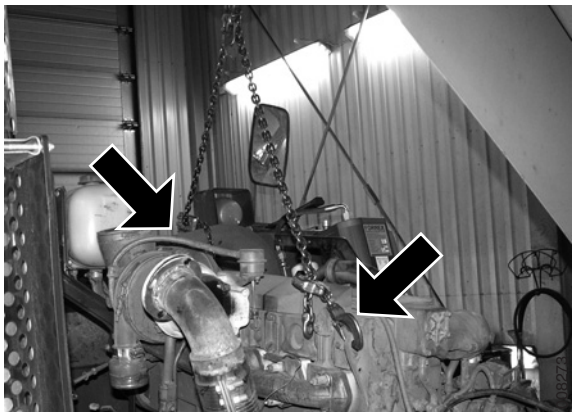
The air cleaner is mounted on the partition wall.

Air cleaner:

- Release the hose connection from the turbo and undo the hose clamp that holds the inlet hose to the left-hand front engine mounting.

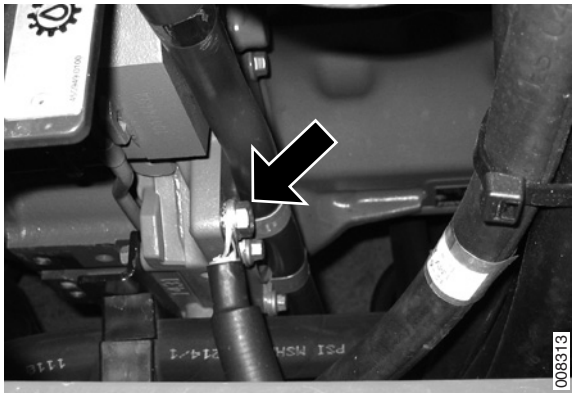
  Protect the air inlet to the engine and the hose with a seal, e.g. a plastic bag.

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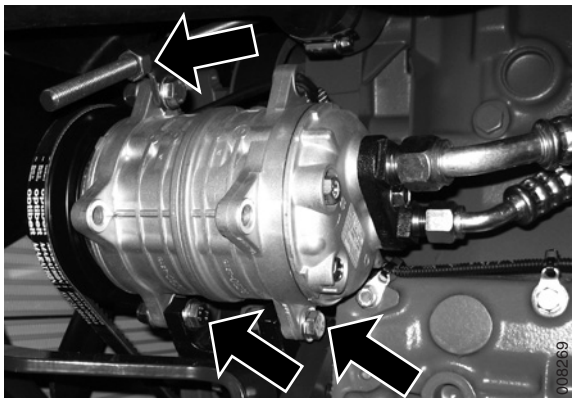
4 Connect lifting equipment to the diesel engine.

5 Undo cables and hoses as necessary before the engine and transmission pump are separated, for example:



Earth strap

- Earth strap for engine, remove the screw from the engine on the machines left-hand side.



AC-compressor

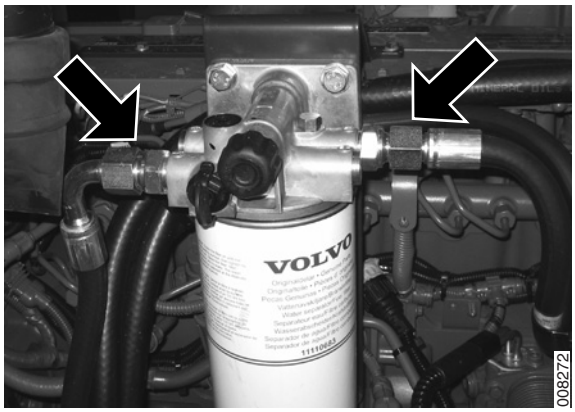
- AC compressor, remove screws and drive belt. Fold the compressor away without undoing the hoses.



Connector, engine cables

- Engine cables, undo the engine cable connector by releasing the screw and pressing the plastic lock on the underside, fold the connector to one side.

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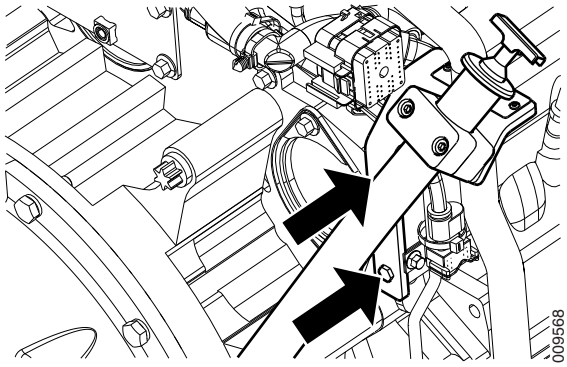


Fuel hoses on fuel filter

NOTE

Empty and collect all fluids before the hoses are undone.

- Fuel hoses, undo and remove the hoses from the primary fuel filter and fuel tank. Plug all connections and hoses immediately to prevent impurities entering fuel or hydraulic system.



Bracket for the gearbox dipstick

- Dipstick for the gearbox, remove the bracket for the dipstick from the engine on the machines left-hand side.



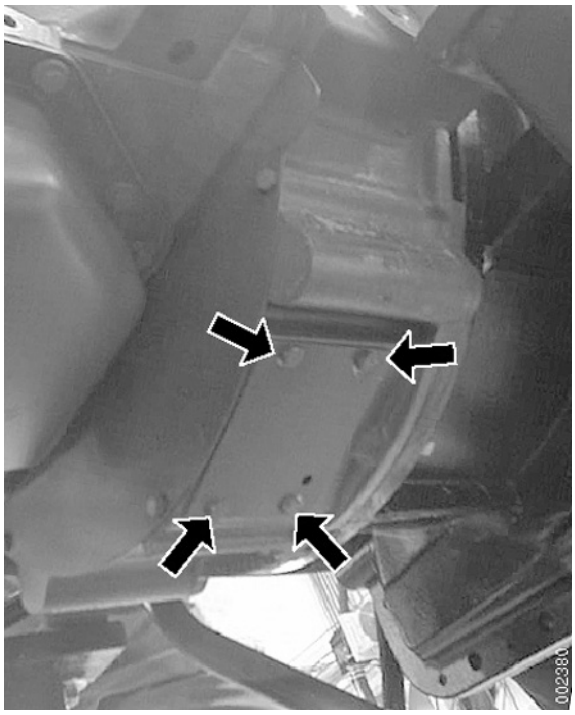
Bracket for the silencer

- Undo the silencer to make it possible to get at the nuts on the flexible plate.

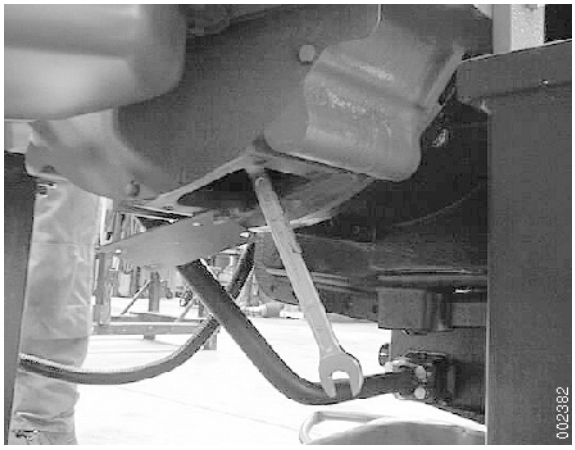
6 Remove the radiator, please refer to *Radiator, replacement page 50*.

7 Use a jack or equivalent to secure the gearbox.

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8 Remove the screws for the cover plate under the flywheel.



9 Remove the screws for the flexible plate through the hole under the cover plate.

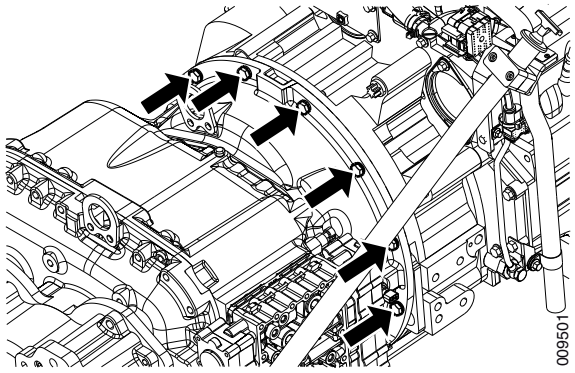
NOTE

Turn the engine for each screw to be removed from the flex plate.

10 Take up the slack in the hoisting equipment.

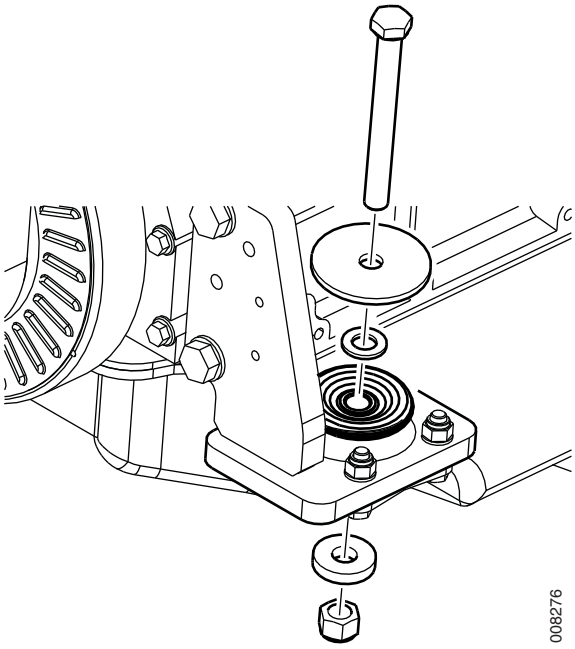
NOTE

Do not raise the engine.



11 Remove the screws between engine and gearbox.

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12 Remove the screws in the engine brackets.

13 Withdraw the engine rearwards to separate it from the gearbox.

NOTE

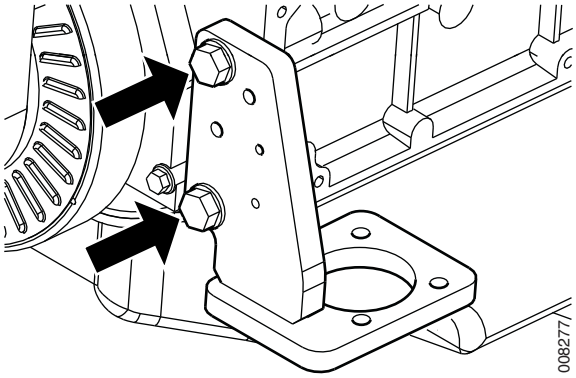
If the flexible plates are damaged during an engine replacement, they must also be replaced.

NOTE

Beware of balance before the engine is lifted.

14 Lift the engine away.

Assembly



15 Move the engine mountings from the removed diesel engine to the new one. Torque the screws on the front engine mountings to **189 Nm.**

16 Move other components from the old diesel engine to the new one, as necessary.

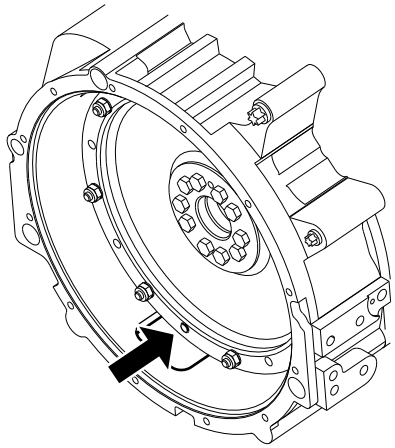


17 Put two studs into the flywheel housing as a guide when the engine is installed.

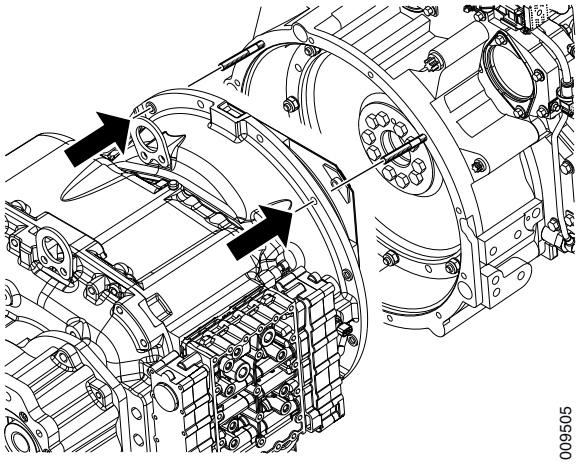
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18 Grease the torque converter connection, both on the Diesel engine and on the transmission.



19 Align one of the holes on the flywheel so that it is centred on the hole in the flywheel housing



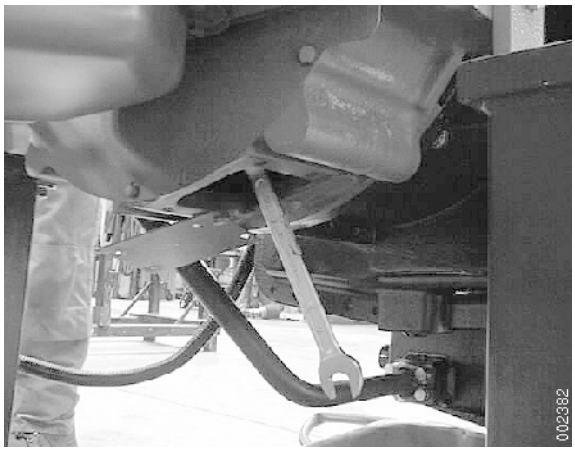
20 Lift the new diesel engine into place.

NOTE

If the flexible plates are damaged during an engine replacement, they must also be replaced.

21 Install the screws which fix the gearbox and engine, but do not tighten the screws fully. Leave about a millimetre between the engine and gearbox, to facilitate installation of the nuts for the flexible plate/flywheel.

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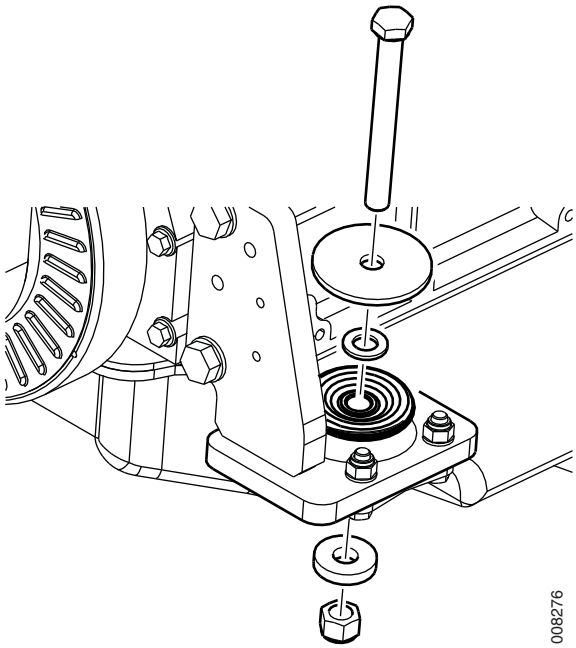
22 Install the screws which hold the flexible plate to the flywheel in two stages. Do not tighten the nuts in the first stage.

NOTE

The diesel engine must be undone from the engine mountings and from the gearbox to remove a dropped nut. Secure the nut in the socket during installation.

23 Tighten the screws which fix the gearbox and engine.

24 Rotate the flywheel a further rotation and tighten the nuts which hold the flexible plate to the flywheel to **46 Nm**.



25 Line up and screw down the engine mountings on the rubber dampers. Torque the screws to **135 Nm.**

26 Fit the cover plate under the flywheel.

27 Undo the lifting equipment from the diesel engine.

28 Remove the jack from underneath the gearbox.

29 Attach relevant hoses and cables to the engine. Check fluid levels and top up as necessary.

30 Put back the radiator, partition wall, silencer and other equipment. Installation is in reverse order.

31 Test drive.

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Engine, replacement (engine alternative Cummins QSB6.7)

DANGER

The engine is very heavy.

Risk of pinch injury!

NOTE

Depending on workshop equipment and other circumstances, an alternative method for replacing engine is to lift the entire installation (engine, cooler and gearbox with detached hydraulic pumps) out of the machine, and replace the engine on the ground.

NOTE

Read the safety instructions for oil and for cooling system before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Remove the hood engine compartment, please refer to Section *9 Frame, body, cab and accessories*, group *9.13.2 Hood engine compartment*.



3 Remove the partition wall between the engine compartment and the cab.

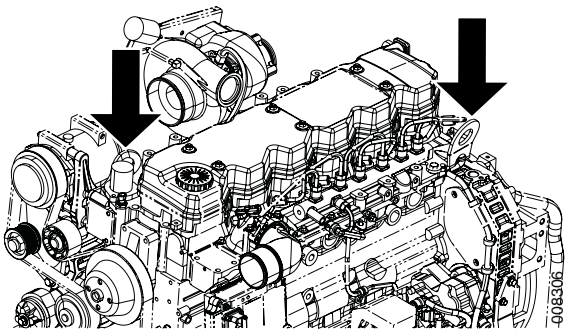
The partition wall is secured with four screws.

The air cleaner is mounted on the partition wall.

Air cleaner:

- Release the hose connection from the turbo and undo the hose clamp that holds the inlet hose to the left-hand front engine mounting.

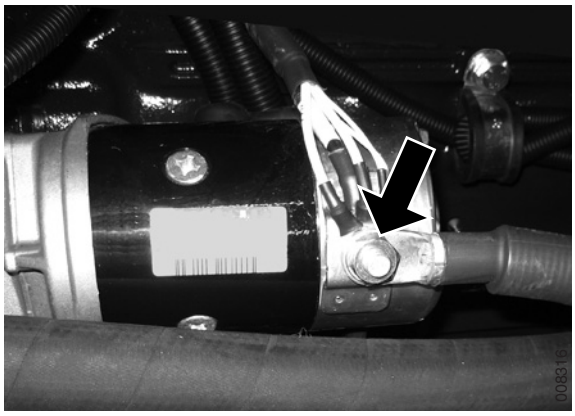
  Protect the air inlet to the engine and the hose with a seal, e.g. a plastic bag.



4 Connect lifting equipment to the diesel engine.

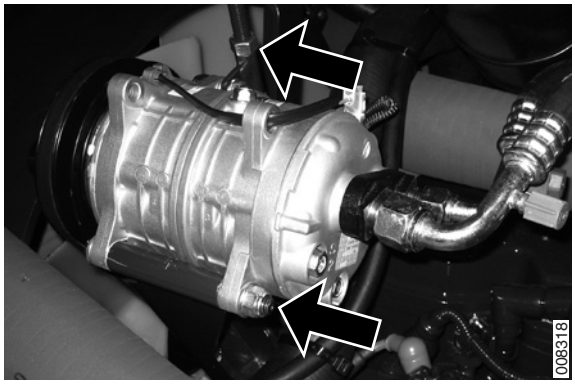
5 Undo cables and hoses as necessary before the engine and transmission pump are separated, for example:

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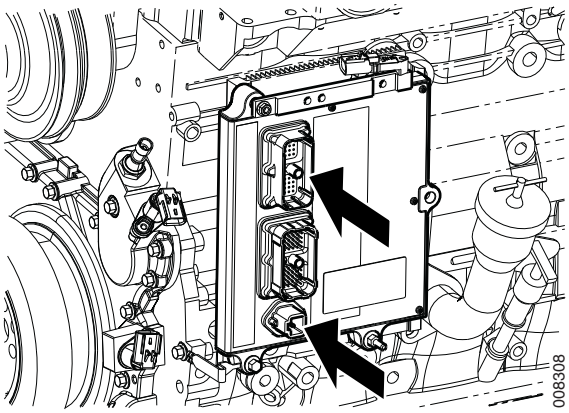
Earth strap for starter motor

- Earth strap for starter motor, remove the screw from the starter motor.



AC-compressor

- AC compressor, remove screws and drive belt. Fold the compressor away without undoing the hoses.



Connector, engine cables

- Engine cables, undo the engine cable connector and fold the connector to one side.

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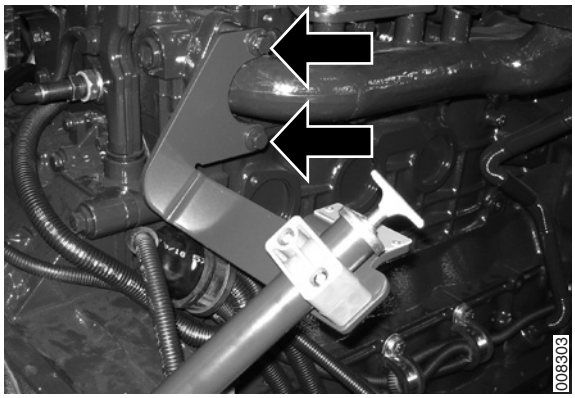


Fuel hoses on fuel filter

NOTE

Empty and collect all fluids before the hoses are undone.

- Fuel hoses, undo and remove the hoses from the primary fuel filter and fuel tank. Plug all connections and hoses immediately to prevent impurities entering fuel or hydraulic system.

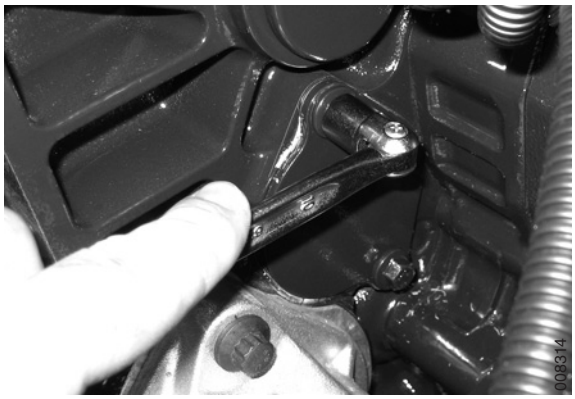


Bracket for the gearbox dipstick

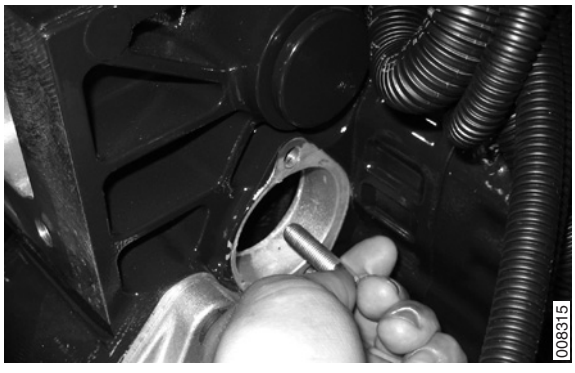
- Dipstick for the gearbox, remove the bracket for the dipstick from the engine on the machines left-hand side.

6 Remove the radiator, please refer to *Radiator, replacement page 50*.

7 Use a jack or equivalent to secure the gearbox.



8 Remove the cover plate fixed with 2 screws on the engines left-hand side.



9 Remove the screws for the flexible plate through the hole under the cover plate.

NOTE

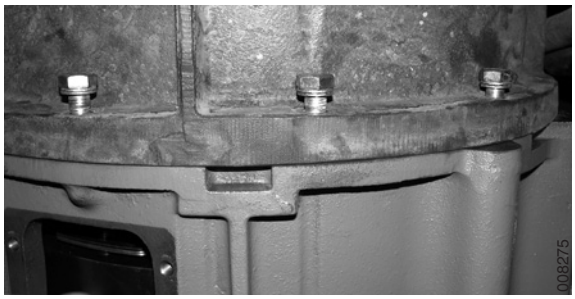
Turn the engine for each screw to be removed from the flex plate.

10 Take up the slack in the hoisting equipment.

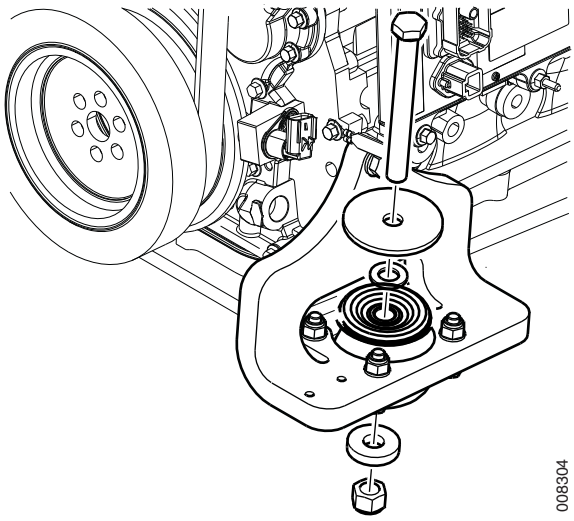
NOTE

Do not raise the engine.

https://truckmanualshub.com/



11 Remove the screws between engine and gearbox.



12 Remove the screws in the engine brackets.

13 Withdraw the engine rearwards to separate it from the gearbox.

NOTE

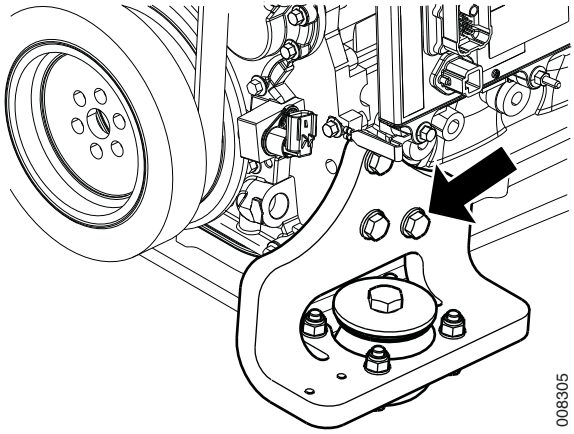
If the flexible plates are damaged during an engine replacement, they must also be replaced.

NOTE

Beware of balance before the engine is lifted.

14 Lift the engine away.

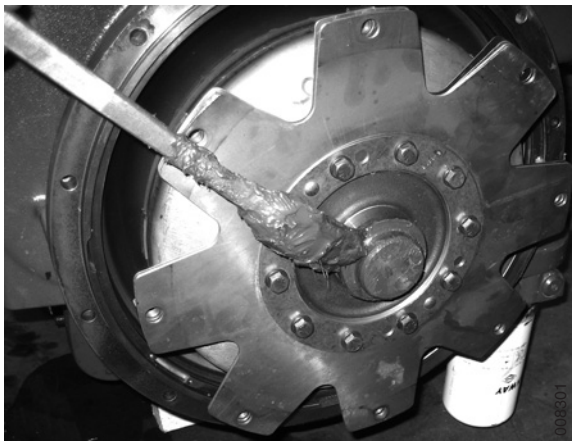
Assembly



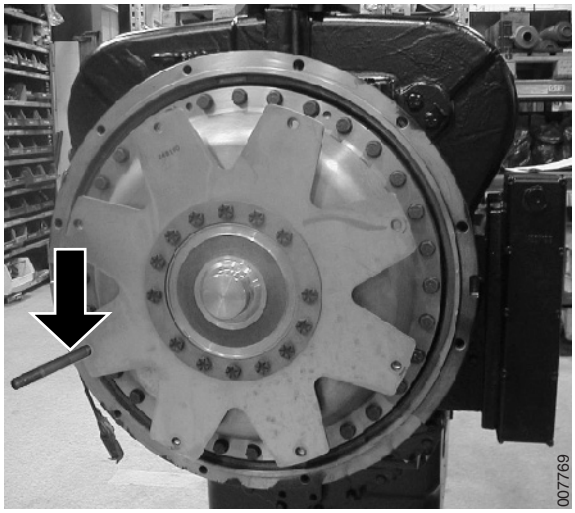
15 Move the engine mountings from the removed diesel engine to the new one. Torque the screws on the front engine mountings to **78 Nm.**

16 Move other components from the old diesel engine to the new one, as necessary.

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17 Grease the torque converter connection, both on the Diesel engine and on the transmission.



Engine guide stud

18 Insert a stud into one of the nuts on the flexible plate as a guide when the engine is installed.

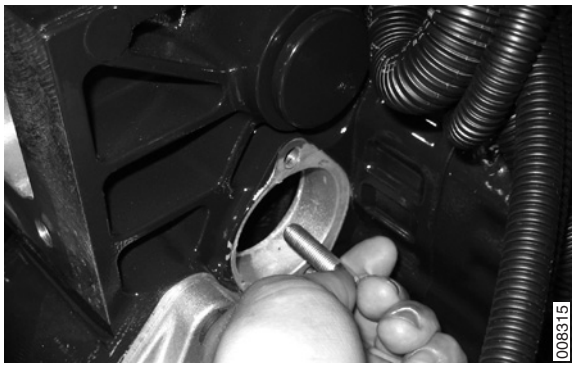


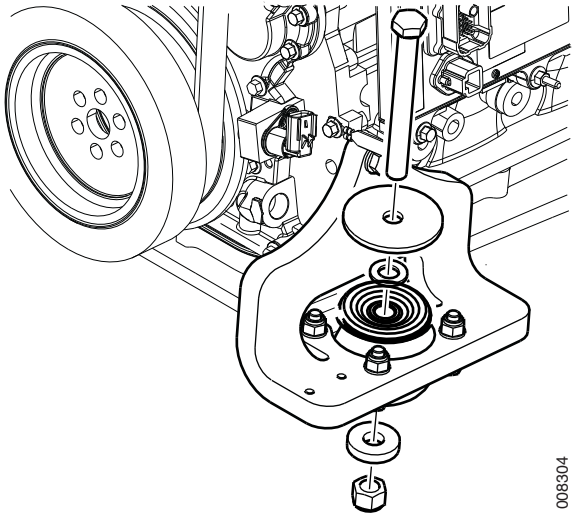
19 Lift the new diesel engine into place. Guide the stud through the flywheel and out through the hole in the flywheel housing.

20 Install the screws which fix the gearbox and engine, and tighten the screws.

21 Remove the stud through the hole in the flywheel housing.

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22 Install the screws which hold the flexible plate to the flywheel in two stages. Do not tighten the screws in the first stage. Then rotate the flywheel a further rotation and tighten the screws.

NOTE

Turn the engine for each screw to be installed to the flex plate.

NOTE

The diesel engine must be undone from the engine mountings and from the gearbox to remove a dropped screw. Secure the screw in the socket during installation.

23 Line up and screw down the engine mountings on the rubber dampers. Torque the screws to **135 Nm.**

24 Fit the cover plate for the flex plate screws.

25 Undo the lifting equipment from the diesel engine.

26 Remove the jack from underneath the gearbox.

27 Attach relevant hoses and cables to the engine. Check fluid levels and top up as necessary.

28 Put back the radiator, partition wall, silencer and other equipment. Installation is in reverse order.

29 Test drive.

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Engine, replacement (engine alternative Caterpillar C6.6)

⚠ DANGER

The engine is very heavy.

Risk of pinch injury!

NOTE

Depending on workshop equipment and other circumstances, an alternative method for replacing engine is to lift the entire installation (engine, cooler and gearbox with detached hydraulic pumps) out of the machine, and replace the engine on the ground.

NOTE

Read the safety instructions for oil and for cooling system before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Remove the hood engine compartment, please refer to Section *9 Frame, body, cab and accessories*, group *9.13.2 Hood engine compartment*.



3 Remove the partition wall between the engine compartment and the cab.

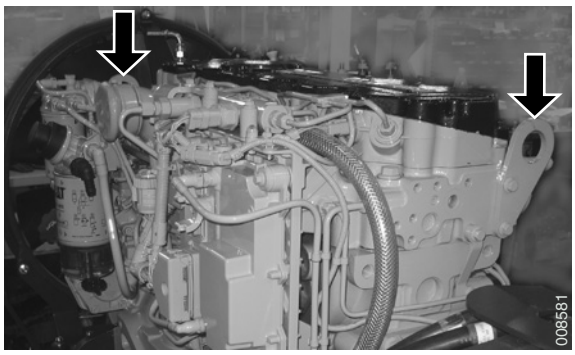
The partition wall is secured with four screws.

The air cleaner is mounted on the partition wall.

Air cleaner:

- Release the hose connection from the turbo and undo the hose clamp that holds the inlet hose to the left-hand front engine mounting.

  Protect the air inlet to the engine and the hose with a seal, e.g. a plastic bag.

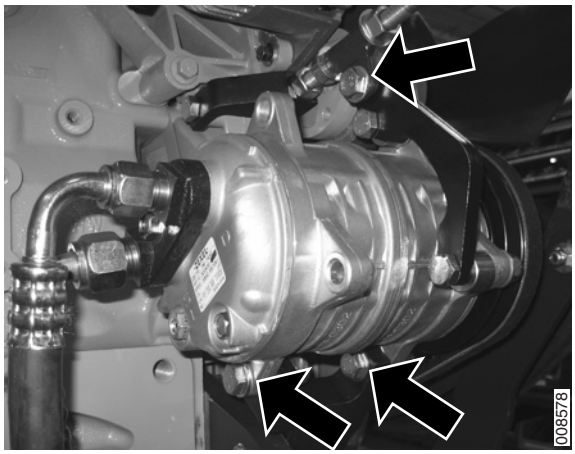


4 Connect lifting equipment to the diesel engine.

5 Undo cables and hoses as necessary before the engine and transmission pump are separated, for example:

- Earth strap for starter motor, remove the screw from the starter motor.

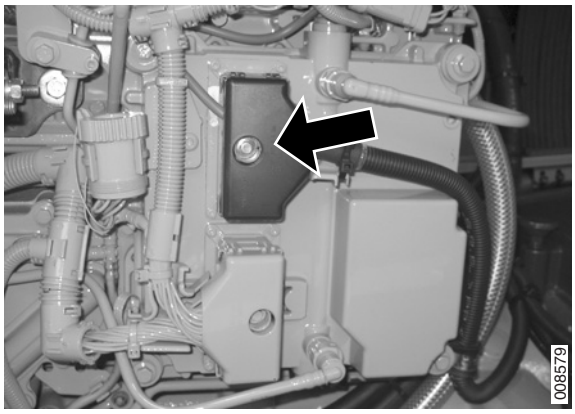
https://truckmanualshub.com/



AC-compressor

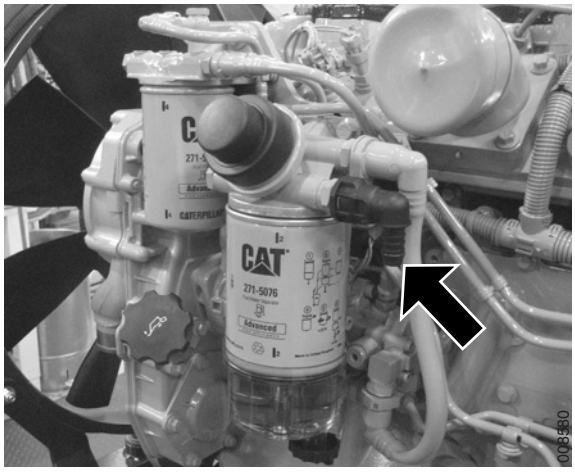
⊞

- AC compressor, remove screws and drive belt. Fold the compressor away without undoing the hoses.



Connector, engine cables

- Engine cables, undo the engine cable connector and fold the connector to one side.



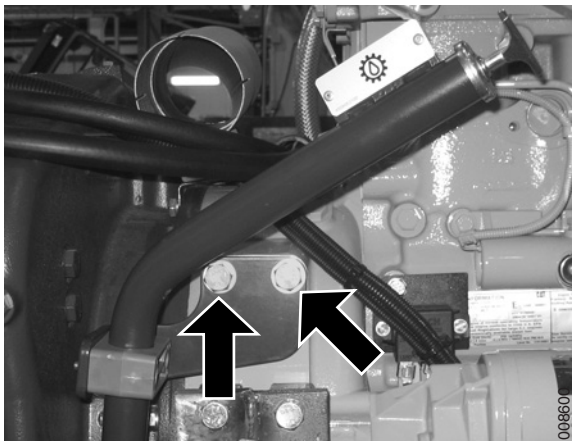
Fuel hoses on fuel filter

NOTE

Empty and collect all fluids before the hoses are undone.

- Fuel hoses, undo and remove the hoses from the primary fuel filter and fuel tank. Plug all connections and hoses immediately to prevent impurities entering fuel or hydraulic system.

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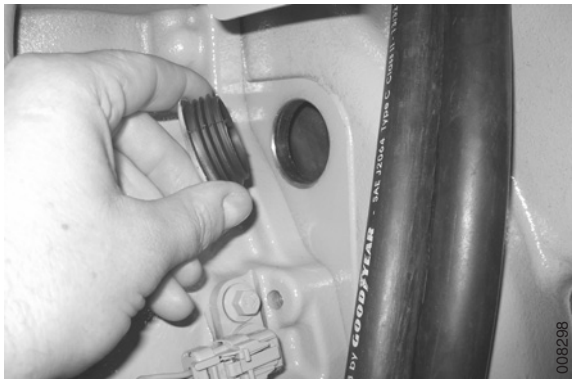


Bracket for the gearbox dipstick

- Dipstick for the gearbox, remove the bracket for the dipstick from the engine on the machines left-hand side.

6 Remove the radiator, please refer to *Radiator, replacement page 50*.

7 Use a jack or equivalent to secure the gearbox.



8 Remove the rubber cover plug on the engine, located on the right-hand side of the machine.



9 Remove the screws for the flexible plate through the hole.

NOTE

Turn the engine for each screw to be removed from the flex plate.

10 Take up the slack in the hoisting equipment.

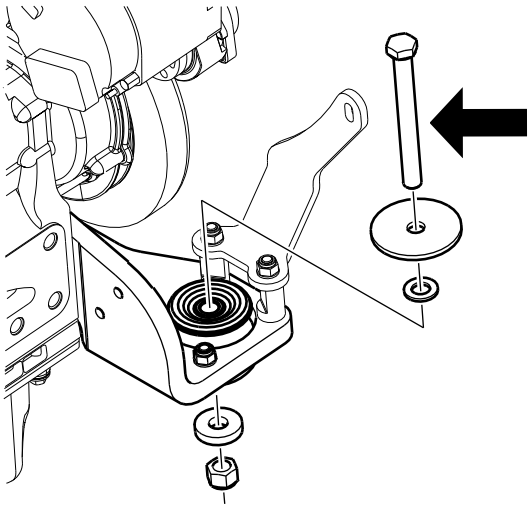
NOTE

Do not raise the engine.



11 Remove the screws between engine and gearbox.

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008321

12 Remove the screws in the engine brackets.

13 Withdraw the engine rearwards to separate it from the gearbox.

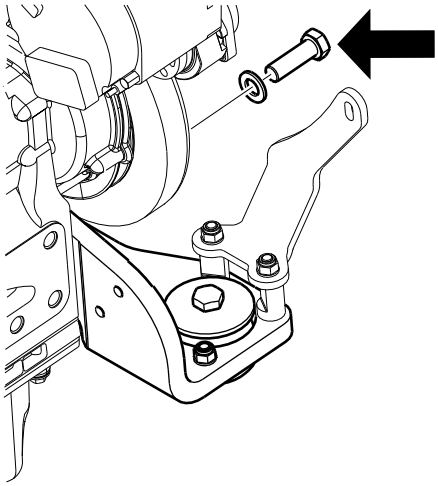
NOTE

If the flexible plates are damaged during an engine replacement, they must also be replaced.

NOTE

Beware of balance before the engine is lifted.

14 Lift the engine away.

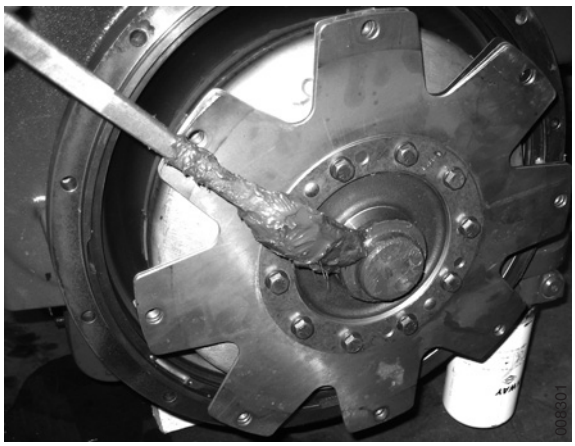


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Assembly

15 Move the engine mountings from the removed diesel engine to the new one. Torque the screws on the front engine mountings to **189 Nm.**

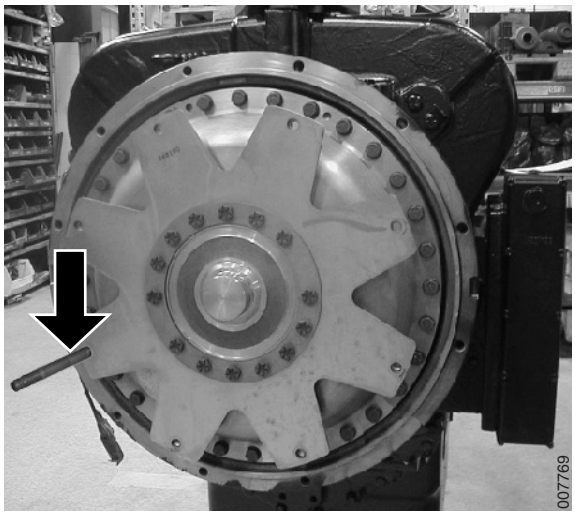
16 Move other components from the old diesel engine to the new one, as necessary.



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17 Grease the torque converter connection, both on the Diesel engine and on the transmission.

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Engine guide stud

18 Insert a stud into one of the nuts on the flexible plate as a guide when the engine is installed.



19 Lift the new diesel engine into place. Guide the stud through the flywheel and out through the hole in the flywheel housing.

20 Install the screws which fix the gearbox and engine, and tighten the screws.

21 Remove the stud through the hole in the flywheel housing.



22 Install the screws which hold the flexible plate to the flywheel in two stages. Do not tighten the screws in the first stage. Then rotate the flywheel a further rotation and tighten the screws.

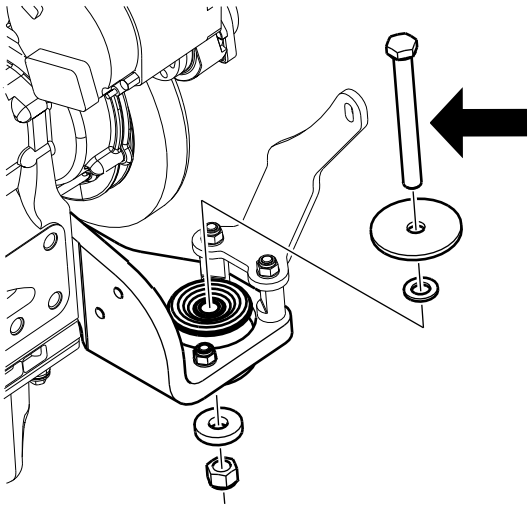
NOTE

Turn the engine for each screw to be installed to the flex plate.

NOTE

The diesel engine must be undone from the engine mountings and from the gearbox to remove a dropped screw. Secure the screw in the socket during installation.

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008321

23 Line up and screw down the engine mountings on the rubber dampers. Torque the screws to **135 Nm.**

24 Fit the rubber cover plug for the flex plate screws.

25 Undo the lifting equipment from the diesel engine.

26 Remove the jack from underneath the gearbox.

27 Attach relevant hoses and cables to the engine. Check fluid levels and top up as necessary.

28 Put back the radiator, partition wall and other equipment. Installation is in reverse order.

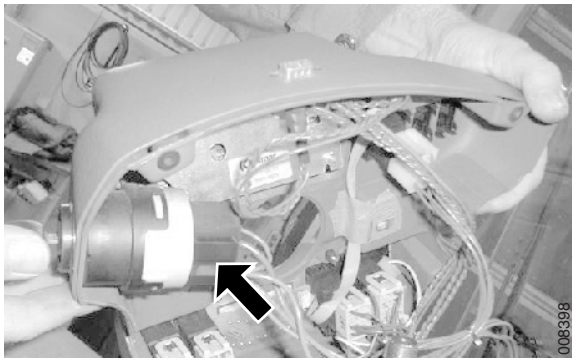
29 Test drive.

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1.1 Controls and instruments

1.1.1 Ignition switch

Ignition switch, replacement



1 Machine in service position.

2 Remove the steering wheel and steering panel covers, please refer to section *9 Frame, body, cab and accessories, Group 9.1.1 Multi-function lever.*

3 Unplug the connector from the ignition switch.

4 Replace the ignition switch.

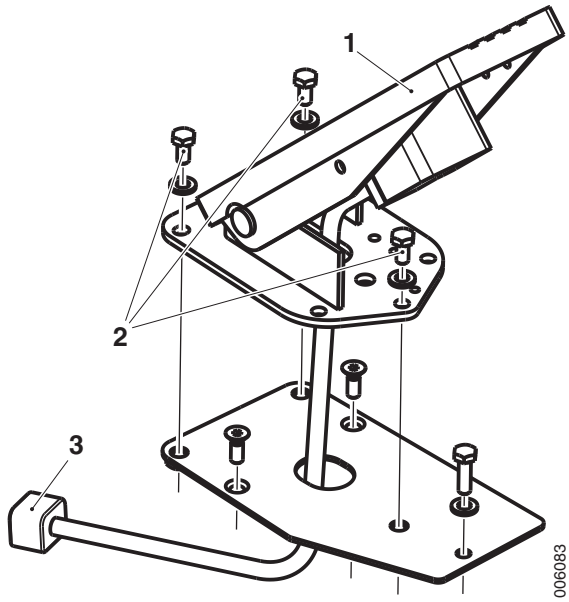
5 Refit in the reverse order.

NOTE

Torque the nut in the centre of the steering wheel to 40 Nm (±5 Nm).

1.1.2 Accelerator pedal

Accelerator pedal, replacement



1. Accelerator pedal
2. Screws
3. Connector

1. Machine in service position, see section *B Safety*.
2. Remove the three screws that hold the accelerator to the floor.
3. Undo the accelerator pedal connector.
4. Remove the accelerator pedal.
5. Installation is in reverse order.

NOTE

The accelerator pedal is factory calibrated, but may need to be recalibrated after replacing.

Accelerator pedal, calibration

See section *8 Control system*.

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1.2 Fuel system

Fuel system, description

The fuel system distributes fuel to the engine and controls the engine output power and rpm.

When the engine starts, the feed pump sucks fuel from the tank, through the primary fuel filter and into the fuel injection pump, which forces it on to the injectors. The injectors atomise and inject the fuel into the engine's combustion chambers.

WARNING

The engine's fuel system operates at very high pressure. Fuel pressure is so high that a jet can injure the skin resulting in serious injuries.

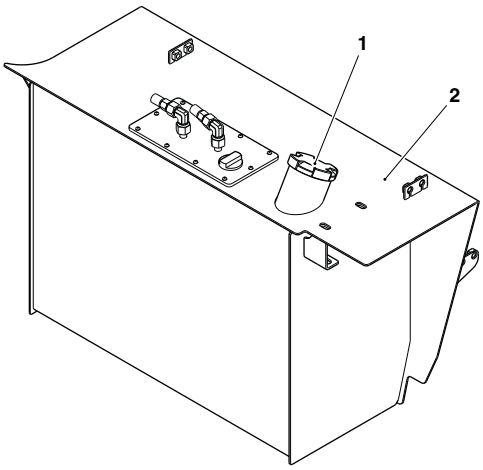
Risk of personal injury!

Use protective gloves and safety glasses, avoid skin contact with fuel. If a component is being loosened then hold a rag over the connection as protection and collect the fuel. Fuel is corrosive to mucous membranes in e.g. the eyes, skin and throat.

1.2.1 Fuel tank

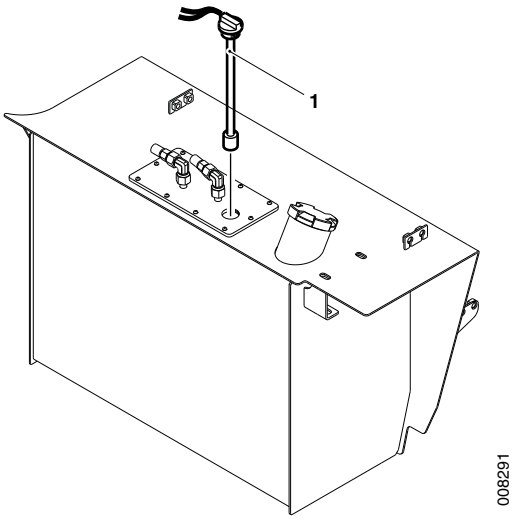
Fuel tank, description

The fuel tank consists of a separate unit which is screwed to the frame. The fuel tank is located on the left side of the vehicle.



1. Fuel filling
2. Fuel tank

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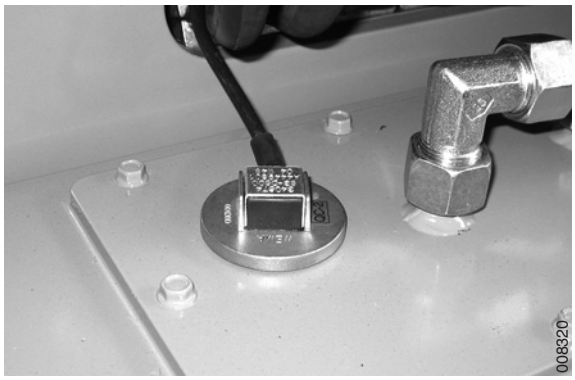
1. Sensor fuel level

1.2.2 Sensor, fuel level

Sensor, fuel level, description

The sensor is inserted directly downwards into the fuel tank from above.

The sensor, fuel level (B757) sends voltage signal proportional to fuel level in tank to control unit general ECU790. An alarm is shown in the display if fuel level is below 15% for more than 40 seconds.

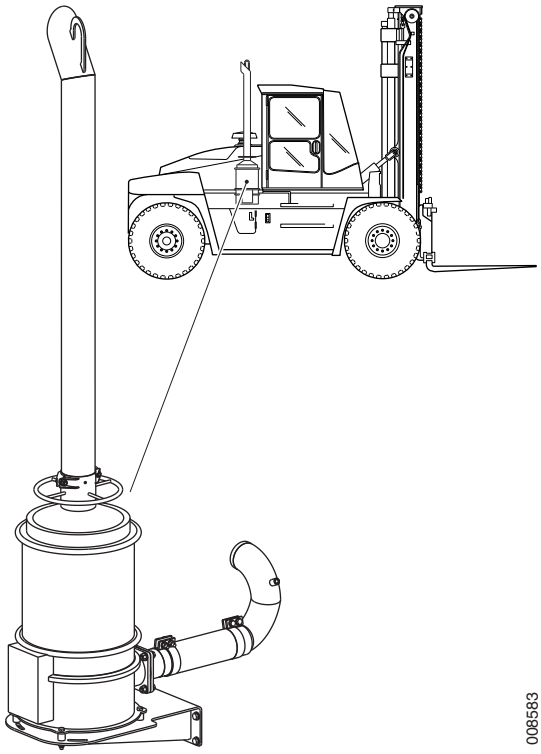


1. Sensor fuel level

Sensor fuel level, replacement

1. Machine in service position, see section *B Safety*.
2. Separate the connector and release the cable.
3. Unscrew the sensor.
4. Screw a new sensor into place. Join the connector and fix the cable with a tie wrap.

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Location of particulate filtering device

1.3 Additional exhaust cleaning system

Additional exhaust cleaning system, general

This section describes components that efficiently contribute to extra exhaust emission control.

1.3.1 Combifilter

Particulate filtering device, description

The particulate filtering device is a combined filter that efficiently cleans diesel exhaust of particles while functioning as a silencer. The particles (carbon) are separated and stored during operation in a robust filter that is burned clean, electrically during air supply, following the end of the working shift.

The filter reduces the discharge of fixed particles (carbon) by more than 95%. If the filter is combined with a catalytic converter then carbon monoxide (CO) and hydrocarbons (HC) are also reduced.

The system with combined filter comprises:

- Filter fitted in exhaust system instead of the silencer.
- Pressure monitor with signal lamp for checking exhaust back pressure. The lamp is fitted in the driver's cab.
- Clean burning unit with components for monitoring clean burning. The unit is fitted at the right-hand side of the machine.

NOTE

The filter must not be covered and combustible material must not be in proximity to or contact with the filter during the clean burning. During clean burning hot air flows from the outlet pipe which can ignite combustible material!

- Cables and hose for electrical and air connections.
- Unit for air supply comprises either a high pressure fan or components for connection to existing compressed air.
- Pressure gauge for continuous monitoring of exhaust counter-pressure.
- Integrated catalytic converter for reduction of gaseous impurities.

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Combi filter, replacement

NOTE

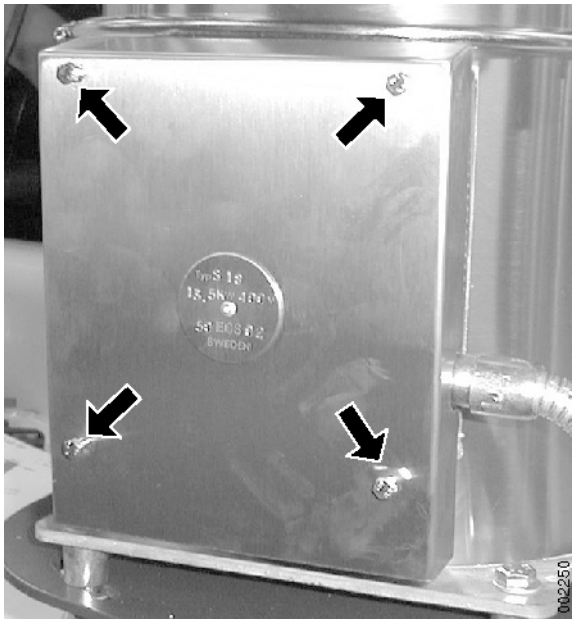
Requires special authorisation.

1. Machine in service position.

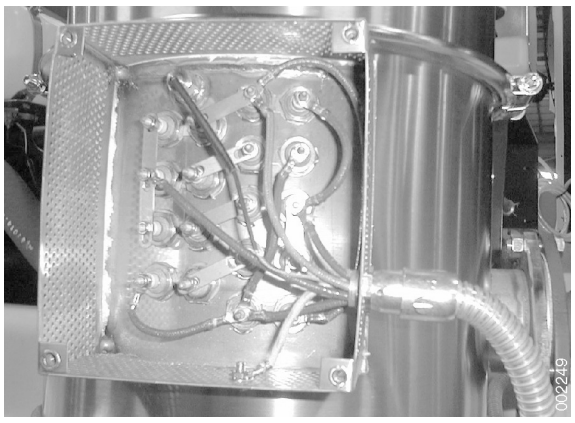
NOTE

Make sure that the combi filter is not connected to the electric mains before work starts.

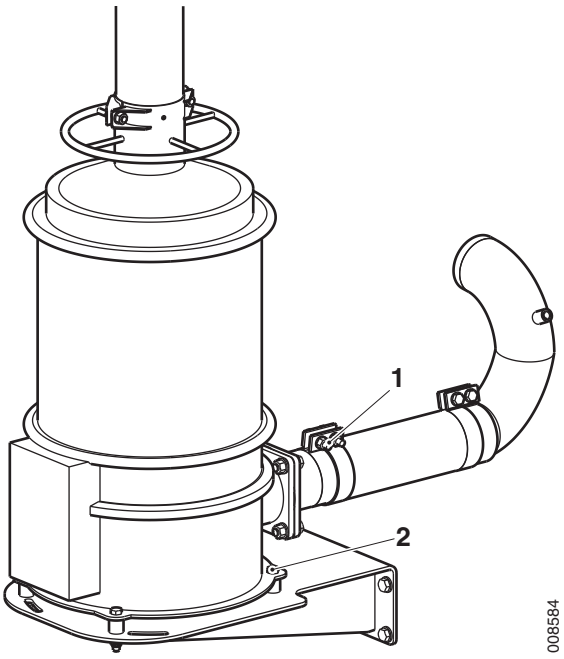
2. Remove the exhaust pipe.
3. Remove the protective cover from the electrical distribution box (four screws).



4. Mark and remove the cables from their connections and the lock nut on the main cable.



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1. Clamp
2. Screw

5. Remove the clamp (position 1) for the inlet manifold.
6. Remove the four screws (position 2) securing the particulate filtering device.
7. Remove the silencer.
8. Fit in the reverse order.

1.3.2 Catalyst

Catalyst, description

The catalyst effectively removes certain types of contamination from the combustion gases. It is located either in the same place as the machine's standard silencer or integrated with the combi filter.

Catalyst, replacement

1. For catalyst replacement, please refer to *Exhaust system, replacement page 45* or *Combi filter, replacement page 40*.

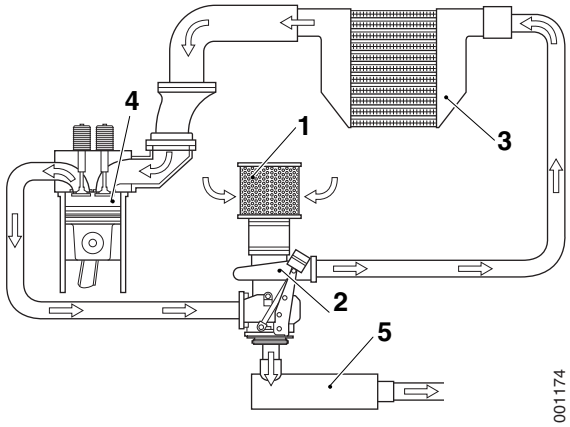
https://truckmanualshub.com/

1.6 Air intake and exhaust outlet

Air intake and exhaust outlet, description

Combustion in the engine requires air. Free unrestricted flow for fresh air and exhaust gases is essential for the engine to work efficiently. It is of the utmost importance for reliable operation of the engine that the air that enters the engine is totally clean.

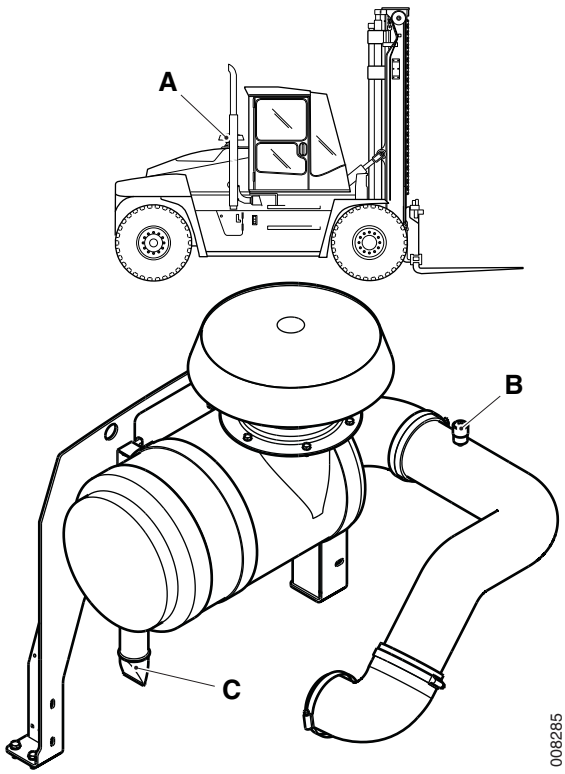
Electronic sensor air filter is available as an option. ⊕



Outline diagram for air flow

1. Air filter
2. Turbo
3. Intercooler
4. Engine combustion chamber
5. Silencer (exhaust emission control)

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A. Position of air filter housing
B. Change indicator
C. Ejector

1.6.1 Air cleaning system

Air cleaning system, description

The induction air is cleaned in a two-stage air cleaner. The first stage separates coarse particles, which then are removed through an ejector (the ejector is closed when engine is running and opened when engine is shut off to release particles). Step two consists of an outer and an inner filter that protect the engine from impurities and dirt particles. Two filters give increased safety during operation in case a filter should become damaged.

A filter indicator in the pipe between filter and engine turns red if an insufficient amount air is able to pass the air filter, that is, the engine does not get enough air for good combustion. If the indicator is red, the air filter must be replaced. The indicator on the air filter must be checked extra often if the machine operates in dirty or dusty conditions.

⊞

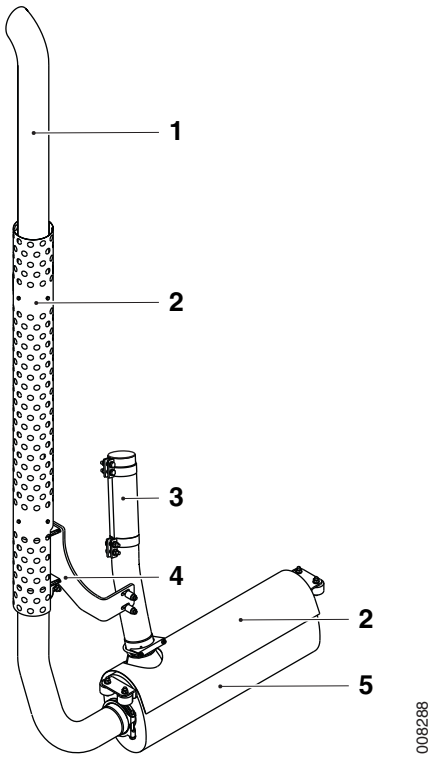
An optional pre-separator (cyclone) is available which replaces the rain cover. Its function is to get the air rotating so that coarse particles can be separated.

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1.6.3 Exhaust system

Exhaust system, description

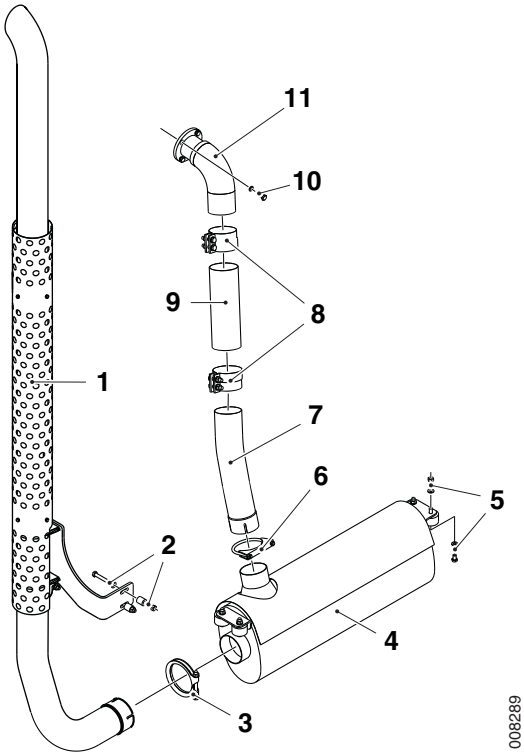
The exhaust system is fixed mounted in the chassis. A heat shield is fitted between engine and exhaust system to protect cables etc. A flexible hose between the turbo and silencer absorbs engine motion. On the outside of the machine is a heat shield above the exhaust system.



Exhaust system

1. Pipe (outlet silencer)
2. Heat shield
3. Flexible hose
4. Bracket
5. Silencer

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1. Pipe (outlet, silencer) with heat shield and bracket
2. Screws
3. Clamp with screws
4. Silencer
5. Screw
6. Clamp with screws
7. Pipe
8. Clamps with screws
9. Flexible hose
10. Screw
11. Elbow

Exhaust system, replacement

WARNING

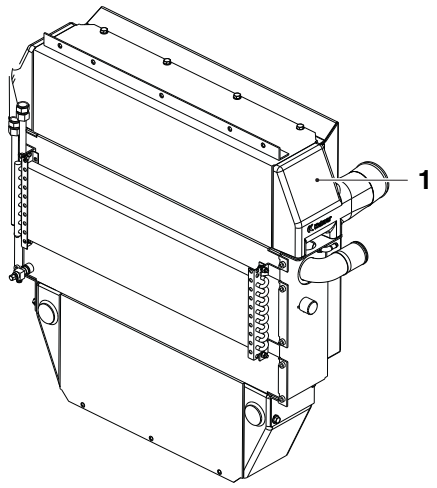
Hot exhaust system!

Risk of burn injuries!

Never touch the turbo or silencer when the machine is running orjust after it has been turned off!

6. Machine in service position, see section *B Safety*.
7. Undo the clamp (position 3) between the outlet pipe (position 1) and the silencer (position 4).
8. Remove the screws (position 2) that fixes the outlet pipe (position 1) to the chassis. Remove the outlet pipe.
9. Undo the clamp (position 6) between the pipe (position 7) and the silencer (position 4).
10. Remove the screws (position 5) that fix the silencer to the chassis.
11. Remove the silencer.
12. Installation is in reverse order.

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Radiator package
1. Intercooler

1.6.4 Intercooler

Intercooler, description

The charged air is cooled in the upper part of the radiator package.

Also refer to *Radiator and expansion tank, description page 49*.

Intercooler, replacement

1. Machine in service position, see section *B Safety*.
2. Removing the radiator package, please refer to *Radiator, replacement page 50*.
3. Remove the screws, which fix the fan housing.
4. Remove the radiator section by undoing the screws.
5. Installation is in reverse order.
6. Check and top up fluids as necessary.

1.6.8 Pipes and hoses

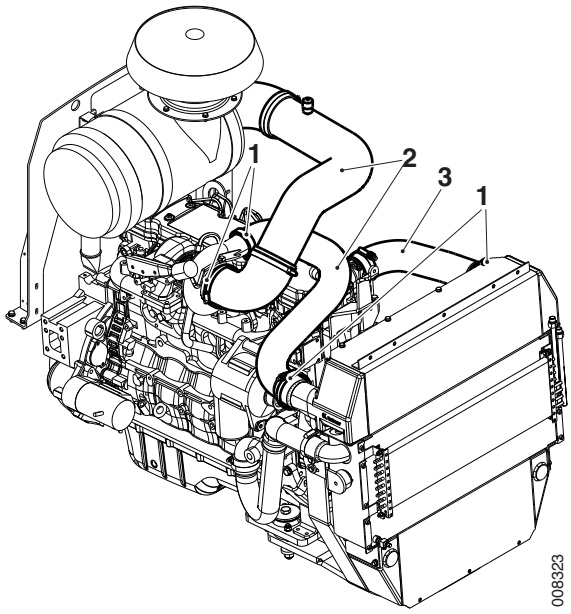
Piped and hoses, description

The air inlet and exhaust outlet components are linked together by pipes and hoses.

Pipes and hoses, replacement

1. Machine in service position, see section *B Safety*.
2. Remove the exhaust system pipes and hoses, please refer to *Exhaust system, replacement page 45*
3. Undo the tie wraps which hold the hoses and cables together.

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1. Hose clamp
2. air hose
3. Intercooler hose

NOTE

Protect the air inlet to the engine and the hose with a seal, e.g. a plastic bag.

4. Remove the hose clamps that hold the air hose to the filter and the turbo.
5. Remove the hose clamps which hold the intercooler hoses in place.
6. Remove the intercooler hoses.
7. Installation is in reverse order.

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1.7 Cooling system

Cooling system, description

The engine is water-cooled and has coolant ducts where the cold water flows from the radiator through a closed system.

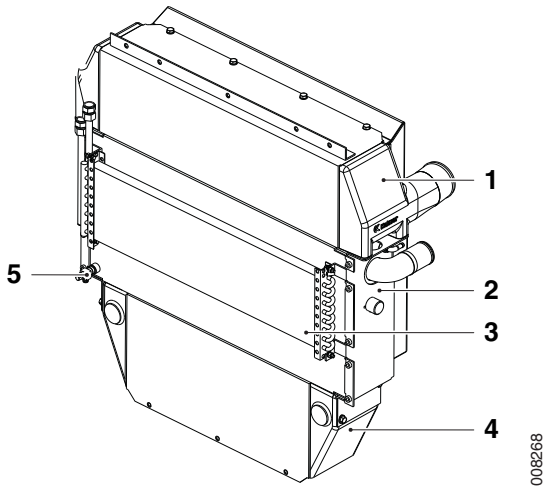
The cooling system has the following main components:

- Coolant pump, located on the engine.
- The radiator core, located at the rear section of the engine compartment and secured in the frame.
- Expansion tank, located in the engine compartment.
- Thermostat, located in the engine.
- Cooling fan, located in front of the radiator.
- Intercooler, part of the radiator core (top).
- Radiator, part of the radiator core (middle).
- Transmission oil cooler, part of the radiator core (lower).
- Fuel cooler (located behind the radiator).
- Engine oil cooler, located in the engine.

IMPORTANT

On machines with ECC or AC, it is extremely important that the engine cooling system is topped up with coolant that contains the correct ratio of anti-freeze. If this is not done, there is a risk that the climate unit would freeze and burst when used.

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1. Radiator intercooler
2. Radiator engine coolant
3. Fuel cooler
4. Cooler transmission oil
5. Drain nipple for coolant

1.7.4 Radiator and expansion tank

Radiator and expansion tank, description

The radiator for the engine coolant is mounted in the radiator assembly (made of aluminium) located behind the engine.

The purpose of the cooler assembly is to cool:

- Engine coolant
- Fuel cooler (located behind the radiator).
- Gearbox oil (cooled in the lower part of the radiator assembly), see also section *2 Transmission*, group *2.6.3 Oil cooler*.
- The charged air is cooled in the upper part of the radiator assembly, see also *Intercooler, description page 46*.

See also *Cooling system, description page 48*.

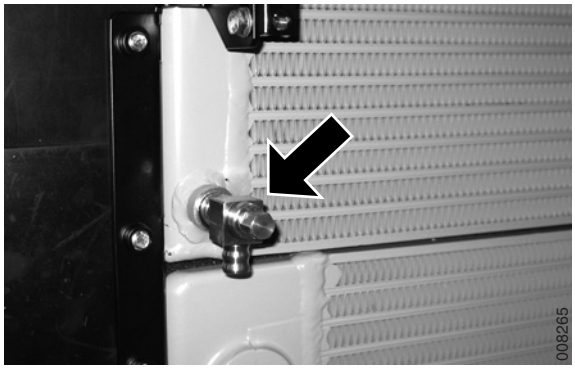
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Radiator, replacement

NOTE

Read the safety instructions for oil and for cooling system before working, see section B Safety.

1. Machine in service position, see section *B Safety*.
2. Remove the hood engine compartment, please refer to Section *9 Frame, body, cab and accessories*, group *9.13.2 Hood engine compartment*.
3. Drain the coolant and transmission oil out of the system.
4. Undo the hoses for intercooler, engine and transmission cooling and for the expansion tank from the radiator.



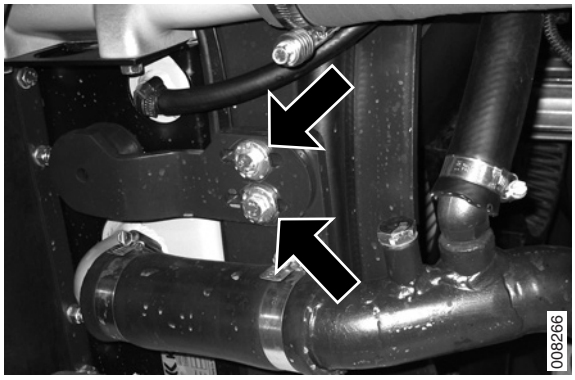
Coolant drain cock

NOTE

Hoses for the expansion vessel only need to be undone if a Volvo TAD750VE or TAD760VE engine is installed, since the expansion vessel bracket is fixed to the engine in this case.

When a Volvo TAD650VE, TAD660VE, Cummins QSB6.7 or Caterpillar C6.6 engine is installed, the expansion vessel is fixed to the radiator package and is removed together with the radiator package.

5. Remove the screws that fix the radiator package to the chassis.





6. Lift the radiator package gently out of the chassis.
7. Installation is in reverse order.
8. Check and top up fluids as necessary.

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1.7.7 Coolant

Coolant level, check

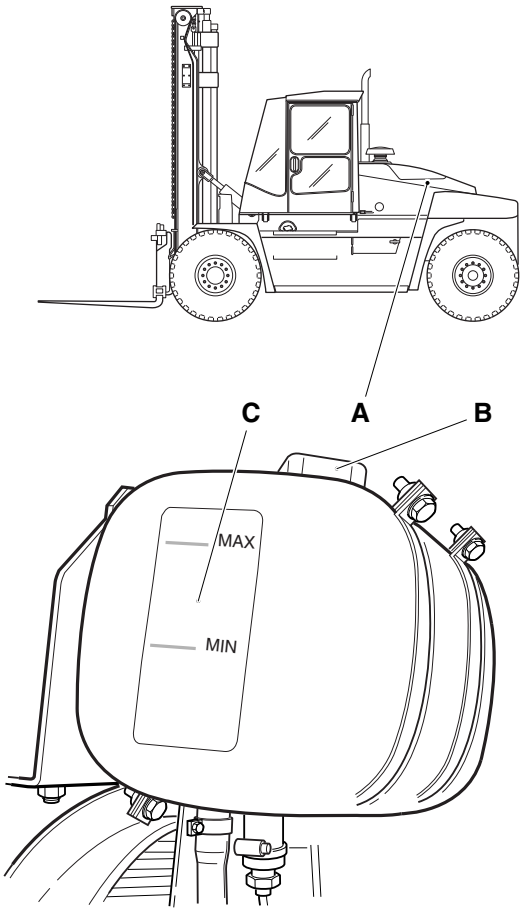
⚠ WARNING

The cooling system is pressurised. Steam or hot fluid may jet out.

Risk of scalding and burn injuries!

Open the filler cap (position B) very slowly when the engine is warm. Wait until the coolant has cooled down before topping up.

Coolant is filled in the system's expansion tank (position A). The coolant level should be between the MIN and MAX markings (position C) on the expansion tank.



A. Position for expansion tank
B. Pressure cap for filling point
C. Level marking, MIN and MAX

NOTE

Open very carefully as hot coolant may jet up.

If the coolant level should become too low an error code is shown in the control system's display.

NOTE

A low coolant level may cause engine damage or may cause the engine to stop.

1 Machine in service position, see section *B Safety*.

2 When needed, top up with ready-mixed recommended coolant. For volume and quality, see section F Technical data.

⚠ CAUTION

Different types of coolant must not be mixed.

Risk of engine damage and damage to the cooling system if different types of coolant are mixed.

When changing and topping up coolant, only use coolant of the same type that was used before.

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IMPORTANT

On machines with ECC or AC, it is of the utmost importance that the engine's cooling system be refilled with coolant that contains the correct mixture of anti-freeze glycol; otherwise there is a risk that the air conditioning will freeze and break during use.

Cooling system, changing the coolant and cleaning (engine alternative Volvo)

Cooling performance is reduced due to deposits in radiator and cooling channels. In connection with changing coolant, clean the system.

WARNING

The cooling system is pressurised. Steam or hot fluid may jet out.

Risk of scalding and burn injuries!

Open the filler cap very slowly when the engine is warm. Wait until the coolant has cooled down before topping up.

WARNING

Glycol and anti-corrosion agents are hazardous to health.

Health hazard!

Handle with care. Avoid skin contact. Wear protective glasses and protective gloves. In case of skin contact, wash the skin.

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IMPORTANT

Machines with ECC or AC are equipped with a combined heating and cooling package which may lead to a risk of freezing if the machine is operated without coolant.

Risk of freezing and damage to heating and cooling package!

When cleaning the radiator with water or cleaning agent without anti-freeze properties, the electrical connection to the AC compressor must be disconnected.

NOTE

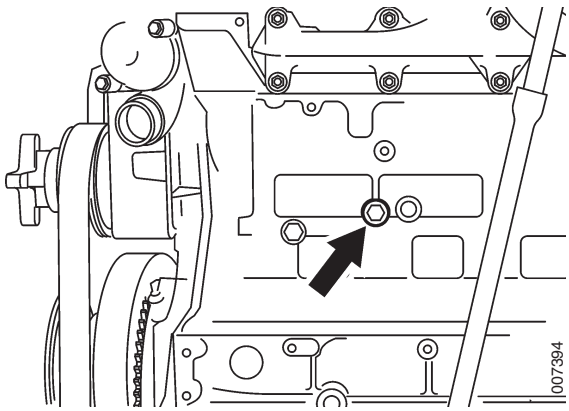
Read safety instructions for coolant before starting work, see section B Safety.

NOTE

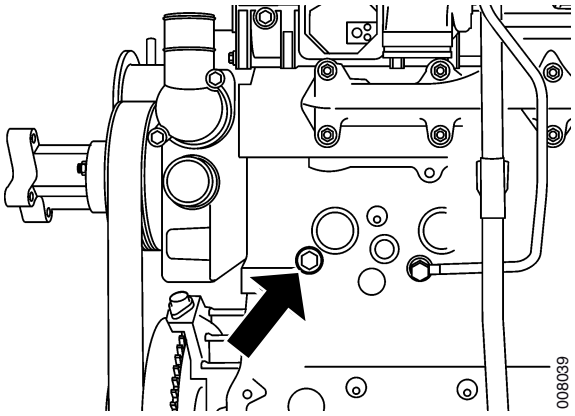
Before draining, stop the engine and remove the filler cap.

1 Remove the filler cap from the cooling system's expansion tank.

2 Open all drain points. Drain the coolant from the radiator and engine block using a drainage hose. The drainage nipples are located on the radiator and on the right-hand side of the engine block.



Volvo TAD750VE/TAD760VE



Volvo TAD650VE/TAD660VE

3 Check that all coolant drains.

NOTE

There may be deposits inside the channels/plugs that must be cleaned; otherwise there is a risk that coolant may remain and cause freezing damage.

Allow the drain tap/plugs to remain open and ensure that the heating knob is set to full heat while cleaning.

4 Check the condition of the hoses, clamps and radiator sealing. Replace and clean if needed.

5 Insert a hose in the filler hole in the expansion tank and flush with **clean** water, until the draining water is clear.

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6 If there still are contaminants after flushing for some time, cleaning with coolant can be performed. Otherwise continue in accordance with step 10.

7 **cleaning with coolant:**

Fill the cooling system with 15–20% concentration coolant mix. Only use recommended concentrated coolant mixed with **clean** water.

8 Drain the coolant after 1–2 days operation.

NOTE

To avoid that dissolved loose material jams in the system again, drain the system quickly, within 10 minutes, without the engine being switched off for a long time. Remove the filler cap from the expansion tank and the lower coolant hose if necessary to increase drain speed.

9 Flush the system immediately and very thoroughly with **clean** warm water to avoid dirt from being deposited on the inside surfaces once again. Flush until the draining water is completely clean. Make sure that the heat control is set to full heat during cleaning.

10 If there still are contaminants after flushing for some time, cleaning with coolant flush can be performed, contact Cargotec Service.

NOTE

Only use cleaning agents approved by the engine manufacturer. Make sure that you follow the instructions on the packaging.

NOTE

Only use recommended coolant.

IMPORTANT

It is of utmost importance that the right concentration and volume of the coolant is filled in the system. Mix in a separate, clean container before filling the cooling system. Make sure the fluids mix well.

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Filling point

1. When the cooling system is completely free from impurities, close the drain taps and plugs.

NOTE

Only use recommended coolant.

⚠ CAUTION

Different types of coolant must not be mixed.

Risk of engine damage and damage to the cooling system if different types of coolant are mixed.

When changing and topping up coolant, only use coolant of the same type that was used before.

2. Fill the coolant to a level between the MIN and MAX markings. **The engine may not be started before the system has been bled and completely filled.**
3. Start the engine when the cooling system is bled and completely filled. Open any bleeder valves some time after start, so that the trapped air can escape.

   Check that the water valve is fully open so that the heater unit is bled.
4. Stop the engine after about one hour and check the coolant level, top up if needed.

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Cooling system, changing the coolant and cleaning (engine alternative Caterpillar)

WARNING

The cooling system is pressurised. Steam or hot fluid may jet out.

Risk of scalding and burn injuries!

Open the filler cap very slowly when the engine is warm. Wait until the coolant has cooled down before topping up.

WARNING

Glycol and anti-corrosion agents are hazardous to health.

Health hazard!

Handle with care. Avoid skin contact. Wear protective glasses and protective gloves. In case of skin contact, wash the skin.

IMPORTANT

Machines with ECC or AC are equipped with a combined heating and cooling package which may lead to a risk of freezing if the machine is operated without coolant.

Risk of freezing and damage to heating and cooling package!

When cleaning the radiator with water or cleaning agent without anti-freeze properties, the electrical connection to the AC compressor must be disconnected.

NOTE

Read safety instructions for coolant before starting work, see section B Safety.

Clean and flush out the cooling system before the recommended maintenance interval, if any of the following occurs:

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- The engine often overheats.
- Foam is observed in the coolant
- Oil has seeped into and contaminated the cooling system.
- Fuel has seeped into and contaminated the cooling system.

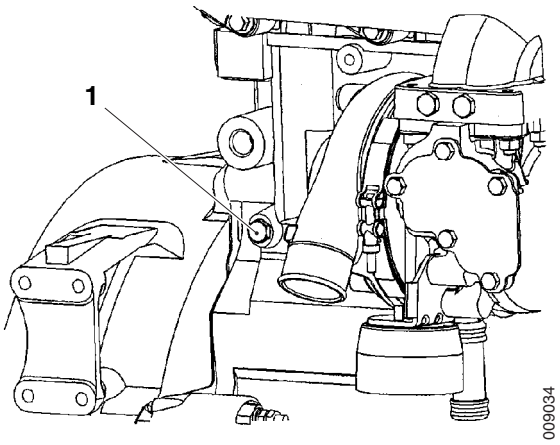
NOTE

Only clean water is required for cleaning the cooling system.

NOTE

Read safety instructions for coolant before starting work, see section B Safety.

1. Machine in service position, see section *B Safety*.
2. Stop the engine and let it cool down. Open the filler cap on the cooling system's expansion tank slowly and remove it.
3. Open all drain points. Drain the coolant from the radiator and engine block with a drain hose. The drainage nipples are located on the radiator and on the right-hand side of the engine block.
4. Check that all coolant drains.



NOTE

There may be deposits inside the cock or the plug that must be cleaned; otherwise there is a risk that coolant may remain and cause freezing damage.

Allow the drain cocks/plugs to remain open and ensure that the heating knob is set to full heat during cleaning.

5. Check the condition of the hoses, clamps and radiator sealing. Replace and clean if needed.
6. Insert a hose in the filler hole in the expansion tank and flush with **clean** water, until the draining water is clear.
7. When the cooling system is completely free from impurities, close the drain cocks and plugs.
8. Fill with clean water so that the level is between the MIN and MAX marks. Fit the filler cap on the cooling system's expansion tank.
9. Switch off the system voltage and start the engine when the cooling system is fully bled and filled. Allow the engine to run at idling speed until the temperature is between 49 and 66 °C.

   Open all heat controls on the heater unit so that it is ventilated.
10. Stop the engine and let it cool down. Open the filler cap on the cooling system's expansion tank slowly and remove it. Open all drain points. Drain the coolant from the radiator and engine block with a drain hose. Insert a hose in the filler hole in the expansion tank and flush with **clean** water, until the draining water is clear.
11. When the cooling system is completely free from impurities, close the drain cocks and plugs.

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12. Fill the coolant to a level between the MIN and MAX markings. **The engine must not be started before the system has been bled and completely filled.** Do not fit the filler cap on the cooling system's expansion tank.

NOTE

Air pockets in the cooling system can damage the engine.

⚠ CAUTION

Different types of coolant must not be mixed.

Risk of engine damage and damage to the cooling system if different types of coolant are mixed.

When changing and topping up coolant, only use coolant of the same type that was used before.

13. Start the engine and let the engine run at idling speed until the cooling system is fully bled and filled. Increase the engine speed to raised idling speed and open all the heat controls on heater unit so that it is ventilated.

    Allow the engine to run at raised idling speed for a minute to expel air that may be present in the cavities in the engine block. Stop the engine.

14. Check coolant level and top up if required.
15. Clean the pressure cap on the radiator and check the gasket, replace the pressure cap with a new one if the gasket is damaged. If the gasket is intact, pressurise the pressure cap with a suitable pressurising pump. The pressure that the pressure cap should withstand is stamped on the top of the cap. If the pressure cap does not withstand the intended pressure, replace the pressure cap.
16. Start the engine. Check the cooling system's sealing integrity and the engine will reach the correct operating temperature.

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Cooling system, changing the coolant and cleaning (engine alternative Cummins)

Cooling performance is reduced due to deposits in radiator and cooling channels. In connection with changing coolant, clean the system.

⚠ WARNING

The cooling system is pressurised. Steam or hot fluid may jet out.

Risk of scalding and burn injuries!

Open the filler cap very slowly when the engine is warm. Wait until the coolant has cooled down before topping up.

⚠ WARNING

Glycol and anti-corrosion agents are hazardous to health.

Health hazard!

Handle with care. Avoid skin contact. Wear protective glasses and protective gloves. In case of skin contact, wash the skin.

IMPORTANT

Machines with ECC or AC are equipped with a combined heating and cooling package which may lead to a risk of freezing if the machine is operated without coolant.

Risk of freezing and damage to heating and cooling package!

When cleaning the radiator with water or cleaning agent without anti-freeze properties, the electrical connection to the AC compressor must be disconnected.

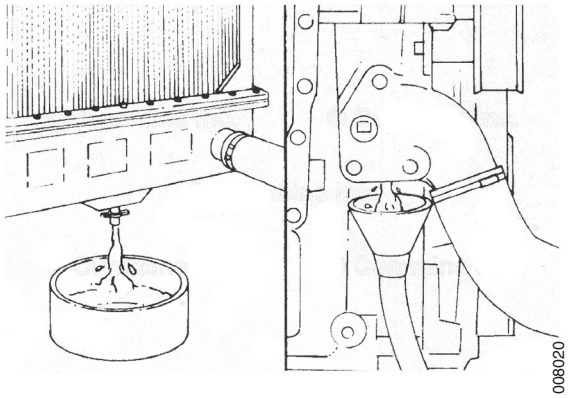
NOTE

Read safety instructions for coolant before starting work, see section B Safety.

NOTE

Before draining, stop the engine and remove the filler cap.

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1 Remove the filler cap from the cooling system's expansion tank.

2 Open all drain points. Drain the coolant from the radiator and engine block. A drain nipple is located under the radiator and a drain plug under the coolant intake on the engine block.

3 Check that all coolant drains.

NOTE

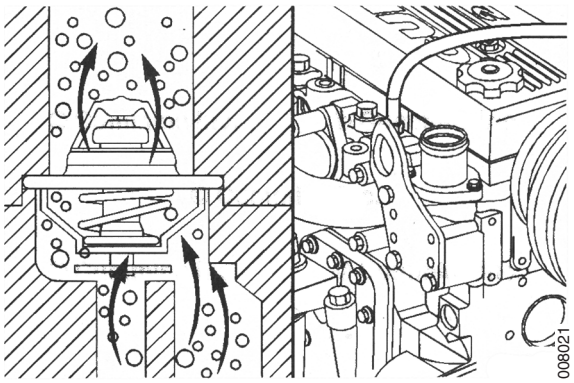
There may be deposits inside the cock or the plug that must be cleaned; otherwise there is a risk that coolant may remain and cause freezing damage.

Check if the installation has additional taps or plugs on the coolant line's lowest points. Leave drain valves or plugs open and make sure that the heat control is at full heat while cleaning.

4 Check the condition of the hoses, clamps and radiator sealing. Replace and clean if needed.

⚠ CAUTION

The system must be filled well to prevent air pockets. During filling, the air must be ventilated out from the cooling channels. Wait 2–3 minutes to allow the system to bleed; then fill the system.



5 **Cleaning:**

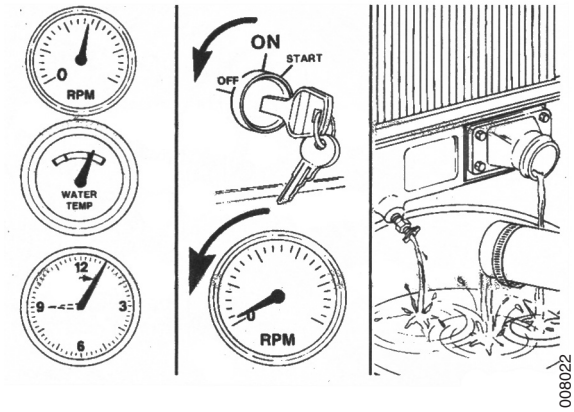
NOTE

Do not put on the pressure cap. The engine must run without pressure cap during this process.

Fill the system with a mixture of sodium carbonate and water (or equivalent).

NOTE

Use 0.5 kg of sodium carbonate per 23 litres of water.



6 Start and run the engine for 5 minutes with a coolant temperature over 80 °C.

Turn off the engine and empty the cooling system.

7 Fill the cooling system with clean water.

NOTE

Ensure that the cooling system is properly bled when filling.

NOTE

***Do not** put on the pressure cap.*

8 Start and run the engine for 5 minutes with a coolant temperature over 80 °C.

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Turn off the engine and empty the cooling system.

NOTE

*If the emptied water is still dirty, the system **must** be flushed until the water is clean.*

9 When the cooling system is completely free from impurities, close the drain cocks and plugs.

NOTE

Only use recommended coolant.

⚠ CAUTION

Different types of coolant must not be mixed.

Risk of engine damage and damage to the cooling system if different types of coolant are mixed.

When changing and topping up coolant, only use coolant of the same type that was used before.

10 **Filling:**

Fill the coolant to a level between the MIN and MAX markings.

11 Put on the pressure cap, switch off the system voltage and start the engine.

Open all heat controls on the heater unit so that it is ventilated.

12 Stop the engine after about one hour and check the coolant level, top up if needed.

1.7.8 Switch normally open (NO), coolant level

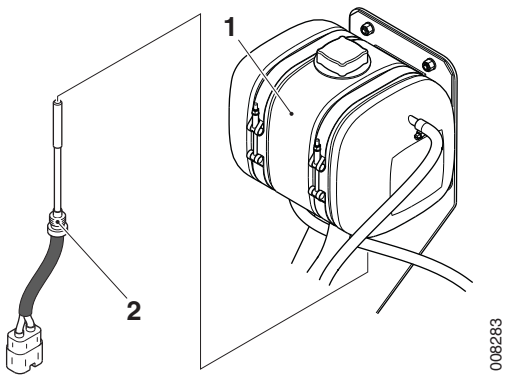
Switch normally open (NO), coolant level description

The cooling system is equipped with an electrical switch (level monitor) that activates an alarm on the display if the coolant level is to low.

The switch is located in the bottom of the expansion tank.

The switch (B759) sends voltage signal to control unit engine ECU794.

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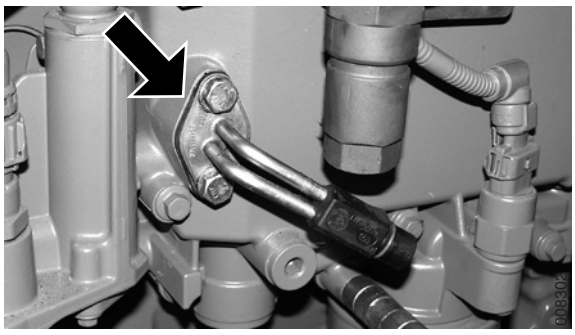
1. Expansion tank
2. Switch normally open (NO), coolant level

Switch normally open (No), coolant level, replacement

1. Machine in service position, see section *B Safety*.
2. Open the engine hoods.
3. Release the expansion tank from the bracket.
4. Unplug the connector for the switch.
5. Withdraw the switch from the expansion tank.
6. Installation is in reverse order.

1.7.10 Engine heater

Engine heater, description



Engine heater (picture shows engine alternative Volvo TAD750VE/TAD760VE)

The engine heater is connected via an external mains plug. The mains plug is located above the left-hand step. The engine heater is used to heat the engine and facilitate starting when the machine has been shut off for a long period of time.

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1.9 Engine control system

Engine control system, description

The truck is equipped with an electronic control system as standard. This control system controls and monitors the truck's functions (diagnostics, alarm and operation menus) for best reliability and overall economy. The system is constructed from modules which can be combined in several ways and which communicate via a so-called CAN bus (Controller Area Network).

System information is presented to the driver in the form of ISO symbols on the steering wheel display, for language independence, and can consist of three alarm levels plus operation information. This can be speed, engine speed, fuel level etc. If there is an alarm, a red warning lamp lights up to call the driver's attention to the fault.

There are six function keys which are used to navigate between the operation information menus, update values into the system and confirm alarms.

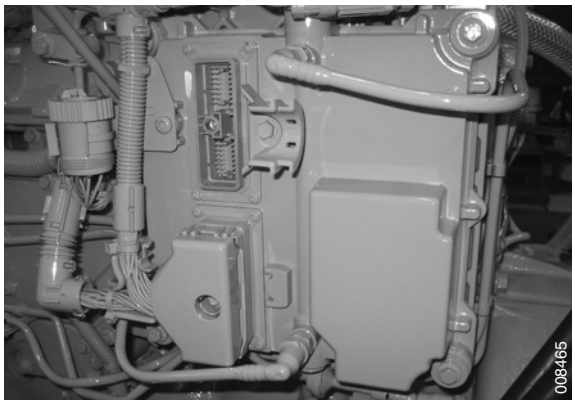
All vital sensors and actuators in each of the truck's systems are connected to the control system ECUs (Electronic Control Unit) and a terminal (display) in the driver's cab shows current values and sounds the alarm if the values fall outside the tolerance levels.

The greatest advantages of a digital system like the Kalmar Control System are the opportunities for calculation and for precise control / compensation. The system receives and processes information about operation, maintenance and use, leaving the driver to concentrate on driving. This means that both safety and user-friendliness can be raised to levels that have not previously been possible.

1.9.1 Control unit engine (ECU 794)

Engine control unit (ECU 794), description

Caterpillar C6.6, description



Control unit ECU 794 for Caterpillar C6.6

ECU794 controls engine functions such as engine speed, torque and power, using specially developed software. Senders and sensors are installed at various places on the engine, and are connected to the ECU in turn.

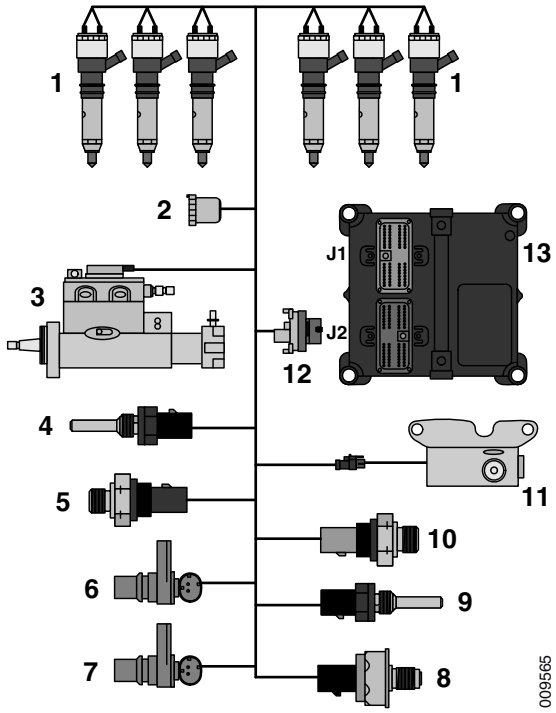
One injector, which works at very high fuel pressure, is installed for each cylinder and is directly connected to ECU 794 via a twisted pair cable, both positive and negative. The voltage can rise as high as 70 V. ECU 794 controls the required fuel flow, using high powered current pulses with very steep rise and fall times.

The ECU has a built-in diagnostic function and sends an alarm via warning lamps or via the CAN bus and a display in the KCS system.

The engine is supplied complete with all sensors and a pre-programmed ECU, so that it will be able to replace a traditional engine as far as possible.

The ECU 794 is supplied via a 25 A fuse.

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Caterpillar C6.6, wiring and components

1. Electronic unit injectors
2. Diagnostic
3. Fuel pump
4. Coolant temperature sensor
5. Oil pressure sensor
6. Pump camshaft speed sensor
7. Crankshaft speed/timing sensor
8. Fuel pressure sensor
9. Inlet air temperature sensor
10. Inlet air pressure sensor
11. Wastegate regulator
12. 64 pin plug
13. Control unit engine (ECU794)

Input signals

The control unit receives input signals about engine operating conditions from the following components:

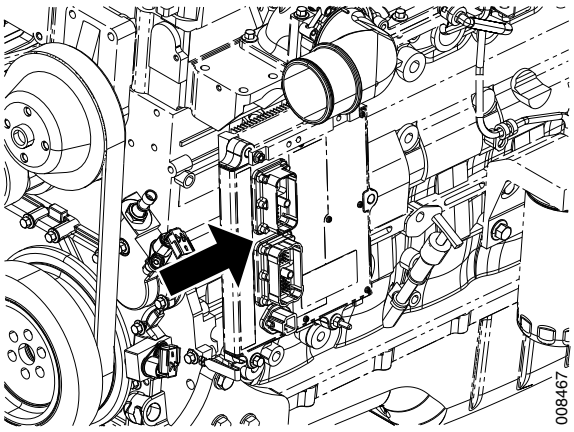
- Crankshaft speed/timing sensor
- Pump camshaft speed sensor
- Coolant temperature sensor
- Inlet air pressure sensor
- Inlet air temperature sensor
- Oil pressure sensor
- Fuel pressure sensor
- Water in fuel indicator

Output signals

The control unit controls the following components, depending on the input signals:

- Fuel pump solenoid
- Unit injectors
- Wastegate regulator
- Pre-heating relay

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Control unit ECU 794 for Cummins QSB6.7

Cummins QSB6.7, description

ECU794 controls engine functions such as engine speed, torque and power, using specially developed software. Senders and sensors are installed at various places on the engine, and are connected to the ECU in turn.

The ECU constantly calculates the volume of fuel and injection timing, depending on operation conditions, and controls the injector for each cylinder via a solenoid valve. A high pressure pump provides a common fuel pipe with fuel, which is then connected to each injector.

The ECU has a built-in diagnostic function and sends an alarm via warning lamps or via the CAN bus and a display in the KCS system if this is installed. There is also a built-in oil / service monitor.

The engine is supplied complete with all sensors and a pre-programmed ECU, so that it will be able to replace a traditional engine as far as possible.

Input signals

The control unit receives input signals about engine operating conditions from the following components:

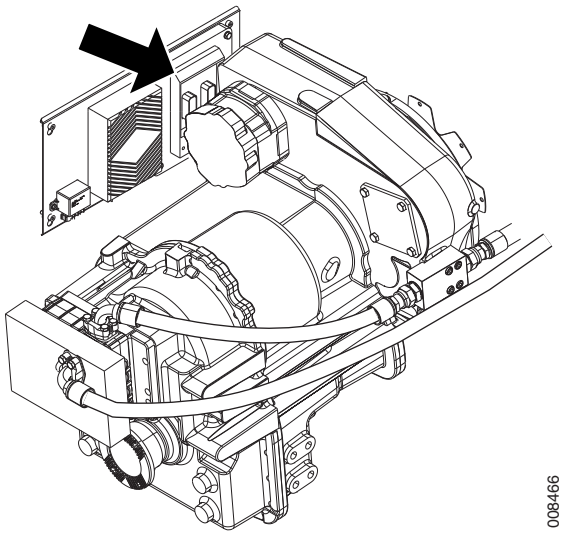
- Camshaft position sensor
- Engine coolant temperature sensor
- Intake manifold pressure / Air temperature sensor
- Engine oil pressure sensor
- Barometric pressure sensor
- Rail fuel pressure sensor
- Coolant level sensor
- Crankshaft speed sensor
- Water in fuel sensor

Output signals

The control unit controls the following components, depending on the input signals:

- Fuel pump actuator
- Fuel lift pump
- Unit injectors
- Pre-heating relay

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Control unit ECU 794 for Volvo TAD650VE, TAD660VE, TAD750VE, TAD760VE

Volvo TAD650VE, TAD660VE, TAD750VE, TAD760VE, description

EMS 2 (Engine Management System) is an electronic system with CAN communication (Controller Area Network) for Diesel engine control. The system has been designed by Volvo, and includes fuel control, a diagnostic function etc.

The system includes the control unit, sensors and injectors. The sensors send input signals to the control unit, which then controls the injectors.

Information from the sensors gives precise information about current operating conditions and makes it possible for the processor in the control unit to calculate the correct injection volume and timing, and monitor the condition of the engine.

Input signals

The control unit receives input signals about engine operating conditions from the following components:

- Engine speed sensor, camshaft
- Coolant temperature sensor
- Charge air pressure and temperature sensor
- Oil pressure sensor
- Fuel pressure sensor
- Fuel pressure in common rail
- Coolant level sensor
- Engine speed sensor, flywheel
- Water in fuel indicator

Output signals

The control unit controls the following components, depending on the input signals:

- Unit injectors
- Starter motor
- Main relay
- Pre-heating relay
- MPROP, a valve which connects pressure from the high pressure fuel pump
- Solenoid valve, EGR

Fuel control

The engine’s fuel requirement is analysed up to 100 times per second. The amount of fuel injected into the engine, and injection timing are entirely electronically controlled via fuel valves on the unit injectors.

This means that the engine always receives the correct amount of fuel in all operating conditions, which leads to lower fuel consumption, minimal exhaust emissions etc.

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Diagnostic function

The task of the diagnostic function is to discover and localise malfunctions in the EMS2 system, to protect the engine and to inform about any problems which may occur.

If a malfunction is discovered, this is either notified by warning lamps, a flashing diagnostic lamp or via the CAN bus and a display. If a fault code is set, this can be read out as a guide during any fault tracing. Fault codes can also be read by Volvo's VODIA tool at an authorised Volvo Penta workshop.

If there is a serious malfunction, the engine is shut off completely, or the control unit might reduce the available power (depending on the application). Once again, a fault code is set as a guide for any fault tracing.

1.9.3 Cables engine

Connectors, description

Caterpillar C6.6

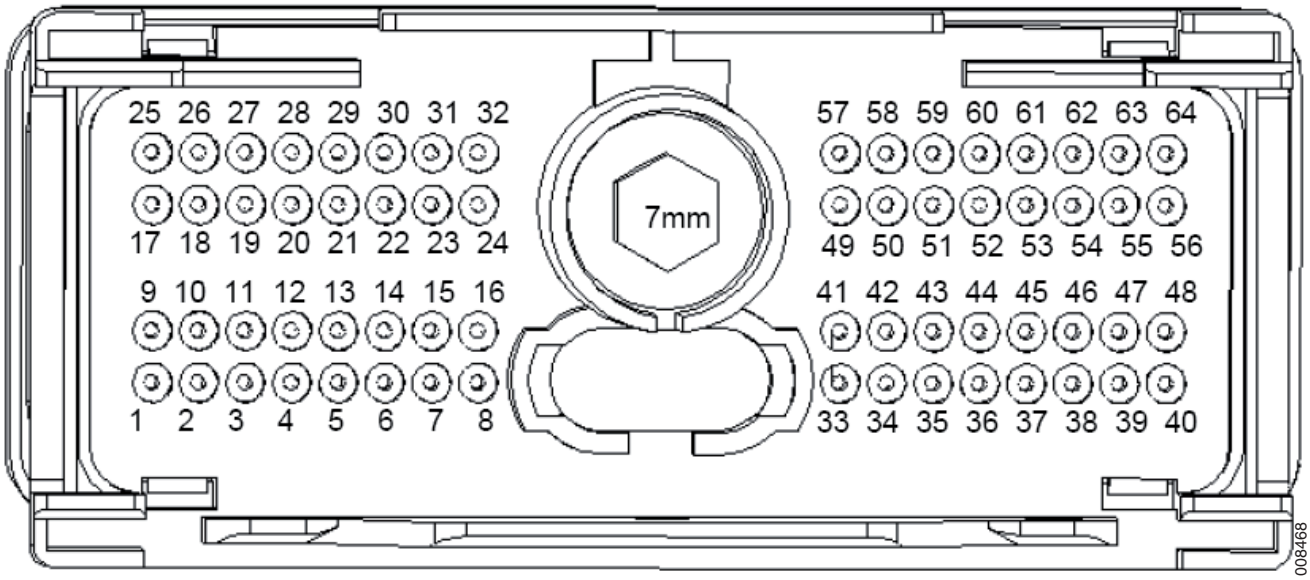


Table 1. Connectors

Pin No.	Description	Preferred Function	Alternative Function
1	Battery (-)	Battery -ve	N/A
2	Battery (-)	Battery -ve	N/A
3	Battery (-)	Battery -ve	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	Battery (+)	Battery +ve	N/A

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Pin No.	Description	Preferred Function	Alternative Function
8	Battery (+)	Battery +ve	N/A
9	- Battery	Battery -ve	N/A
10	- Battery	Battery -ve	N/A
11	DF_PWM 1 Shield	N/A	N/A
12	DF_PWM 1-	N/A	N/A
13	DF_PWM 1+	N/A	N/A
14	N/A	N/A	N/A
15	Battery (+)	Battery +ve	N/A
16	Battery (+)	Battery +ve	N/A
17	N/A	N/A	N/A
18	N/A	N/A	N/A
19	N/A	N/A	N/A
20	CAN (+)	SAE J1939 CAN DL +	N/A
21	CAN (-)	SAE J1939 CAN DL -	N/A
22	CAN A Shield	CAN Shield	N/A
23	CDL (+)	PDL +	N/A
24	CDL (-)	PDL -	N/A
25	N/A	N/A	N/A
26	N/A	N/A	N/A
27	N/A	N/A	N/A
28	N/A	N/A	N/A
29	N/A	N/A	N/A
30	N/A	N/A	N/A
31	PWM_2A Return 1	N/A	N/A
32	PWM_2A Driver 1	N/A	N/A
33	VS_RET	Sensor 0V return	N/A
34	VS_RET	Sensor 0V return	N/A
35	SWG_ RET	Switch return	N/A
36	SWB 2	N/A	N/A
37	SWB 1	N/A	N/A
38	SWG 11	Air Filter Restriction	N/A
39	SWG 10	Mode switch 2	N/A
40	SWK_0	Ignition switch input	N/A
41	VS_5_200mA	Sensor 5V supply	N/A

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Pin No.	Description	Preferred Function	Alternative Function
42	VS_5_200mA	Sensor 5V supply	N/A
43	VS_8_100mA	PWM Throttle Sensor 8V supply	N/A
44	SWG 9	Throttle 2 IVS	Fuel Water Trap Monitor
45	SWG 8	Throttle 1 IVS	N/A
46	SWG 7	Mode switch 1	N/A
47	SWG 6	Throttle Arbitration Switch	Coolant Level Switch
48	SWG 5	Remote Shutdown Switch (NO)	N/A
49	SWG 4	PTO mode disengage (NC)	MPTS4
50	SWG 3	PTO mode raise/ Resume	MPTS3
51	SWG 2	PTO mode Set/Lower	MPTS2
52	SWG 1	PTO mode ON/OFF	MPTS1
53	AIN_ACT/PWM _I 1	PWM throttle input	N/A
54	AIN_ACT 7	Throttle 1 Analogue input	N/A
55	AIN_ACT 5	Throttle 2 Analogue input	N/A
56	AIN_ACT 4	N/A	N/A
57	DOUT_1A 1	Start aid control	N/A
58	DOUT_0.3A 10	N/A	N/A
59	DOUT_0.3A 9	Warning Lamp	N/A
60	DOUT_0.3A 8	Shutdown Lamp	N/A
61	DOUT_0.3A 4	PTO mode lamp	N/A
62	DOUT_0.3A 3	Low oil pressure lamp	N/A
63	DOUT_0.3A 2	Wait to Start Lamp	N/A
64	DOUT_0.3A 1	N/A	N/A

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Cummins QSB6.7

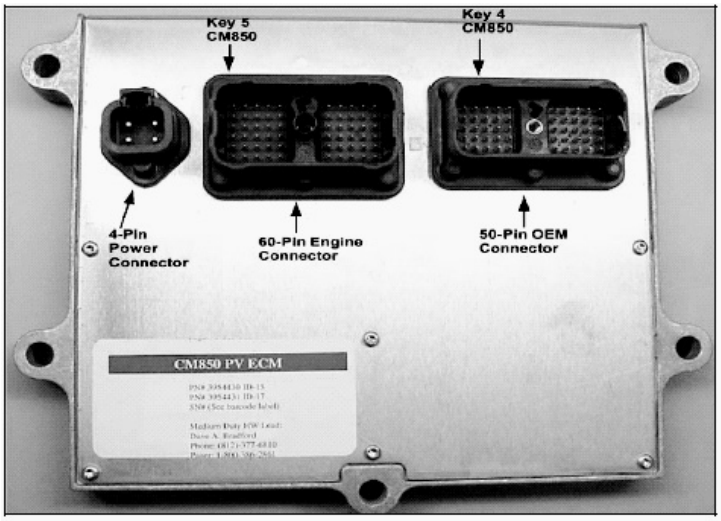
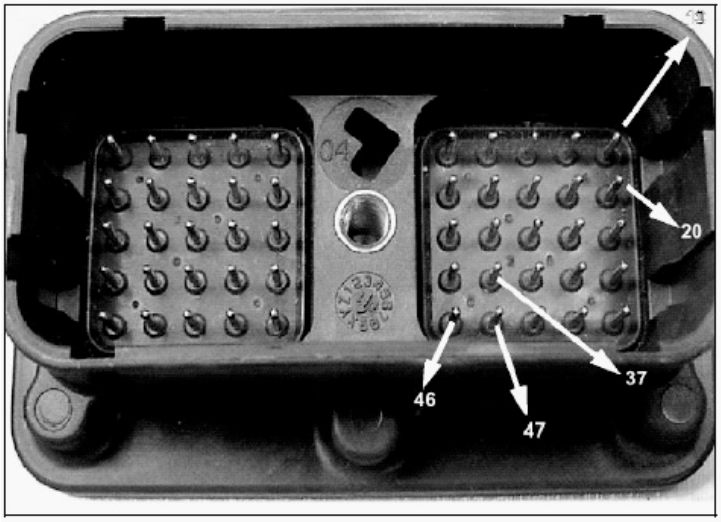
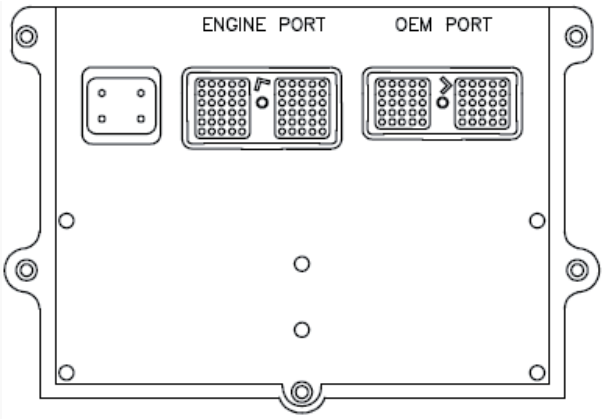
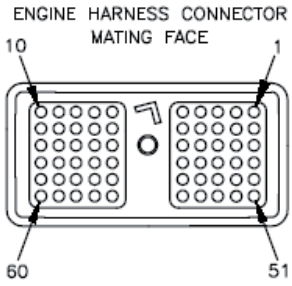
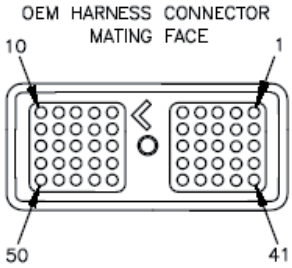


Figure 5.5 ECM Connector Plate CM850









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Table 2. Connections OEM contact

Pin	Pinout Type	M/R a	Signal Name	Notes	Application
1	IVS 5V Switched Pull-up Input		Off Idle Switch		All applications
2	6V Switched Pull-up Input	M	Diagnostics On/ Off Switch		All with diagnostics
3	6V Switched Pull-up Input		Remote Accelerator On/Off Switch		Remote Accelerator Feature
4	6V Switched Pull-up Input		ISC Switch 1		Intermediate Speed Control Feature

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Pin	Pinout Type	M/R a	Signal Name	Notes	Application
5b	6V Switched Pull-up Input	R	AXG Switch (Future Functionality)		Auxiliary Governor for Industrial Applications (Future Development)
		R	MUS Enable		Multi Unit Synchronisation Feature for Marine Applications.
6b	6V Switched Pull-up Input	R	Cruise On/Off		Engine Speed based cruise Control for Industrial Applications
		R	MUS Complementary		Multi Unit Synchronisation Feature for Marine applications.
7b	6V Switched Pull-up Input	R	Clutch/ Service Brake Switch		Clutch for all manual transmission in Industrial Applications Brake switch for all Industrial
		R	MUS ID Pin 1		Multi Unit Synchronisation Feature for Marine applications.
8b	6V Switched Pull-up Input		Engine Brake Switch (Future Functionality)		Engine Brakes for Industrial applications (Future Functionality)
		R	MUS ID Pin 2		Multi Unit Synchronisation Feature for Marine applications.
9	Ratiometric Analogue Input		Accelerator Position Signal		All applications
10	Non-Functional		Not Applicable		No functionality
11	IVS 5V Switched Pull-up Input		On Idle Switch		All applications

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Pin	Pinout Type	M/R a	Signal Name	Notes	Application
12b	6V Switched Pull-up Input	R	OEM Switch	Special calibration required	Switched Outputs (Dual Outputs) Based On Sensed Parameters Feature - Input for Industrial Applications
		R	MUS ID Pin 3		Multi Unit Sync Feature for Industrial and Marine applications. Refer to Note b for optional Industrial functions of this switch
13	6V Switched Pull-up Input	R	Alternate Low Idle Switch		Switched Alternate Low Idle Speed Feature
14	6V Switched Pull-up Input	R	Boost Power Switch		Boost Power Feature
15	6V Switched Pull-up Input	R	Engine Protection Shutdown Override Switch		Engine Protection Shutdown Override Function of Engine Protection Feature
16	6V Switched Pull-up Input	M	ISC Switch 2		Intermediate Speed Control Feature
17	6V Switched Pull-up Input		Fan Control Accessory Switch		Manual Control of Fan for Industrial Applications only
18	6V Switched Pull-up Input		ISC Switch 3 with Validation		Intermediate Speed Control Feature for Industrial Applications only
19	Resistive Analogue Input	R	HSG Droop Select Switch		Switched Droop Feature for Industrial Applications
		R	OEM Temperature		OEM Temperature for Marine Applications
20	Non-Functional		Not Applicable		No functionality
21	5V Sensor Voltage Source		Sensor Supply		All applications
22	5V Sensor Voltage Source		Accelerator Position Supply		All applications
23	ECM (ECU) Return		Accelerator Position Return		All applications

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Pin	Pinout Type	M/R a	Signal Name	Notes	Application
24	6V Switched Pull-up Input	M	Increment/Set - Decrement/Resume Switch (Increment/Set) for Industrial	Operates: Engine Speed Cruise Control, Intermediate Speed Control, Idle Adjust and Diagnostics	All applications with any underlying feature
			Increment for Marine		
25	6V Switched Pull-up Input	M	Increment/Set - Decrement/Resume Switch (Decrement/ Resume) for Industrial	Operates: Cruise Control, Intermediate Speed Control, Idle Adjust and Diagnostics	All applications with any underlying feature
			Decrement for Marine		
26	APS Ratiometric Analogue Input	M	Remote Accelerator Position		All Remote Accelerator
			Variable ISC		Intermediate Speed Control wit Variable ISC feature
27	Vehicle Speed Sensor (+) - Digital Vehicle Speed Sensor - Magnetic Pickup	M	Digital VSS Signal (Not available)		Vehicle Speed (Not available currently for Industrial
		M	Magnetic Pickup VSS (+) (Not available)		Spare pin for Marine
28	Resistive Analogue Input		Coolant Level Sensor		All applications
29	ECM (ECU) return		ECM (ECU) return (General)		All applications
30	-Hall Effect sensor Input	M	Frequency Accelerator Position		Frequency Accelerator Pedal or Lever Feature for Industrial Applications only
		M	Auxiliary Governor Speed		Auxiliary Governor for Industrial Applications only
31	Resistive Analogue Input	R	Alternate Torque Switch		Alternate Torque feature for Industrial Applications
		R	OEM Temperature 2		OEM Temperature 2 Sensor for Marine Applications
32	ECM (ECU) Return		ECM (ECU) Return (Sensor)		All applications

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Pin	Pinout Type	M/R a	Signal Name	Notes	Application
33	ECM (ECU) Return		ECM (ECU) Return (General)		All applications
34	ECM (ECU) Return		ECM (ECU) Return (Switch)		All applications
35	Ratiometric Analogue Input	R	OEM Pressure	Requires a special calibration	Switched Outputs (Dual Outputs) Based On Sensed Parameters feature - Input
		R	OEM Temperature		Switched Outputs (Dual Outputs) Based On Sensed Parameters feature - Input
36	Vehicle Speed Sensor - Magnetic Pick-up		Magnetic Pickup VSS (-) (Not available)		Vehicle Speed (Not available currently in Industrial Applications) Spare pin for Marine Applications
37	J1939 Datalink Shield		J1939 Datalink (Shield)		All J1939 Datalink
38	Switched Source Driver Output	R	Fan Clutch Output (Discrete)		Electronic Fan Control Feature- Fan Control Type = On-Off for Industrial Only
		R	Fan Clutch Output (Variable)		Electronic Fan Control feature - Fan Control Type = Variable for Industrial applications only
		R	PWM Out		Dedicated PWM for Industrial applications only Spare pin for Marine
39	Keys witch Input		Keys witch		All applications
40	Switched Source Driver Output		Intake Air Heater Output		Grid Heaters in all Applications
41	Tachometer Source Driver output		Tachometer Output		All with dashboard Tachometer
42	ECM (ECU) Return		ECM (ECU) Return (General)		All applications
43	Switched Sink Driver Output		Stop Lamp		All applications
44	Switched Sink Driver Output		Warning Lamp		All applications
45	Switched Sink Driver Output		Malfunction Indicator Lamp (OBD)	Future Support	Spare lamp
46	J1939 Datalink (+)		J1939 Datalink (+)		All J1939 Datalink
47	J1939 Datalink (-)		J1939 Datalink (-)		All J1939 Datalink

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Pin	Pinout Type	M/R a	Signal Name	Notes	Application
48	Switched Source Driver Output	R	Switched Output B	Requires a special calibration	Switched Outputs (Dual Outputs) Based On Sensed Parameters feature - Output for Industrial applications only, Spare pin for marine Applications
49	Switched Source Driver Output	R	Switched Output A	Requires a special calibration	Switched Outputs (Dual Outputs) Based On Sensed Parameters feature - Output
50	Switched Sink Driver Output		Wait to Start Lamp		

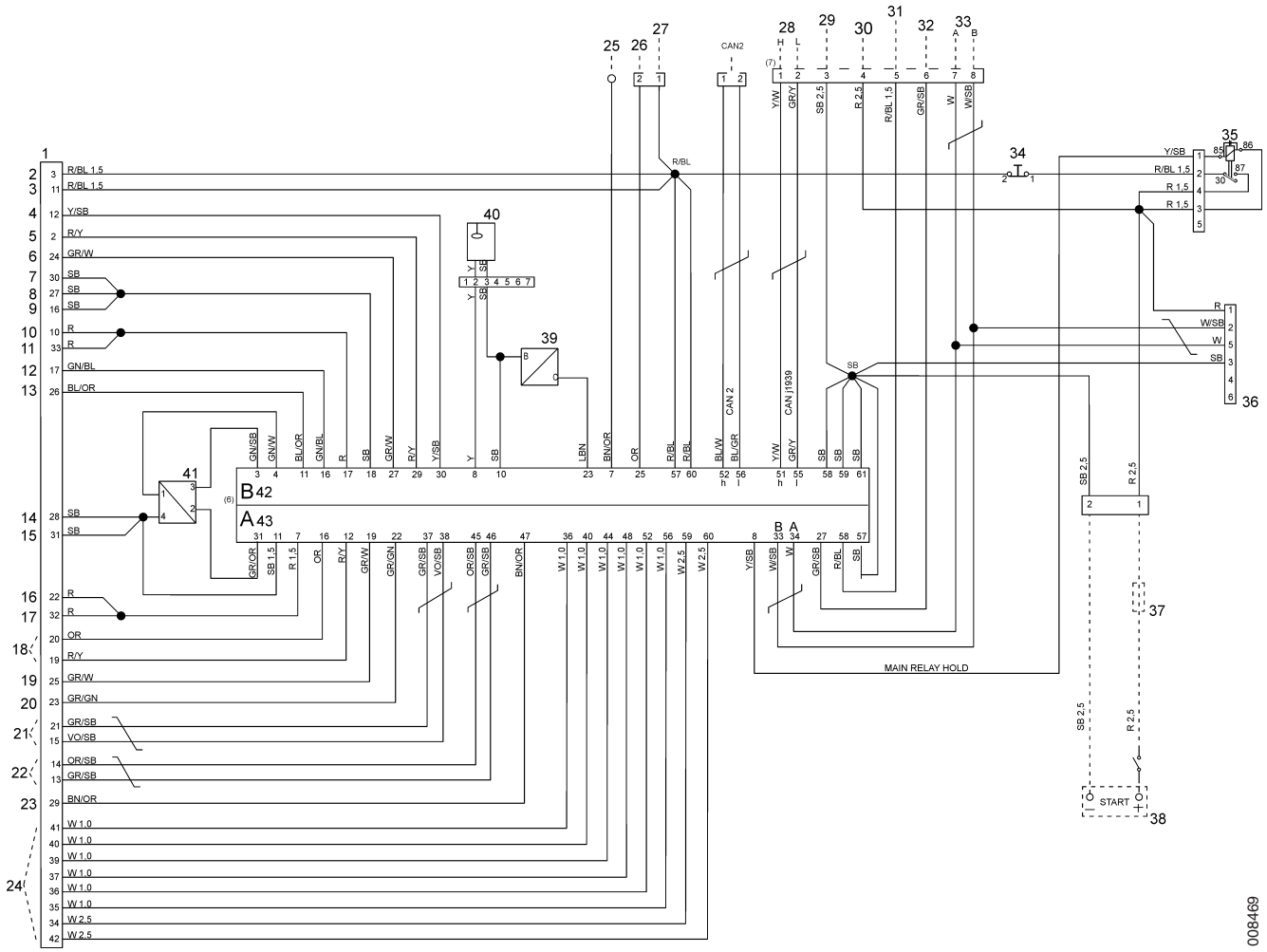
M = multifunction, R = reconfigurable

Table 3. Connections 4-pin power supply

Pin	Pinout Type	Signal Name	Notes
1	ECM (ECU) Return (Power)	ECM (ECU) Return	Primary Return pin
2	ECM (ECU) Return (Power)	ECM (ECU) Return	Secondary Return pin; use if required
3	ECM (ECU) Supply (Vbatt+)	ECM (ECU) Supply	Secondary Supply pin; use if required
4	ECM (ECU) Supply (Vbatt+)	ECM (ECU) Supply	Primary Supply pin

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Volvo TAD650VE, TAD660VE, TAD750VE, TAD760VE, Wiring diagrams



EMS2, vehicle harness

1	Connector (X17)	23	Boost temperature
2	Start relay, supply	24	Injectors
3	Internal EGR, supply	25	Preheat, sensor
4	Internal EGR	26	Preheat relay
5	Start relay	27	Preheat, supply
6	Coolant temperature	28	J1939 CAN bus
7	Coolant temperature, ground	29	Battery negative
8	Oil pressure, ground	30	Battery plus
9	Fuel pressure, ground	31	Ignition
10	Fuel pressure, supply	32	Stop
11	Oil pressure, supply	33	J1587/1708 (bus)
12	Fuel pressure	34	Extra stop (AUX stop)

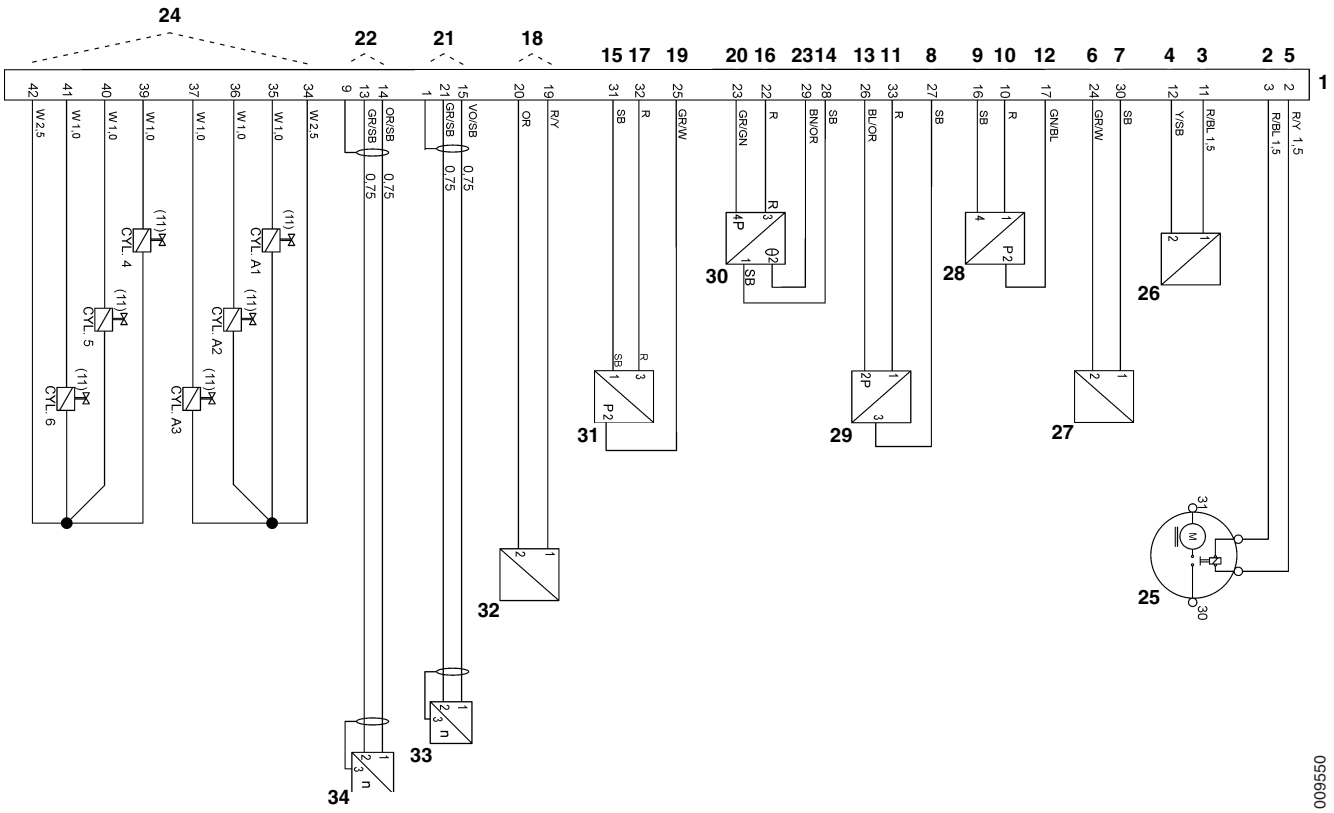
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13	Oil pressure	35	Main relay
14	Boost pressure/temperature, ground	36	Connector engine interface
15	Rail pressure, ground	37	Main fuse 10A
16	Boost pressure/temperature, supply	38	Battery (24V)
17	Rail pressure, supply	39	Coolant level
18	M PROP	40	Water in fuel
19	Rail pressure	41	Oil level/temperature
20	Boost pressure	42	Connector A, control unit EMS 2
21	Speed sensor, crankshaft	43	Connector B, control unit EMS 2
22	Speed sensor, camshaft		

Cable colours

BL =	Blue	P =	Pink
LBL =	Light blue	R =	Red
BN =	Brown	SB =	Black
LBN =	Light brown	VO =	Violet
GN =	Green	W =	White
GR =	Grey	Y =	Yellow
OR =	Orange	Cable area =	0.75 mm² unless otherwise specified

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EMS2, engine harness

1	Connector (X17)	18	M PROP
2	Start relay, supply	19	Rail pressure
3	Internal EGR, supply	20	Boost pressure
4	Internal EGR	21	Speed sensor, crankshaft
5	Start relay	22	Speed sensor, camshaft
6	Coolant temperature	23	Boost temperature
7	Coolant temperature, ground	24	Injectors
8	Oil pressure, ground	25	Start motor and prestart relay
9	Fuel pressure, ground	26	Internal EGR, sensor
10	Fuel pressure, supply	27	Coolant temperature, sensor
11	Oil pressure, supply	28	Fuel pressure, sensor
12	Fuel pressure	29	Oil pressure, sensor
13	Oil pressure	30	Boost pressure/temperature, sensor
14	Boost pressure/temperature, ground	31	Rail pressure, sensor
15	Rail pressure, ground	32	M PROP
16	Boost pressure/temperature, supply	33	Speed sensor, crankshaft
17	Rail pressure, supply	44	Speed sensor, camshaft

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Cable colours

BL =	Blue	P =	Pink
LBL =	Light blue	R =	Red
BN =	Brown	SB =	Black
LBN =	Light brown	VO =	Violet
GN =	Green	W =	White
GR =	Gray	Y =	Yellow
OR =	Orange	Cable area =	0.75 mm² unless otherwise specified

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1.11 Start/stop

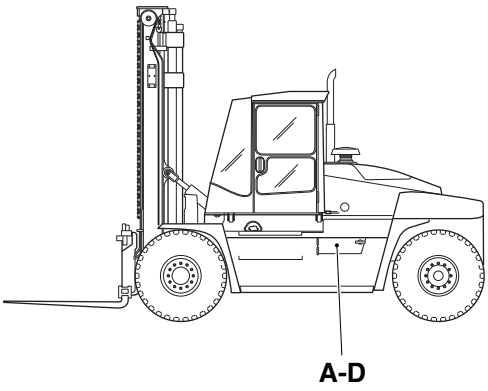
Start/stop, general

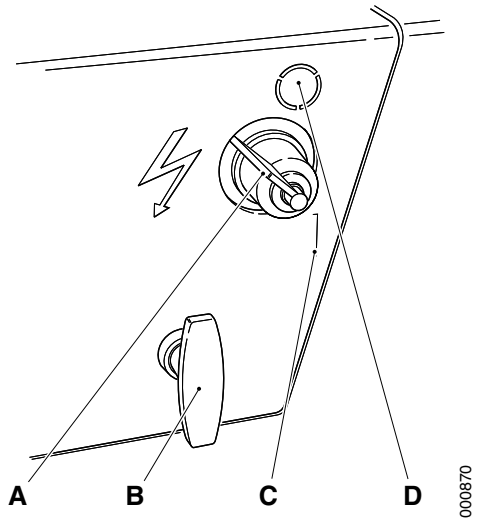
The electrical system works with 24 volts voltage.

The plus terminal is connected to a battery disconnect switch (A).

NOTE

The battery disconnect switch cannot be used as emergency stop!





A. Battery disconnector
B. Handle for opening battery cover
C. Position for main electric power on
D. Position for main electric power off

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1.11.2 Stopping device

Stopping device, description

The engine is stopped via the injectors, which cease to provide the cylinders with fuel when the stop signal is given to the engine ECU via the key switch or AUX STOP.

Stop signal to engine controller is by default from Volvo inverted and must be changed with VODIA Tool to parameter setting “Energised (24V) to Run”.

Engine alternatives Caterpillar and Cummins can only be stopped by turning off the ignition at the ignition switch.

Engine alternative Volvo is also in normal case stopped on the ignition switch but is for emergency or service use also equipped with an AUX STOP button in the engine room on the machines left-hand (marked with a small sign).

1.11.3 Automatic engine stop 5 minutes after driver’s seat is empty

Automatic engine stop 5 minutes after driver’s seat is empty, description



The machine is equipped with a function that turn the engine off if the driver leaves the cab for more than five minutes.

(Five minutes is the normal standard setting, the time can however be altered by an by Cargotec authorised service technician).

1.11.5 Automatic engine power derate

Automatic engine power derate, description

The control unit engine (ECU794) monitors the engine and will derate the power down to 50% of normal capacity if necessary.

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2 Transmission

Transmission, general

The forklift trucks uses Powershift transmissions as standard, which is electrically controlled via ECU 793 that controls gear changes in an intelligent way.

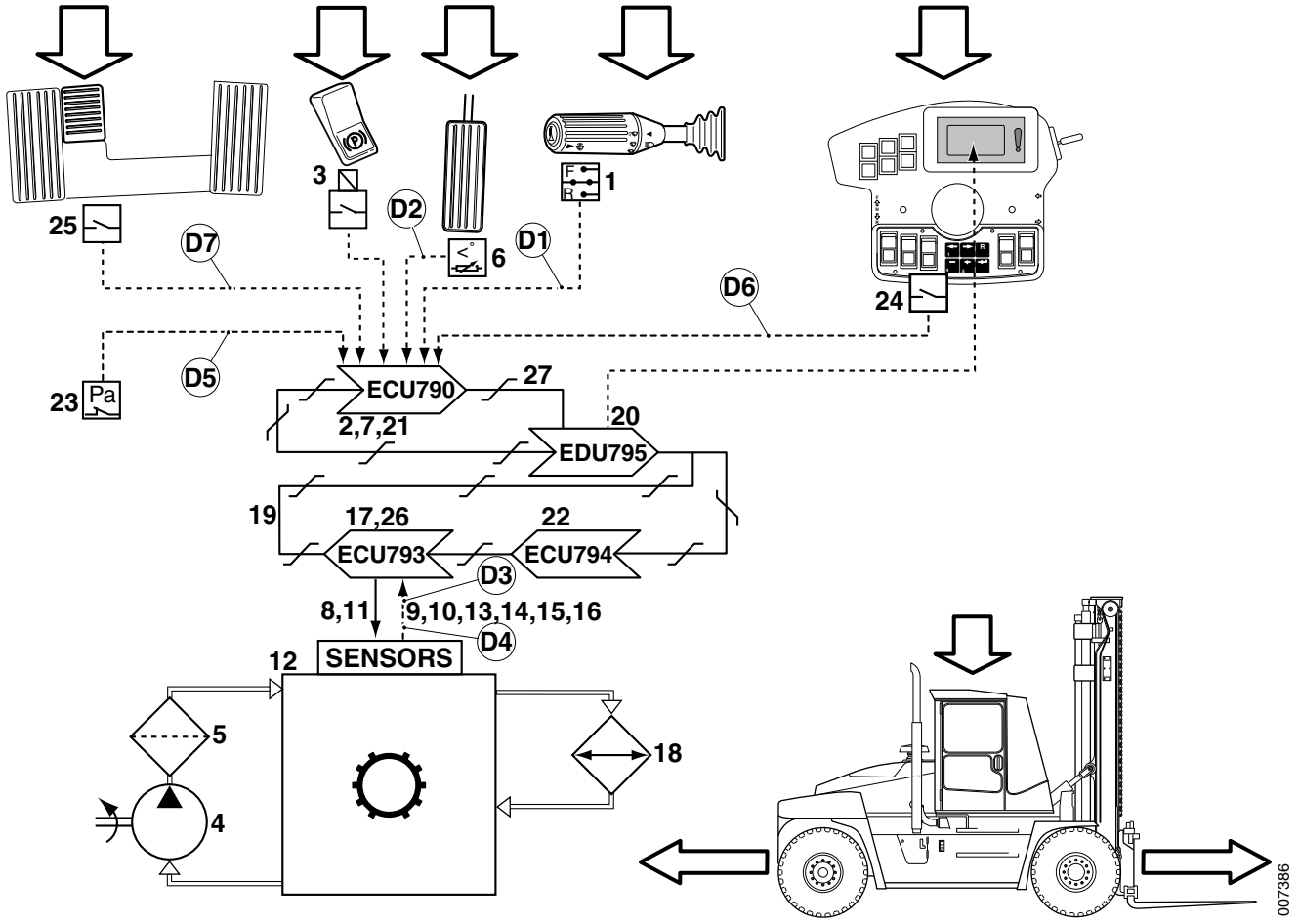
Component supplier documentation

The workshop manual only describes components and job descriptions related to installation in the machine. Please refer to the component supplier documentation for descriptions and instructions of the transmission components and systems.

References to component supplier documentation are only provided in exceptional cases. If information about a component is not found, the component supplier documentation should be used.

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Transmission Dana TE13000 and TE17000, function description



Pos	Explanation	Signal description	Reference
1	The gear selector (S160) sends voltage signal to Control unit general (ECU790).	Forward: K1:12=24V Reverse: K1:13=24V Gear 1: K1:9=24V, K1:10=24V. Gear 2: K1:9=24V, K1:10=0V. Gear 3: K1:9=0V, K1:10=0V.	*Gear and direction of travel selector, description page 35* D1: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:9-K1:13.*
2	Control unit general (ECU790) sends selected travel direction (forward, reverse or gear 1-3) on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
3	If switch parking brake (S107) is activated relay parking brake (K314) closes and sends a signal to control unit general (ECU790) and neutral is selected in the transmission.	Switch activated: Conn. 1, U = 22–28 V Conn. 7, U = 0 V	See Section *4 Brakes*, group *4.5 Parking brake system*

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Pos	Explanation	Signal description	Reference
4	The transmission's oil pump pumps oil when the engine is running.	-	-
5	The transmission's oil filter cleans the oil from impurities.	-	-
6	The throttle pedal sends signal to Control unit general (ECU790).	U = 0,5-4,5 V	See Section *1 Engine*, group *1.1.2 Accelerator pedal* D2: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 4, ECU790 input K1:26.*
7	Control unit general (ECU790) sends desired throttle application on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
8	Control unit general (ECU790) sends selected shifting program on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
9	Sensor oil pressure (Name ANI0, pin A2) sends resistance value proportional to the oil pressure to Control unit transmission (ECU793).	Pressure to transmission R = 1.1 kOhm. No pressure to transmission R = 2.2 kOhm. Checked by control system, error shown with error code.	D3: See *Diagnostics page 71*
10	Sensor engine speed (Name SS2+, pin F3) and oil temperature (Name ANI1, pin H3) sends a pulse signal with frequency which is proportional to engine speed and resistance value proportional to the transmission oil temperature to the transmission control unit (ECU793).	The oil temperature sensor is an PTC sensor, R = 0-5 kOhm Checked by Transmission control unit, error shown with error code.	D4: See *Diagnostics page 71*
11	Transmission control unit (ECU793) supplies voltage to valve block transmission control to obtain desired function.	Checked by Transmission control unit, error shown with error code.	*Transmission control unit (ECU 793) for Dana, description page 42*
12	Solenoid valves for travel direction and gear position in valve block transmission control activate gears in the transmission and the engine's power is transmitted to the transmission's output shaft.	Checked by Transmission control unit, error shown with error code.	-

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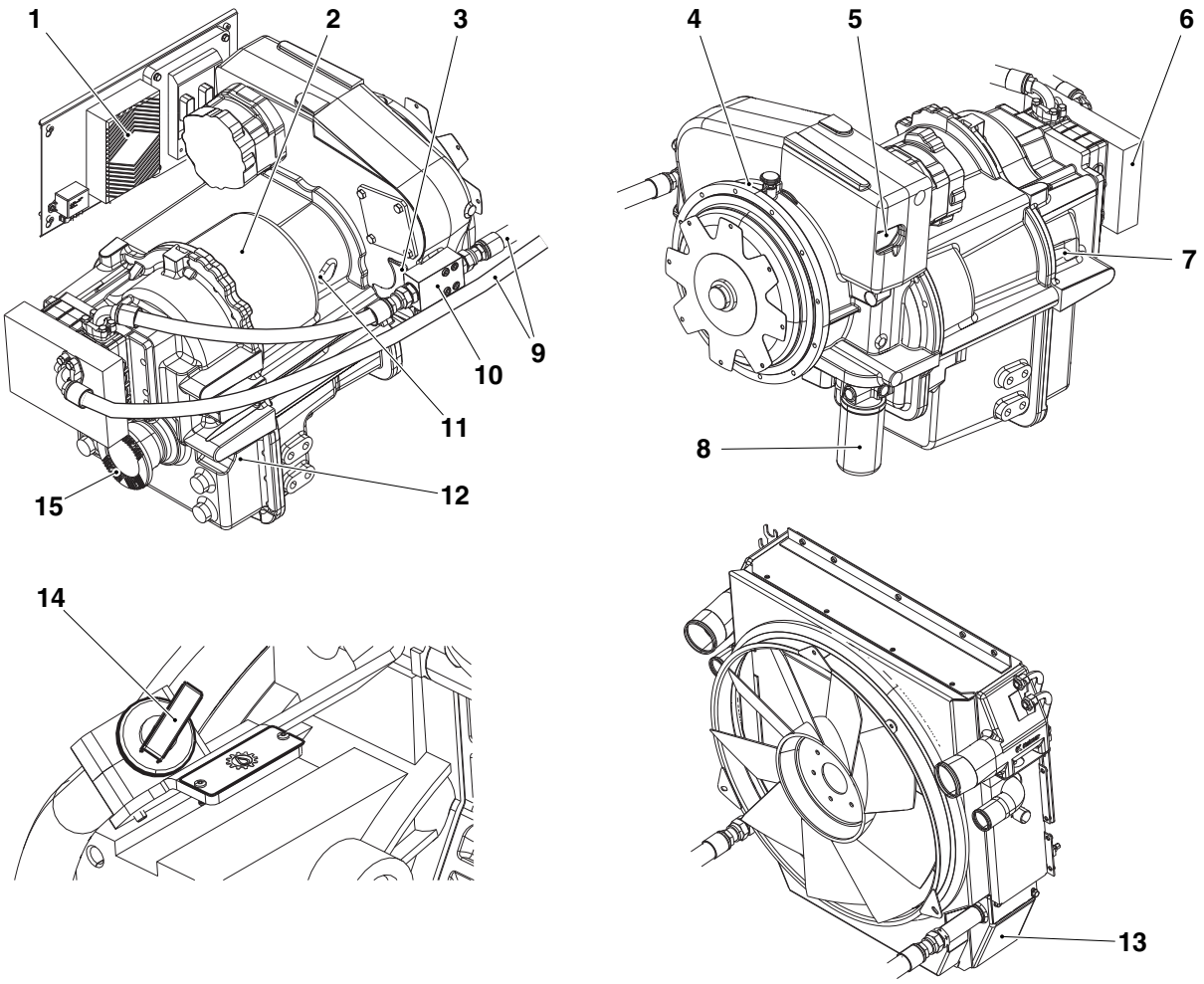
Pos	Explanation	Signal description	Reference
13	Sensor rpm turbine (B751) sends pulse signal with frequency proportional to turbine's rpm to Transmission control unit (ECU793).	Checked by Transmission control unit, error shown with error code.	-
14	Sensor rpm drum (B752) sends pulse signal with frequency proportional to drum's rpm to Transmission control unit (ECU793).	Checked by Transmission control unit, error shown with error code.	-
15	The speed sensor on the output shaft (B758) sends a pulsed signal with frequency proportional to the speed of the output shaft to the Transmission control unit (ECU793).	Checked by Transmission control unit, error shown with error code.	-
16	Temperature monitor torque converter (S221) sends voltage signal to Transmission control unit (ECU793) if oil temperature in torque converter becomes too high.	Checked by Transmission control unit, error shown with error code.	-
17	Transmission control unit (ECU793) controls gear shifting according to selected shifting program.	Checked by Transmission control unit, error shown with error code.	*Transmission control unit (ECU 793) for Dana, description page 42*
18	The oil cooler cools the transmission oil.	-	*Oil cooler, description page 40*
19	Transmission control unit (ECU793) sends information about temperature and rpm on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
20	Control unit terminal (EDU795) shows transmission information in operating menus.	Checked by control system, error shown with error code.	-
21	If the signal from the output shaft speed sensor (B758) indicates that the ground speed of the machine exceeds the speed limitation, the cab control unit (ECU790) sends a request for reduced engine speed on the CAN bus.	-	-
22	Control unit engine (ECU794) reduces engine rpm.	-	See Section *1 Engine*, group *11.9.1 Control unit engine*

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Pos	Explanation	Signal description	Reference
23	Switch (NC) disengagement (S220) opens the circuit if the brake pressure is above 2 MPa and sends a signal to the Control unit general (ECU 790).	U = 24 V	D5: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:15.*
24	Inching enable switch in pedal (S220-1) or inching enable switch (S1039) on wheel panel sends voltage signal to Control unit general ECU790 to allow inching. ⊕	U = 24 V	D6: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:15.*
25	Potentiometer in brake pedal (R690) sends signal to Control unit general (ECU790). ⊕	Inching on/off = K1:15, ECU790.	D7: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:15.*
26	Control unit general (ECU790) sends inching on/off and the inching value on the CAN bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
27	Control unit transmission (ECU793) supplies current to the transmission control valve block, to disconnect the drive.	Checked by Transmission control unit, error shown with error code.	*Transmission control unit (ECU 793) for Dana, description page 42*

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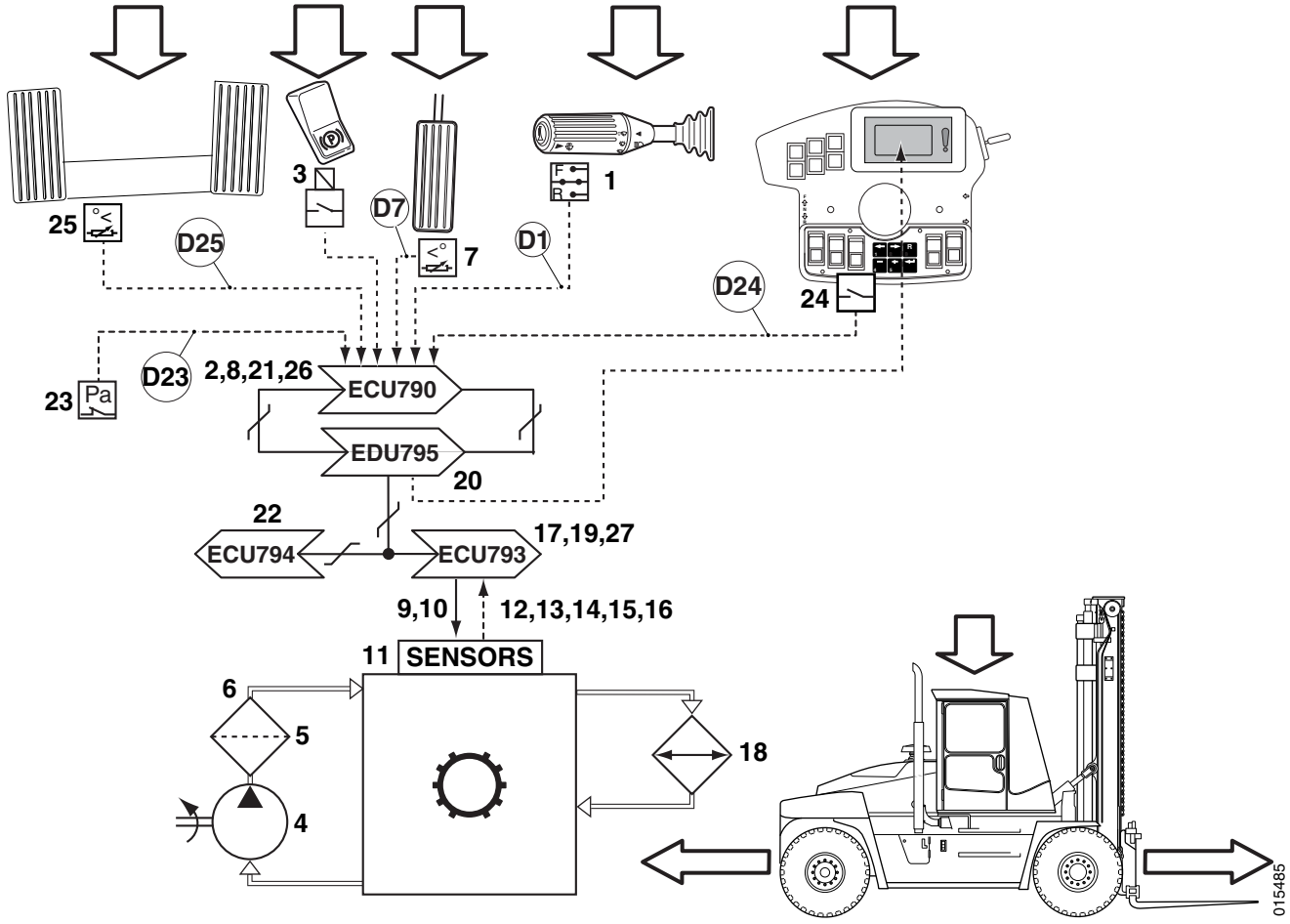
Transmission, component location (Transmission Dana)



1. Control unit, transmission (ECU 793)
2. Transmission
3. Sensor temperature output to oil cooler
4. Torque converter
5. Sensor engine speed (input shaft) incl. temperature in oil sump
6. Sensor oil pressure
7. RPM sensor clutch drum
8. Oil filter transmission
9. Hoses cooling
10. Thermal bypass valve
11. Sensor turbine speed
12. Sensor output shaft speed
13. Transmission oil cooler
14. Oil filling
15. Cross flange (for connection to propeller shaft)

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Transmission ZF 3WG161, function description



Pos	Explanation	Signal description	Reference
1	The gear selector (S160) sends voltage signal to Control unit general (ECU790).	Forward: K1:12=24V Reverse: K1:13=24V Gear 1: K1:9=24V, K1:10=24V. Gear 2: K1:9=24V, K1:10=0V. Gear 3: K1:9=0V, K1:10=0V.	*Gear and direction of travel selector, description page 35* D1: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:9-K1:13.*
2	Control unit general (ECU790) sends selected travel direction (forward, reverse or gear 1-3) on CAN-bus to transmission controller ECU793.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*

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Pos	Explanation	Signal description	Reference
3	Switch 107 sends a digital signal 24V to ECU 790 K1:23. ECU 790 K2:14 sends a digital signal 24V to solenoid Y 642, that activates the parking brake. When parking brake is off pressure sensor S200 closes an activate relay K314 who send a digital - signal to Inching relay K334. When parking brake is on pressure sensor S 200 opens and release relay K314 and the minus signal to inching ends.	Parking brake activated: 0 V Parking brake released: 24 V	See Section *4 Brakes*, group *4.5 Parking brake system*
4	The transmission's oil pump pumps oil when the engine is running.	-	-
5	The transmission's oil filter cleans the oil from impurities.	-	-
6	The differential pressure oil filter switch sends signal to ECU793 if oil filter is polluted.	Normal = 510 Ohm Polluted = Open circuit	-
7	The throttle pedal sends signal to Control unit general (ECU790).	U = 0,5-4,5 V	See Section *1 Engine*, group *1.1.2 Accelerator pedal* D2: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 4, ECU790 input K1:26.*
8	Control unit general (ECU790) sends desired throttle application on CAN-bus to engine controller ECU794.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
9	Control unit general (ECU790) sends selected shifting program on CAN-bus to transmission controller ECU793.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
10	Control unit transmission (ECU793) supplies voltage to valve block transmission control to obtain desired function.	Checked by Control unit transmission, error shown with error code.	*Transmission control unit (ECU 793) for Dana, description page 42*

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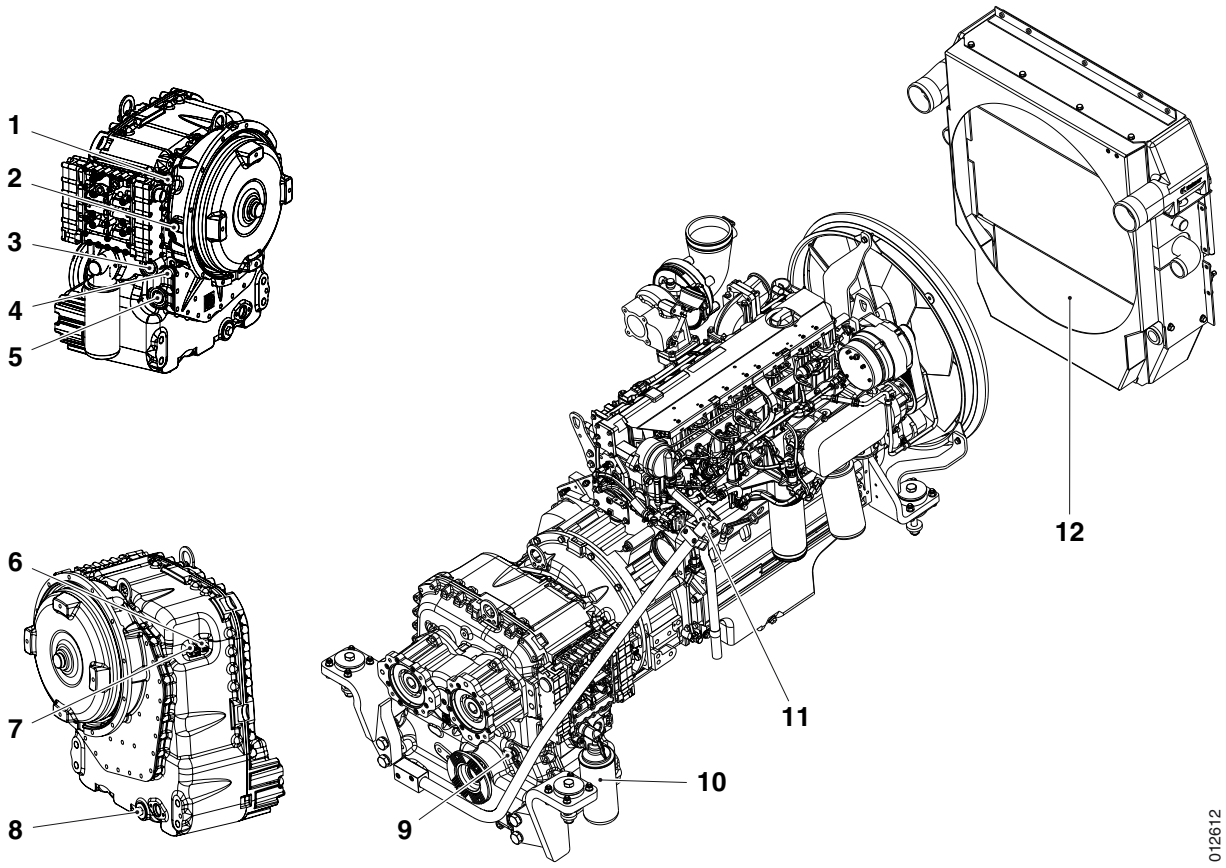
Pos	Explanation	Signal description	Reference
11	Solenoid valves for travel direction and gear position in valve block transmission control activate gears in the transmission and the engine's power is transmitted to the transmission's output shaft.	Checked by Control unit transmission, error shown with error code. Forward = KV (B) Reverse = KR (E) 1st gear = K1 (D) 2nd gear = K2 (A) 3rd gear = K3 (C)	-
12	Sensor rpm turbine (B751) sends pulse signal with frequency proportional to turbine's rpm to Control unit transmission (ECU793).	Checked by Control unit transmission, error shown with error code.	-
13	Sensor engine speed (B753) sends pulse signal with frequency proportional to engine connection flexplates rpm to Control unit transmission (ECU793).	Checked by Control unit transmission, error shown with error code.	-
14	Sensor rpm gear chain (B752) sends pulse signal with frequency proportional to drum's rpm to Control unit transmission (ECU793).	Checked by Control unit transmission, error shown with error code.	-
15	Output speed sensor (B758) sends pulse signal with frequency proportional to output shaft speed to Control unit transmission (ECU793).	Checked by Control unit transmission, error shown with error code. Vehicle speed sensor connected to ECU793 VMG2 and EF4 and power supply to F58-4:4	-
16	Temperature sensor converter (B766) sends voltage signal proportional to oil temperature to Control unit transmission (ECU793).	Checked by Control unit transmission and sent to ECU795 for display, Error code sent if oil temperature too high.	-
17	Control unit transmission (ECU793) controls gear shifting according to selected shifting program.	Checked by Control unit transmission, error shown with error code.	*Transmission control unit (ECU 793) for Dana, description page 42*
18	The oil cooler cools the transmission oil.	-	*Oil cooler, description page 40*
19	Control unit transmission (ECU793) sends information about temperature and rpm on CAN-bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*

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Pos	Explanation	Signal description	Reference
20	Control unit terminal (EDU795) shows transmission information in operating menus.	Checked by control system, error shown with error code.	-
21	If the signal from output speed sensor (B758) indicates that the ground speed of the machine exceeds the speed limitation, the cab control unit (ECU790) sends a request for reduced engine speed on the CAN bus.	-	-
22	Control unit engine (ECU794) reduces engine rpm.	-	See Section *1 Engine*, group *11.9.1 Control unit engine*
23	Switch (NC) disengagement (S220) opens the circuit if the brake pressure is above 2 MPa and sends a signal to the Control unit general (ECU 790).	U = 24 V	D3: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:15.*
24	Inching enable switch (S1039) on wheel panel sends voltage signal to Control unit general ECU790 to allow inching. ⊕	U = 24 V Inching on/off = K1:15, ECU790.	D4: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU790 input K1:15.*
25	Potentiometer in brake pedal (R690) sends signal to Control unit general (ECU790). ⊕	U = 0,5-4,5V Channel 1 = K1:27 Channel 2 = K1:41	D5: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 4, ECU790 input K1:27 och meny 6, ECU790 input K1:41.*
26	Control unit general (ECU790) sends inching on/off and the inching value on the CAN bus.	Checked by control system, error shown with error code.	See Section *11 Common electrics*, group *11.6 Communication*
27	Control unit transmission (ECU793) supplies current to the transmission control valve block, to disconnect the drive.	Checked by Control unit transmission, error shown with error code.	*Transmission control unit (ECU 793) for Dana, description page 42*

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Transmission, component location (Transmission ZF)



1. Filter monitor
2. Sensor engine speed (B753)
3. Output to oil cooler
4. Sensor temperature converter (B766)
5. Input from oil cooler
6. Sensor turbine speed (B751)
7. Sensor inner transfer shaft speed (B752)
8. Oil drain plug
9. Sensor output shaft speed (B758)
10. Oil filter transmission
11. Oil filling
12. Transmission oil cooler

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Transmission Dana TE13000 or TE17000, replacement (engine alternative Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE)

⚠ DANGER

The transmission is very heavy.

Risk of pinch injury!

It is forbidden to go under the transmission when it has been lifted by a jack or similar.

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B safety*.

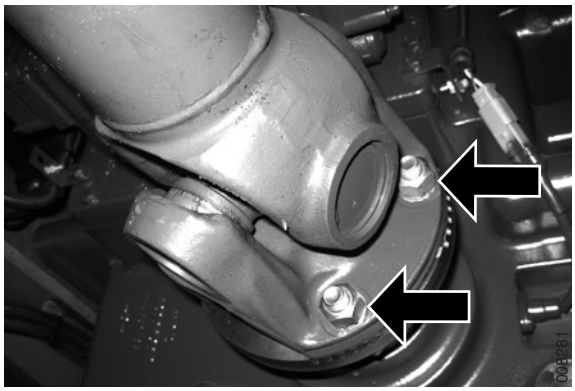
2 Remove the propeller shaft from the transmission.

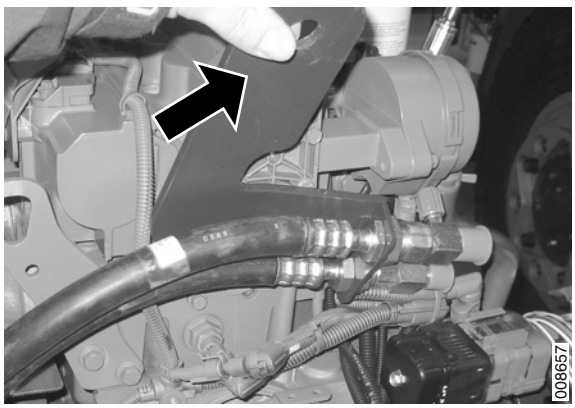
3 Depressurise the system, see section *B Safety*.

4 Detach relevant hoses and cables before separating engine and transmission.

NOTE

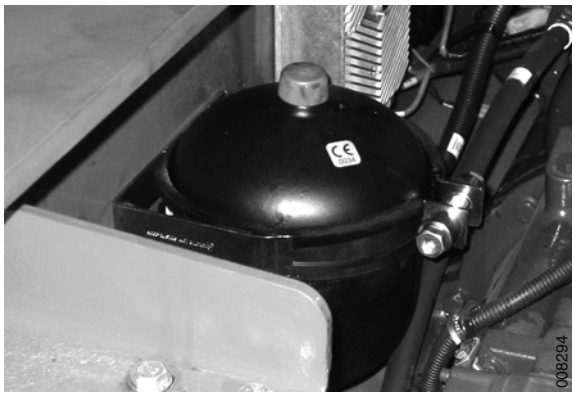
Drain and collect liquids before detaching hoses.



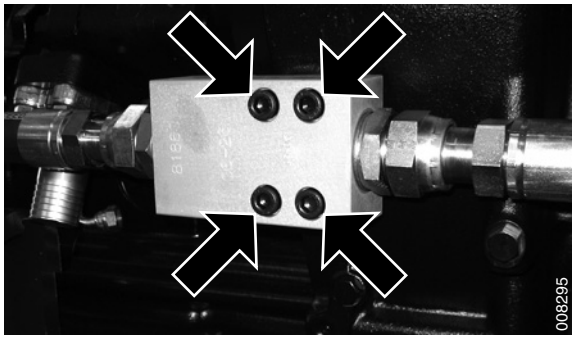


- Undo the hose bracket from the rear of the transmission, tie the bracket up so that the hoses are not damaged.

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- Undo the accumulator and hang it on one side without undoing the hoses.



- Undo the bypass valve from the transmission without undoing the hoses from the valve.

NOTE

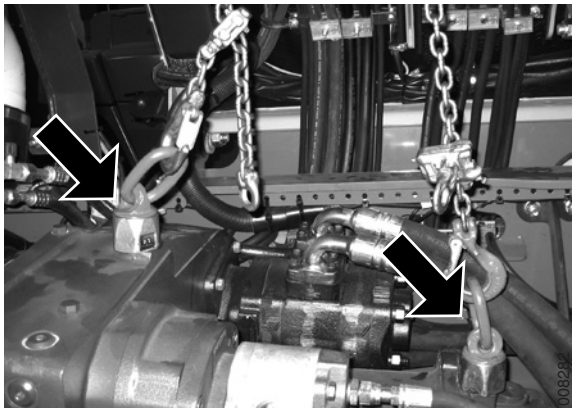
Plug all connections immediately to protect the hydraulic system from impurities.



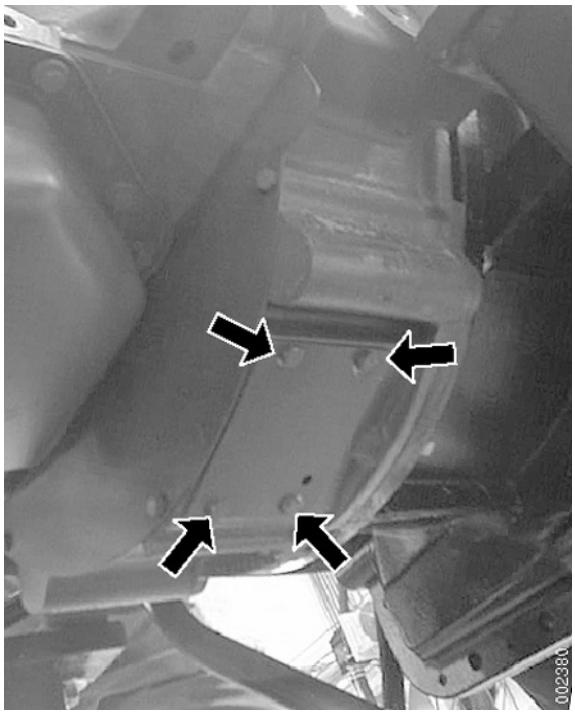
- Undo the silencer to make it possible to get at the nuts on the flexible plate.

Silencer bracket

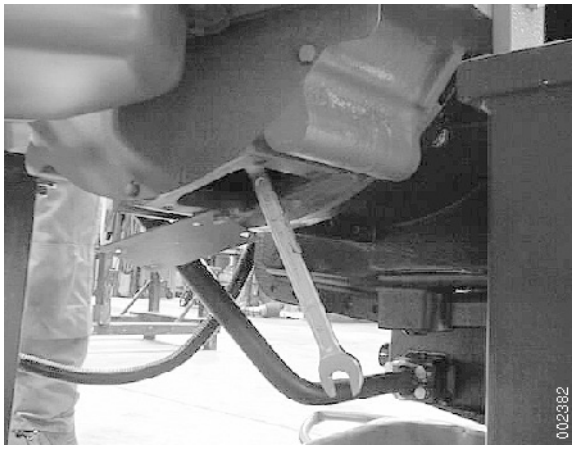
5 Fix the transmission to a travelling crane.



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6 Remove the screws that holds the cover plate underneath the flywheel housing.



7 Remove the nuts for the flexible plate through the hole under the cover plate.

NOTE

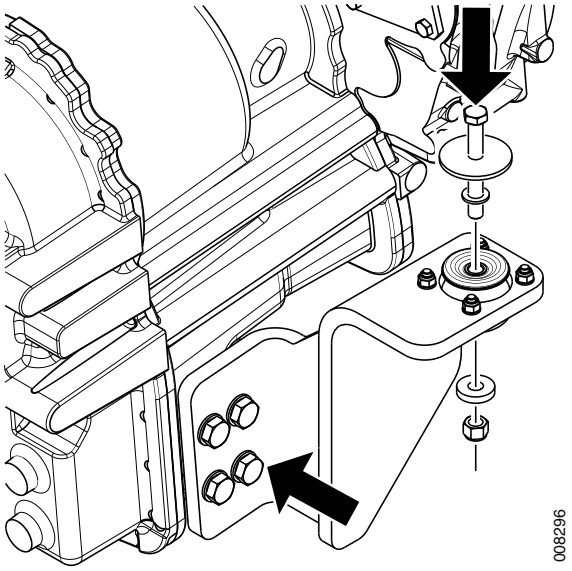
Turn the engine for each nut to be removed from the flex plate.

8 Support the engine from underneath with a jack or equivalent.

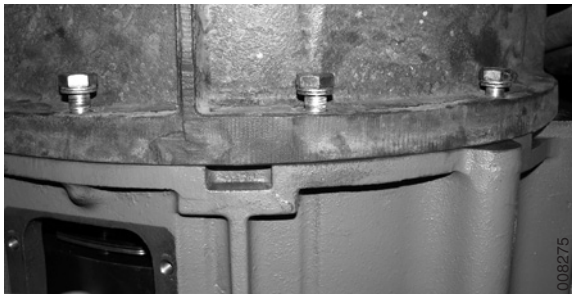
NOTE

Secure the diesel engine so that it does not tip over when the transmission is removed.

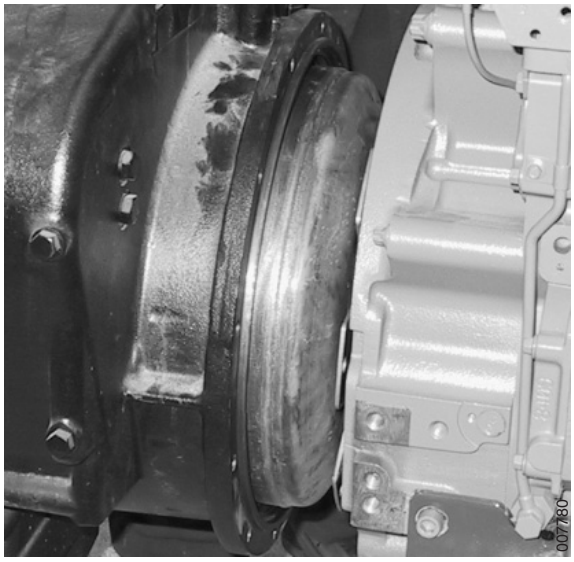
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9 Undo the transmission mountings from the transmission on both sides, leave it in place on the right side of the frame and remove the left side.



10 Remove the bolts holding the transmission and engine together.



11 Carefully separate the transmission and engine.

NOTE

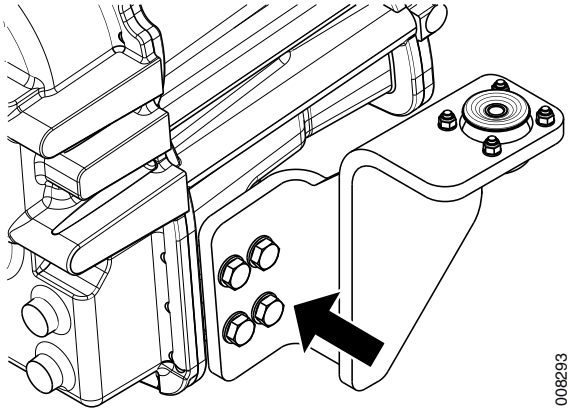
If the flexible plates are damaged during an transmission change, they must also be replaced.

NOTE

Beware of balance before the transmission is lifted.

12 Remove the transmission.

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Assembly

13 Move the transmission mounting over to the new transmission, tighten to a torque of **390 Nm**.

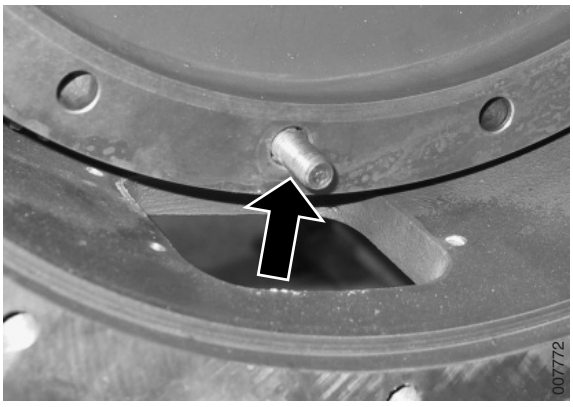
14 Transfer the hydraulic pumps from the old transmission to the new one, see section *10 Common hydraulics, group 10.4 pumps.*



15 Put two studs into the flywheel housing as a guide when the transmission is installed.

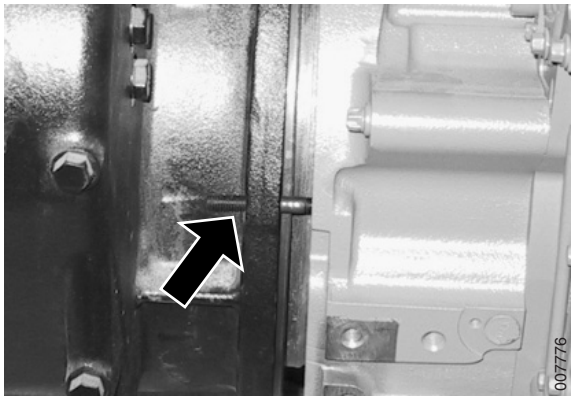


16 Grease the torque converter connection, both on the Diesel engine and on the transmission.



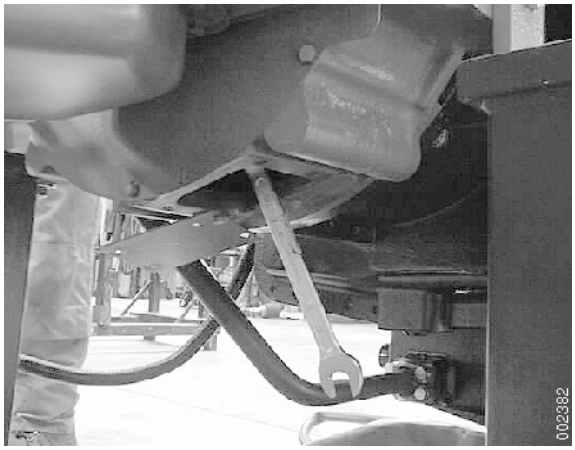
17 Align one of the studs on the flywheel so that it is centred on a hole in the flywheel housing

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18 Lift the transmission into place. Make sure that the studs on the flywheel come into correct alignment and do not damage the flexible plate.

19 Install the screws which fix the transmission and engine, but do not tighten the screws fully. Leave about a millimetre between the engine and transmission, to facilitate installation of the nuts for the flexible plate/flywheel.



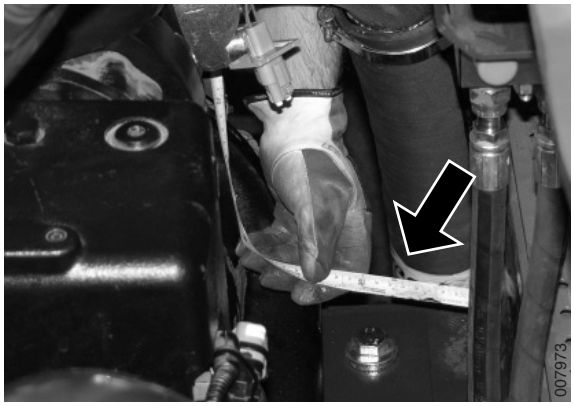
20 Install the nuts which hold the flexible plate to the flywheel in two stages. Do not tighten the nuts in the first stage.

NOTE

The diesel engine must be undone from the engine mountings and from the transmission to remove a dropped nut. Secure the nut in the socket during installation.

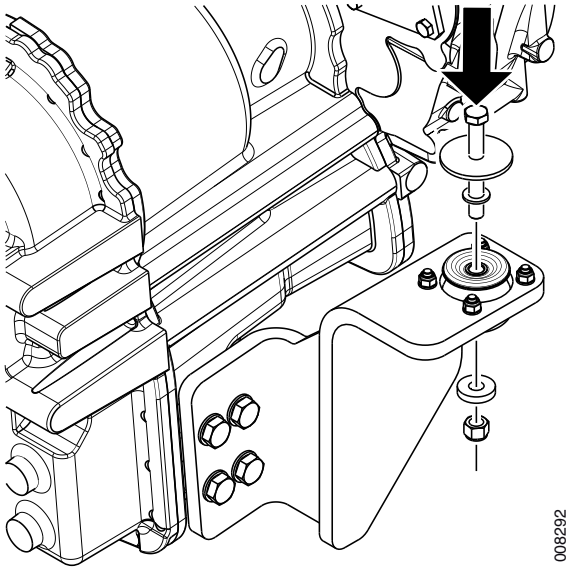
21 Tighten the screws which fix the transmission and engine.

22 Rotate the flywheel a further rotation and tighten the nuts which hold the flexible plate to the flywheel.



23 Measure and check that the transmission is centred in the frame.

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24 Screw the transmission to the transmission mountings (Tighten to a torque of **135 Nm**), put the cover plate and propeller shaft back.

25 Remove the hoisting equipment from the transmission.

26 Remove the jack from underneath the engine.

27 Put back the silencer and other equipment. Installation is in reverse order.

28 Attach relevant hoses and cables to the transmission. Check fluid levels and top up as necessary.

29 Calibrate the transmission, see *Calibration for Dana, description page 76*.

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Transmission Dana TE13000 or TE17000, replacement (engine alternative Caterpillar C6.6 and Cummins QSB6.7)

DANGER

The transmission is very heavy.

Risk of pinch injury!

It is forbidden to go under the transmission when it has been lifted by a jack or similar.

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B safety*.

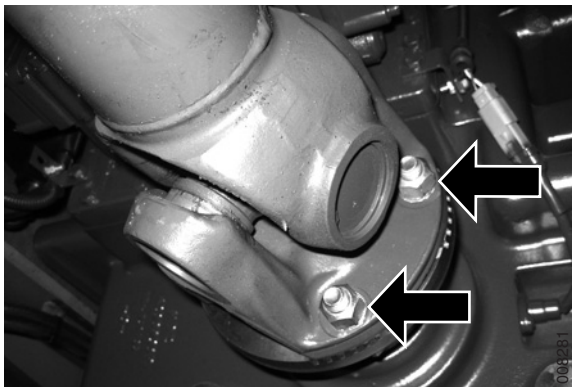
2 Remove the propeller shaft from the transmission.

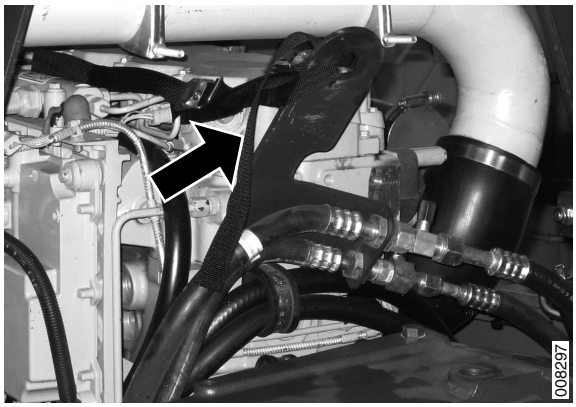
3 Depressurise the system, see section *B Safety*.

4 Detach relevant hoses and cables before separating engine and transmission.

NOTE

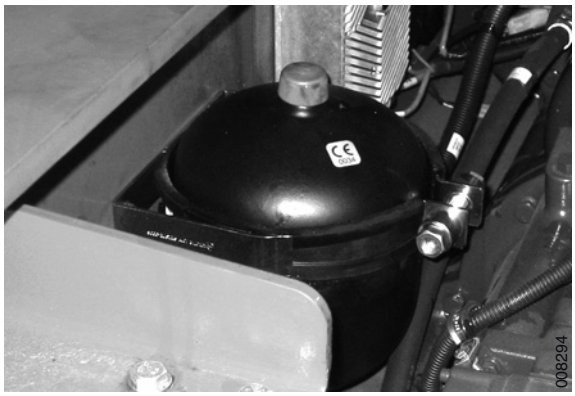
Drain and collect liquids before detaching hoses.



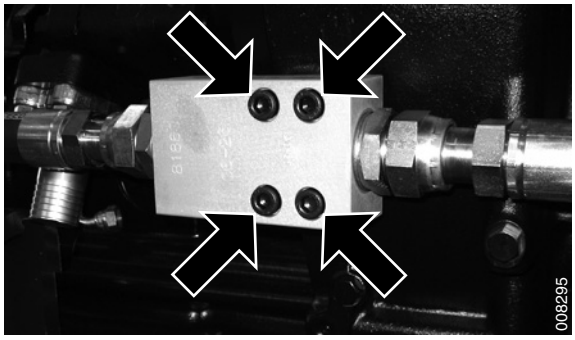


- Undo the hose bracket from the rear of the transmission, tie the bracket up so that the hoses are not damaged.

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- Undo the accumulator and hang it on one side without undoing the hoses.



- Undo the bypass valve from the transmission without undoing the hoses from the valve.

NOTE

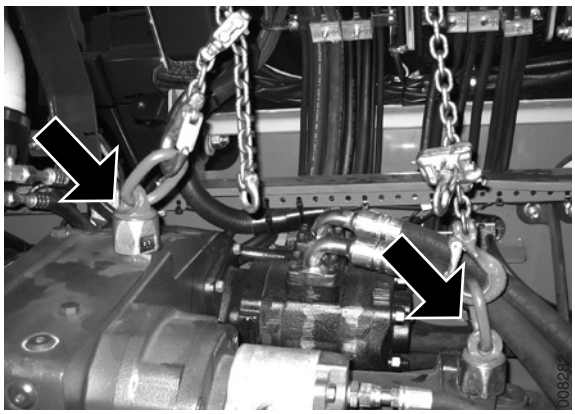
Plug all connections immediately to protect the hydraulic system from impurities.



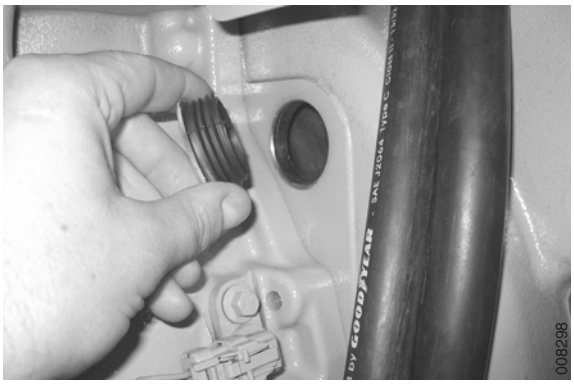
Silencer bracket

- Undo the silencer to make it possible to get at the nuts on the flexible plate.

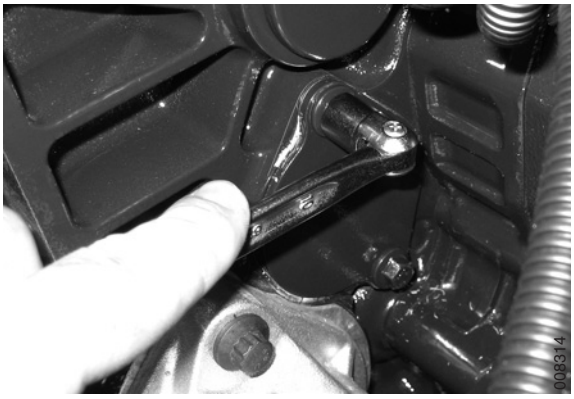
5 Fix the transmission to a travelling crane.



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Caterpillar C6.6



Cummins QSB6.7

6 Remove the rubber cover plug (Caterpillar C6.6) on the machines right-hand side or the cover plate fixed with 2 screws (Cummins QSB6.7) on the machines left-hand side.



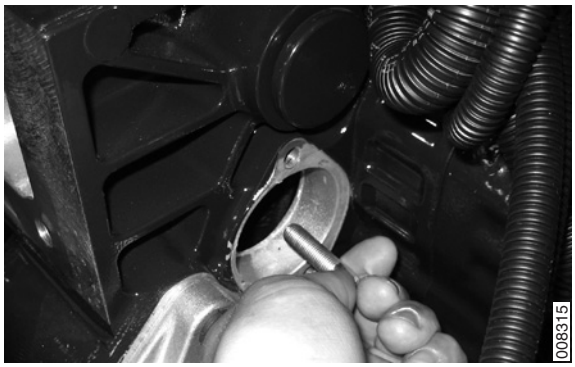
Caterpillar C6.6

7 Remove the screws for the flexible plate through the hole in the flywheel housing.

NOTE

Turn the engine for each screw to be removed from the flex plate.

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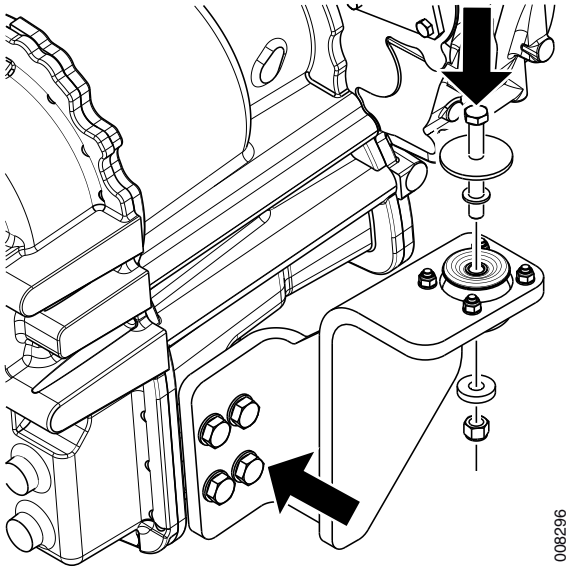


Cummins QSB6.7

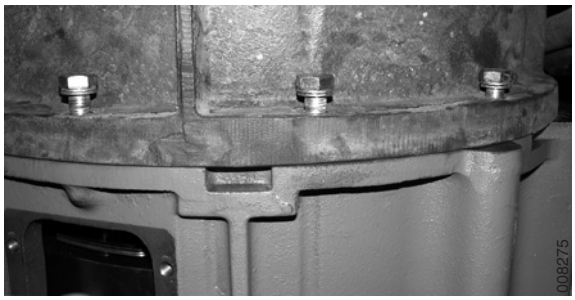
8 Support the engine from underneath with a jack or equivalent.

NOTE

Secure the diesel engine so that it does not tip over when the transmission is removed.

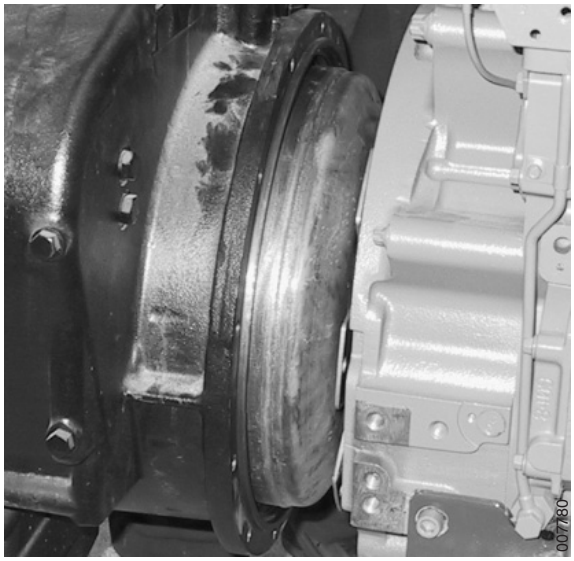


9 Undo the transmission mountings from the transmission on both sides, leave it in place on the right side of the frame and remove the left side.



10 Remove the bolts holding the transmission and engine together.

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11 Carefully separate the transmission and engine.

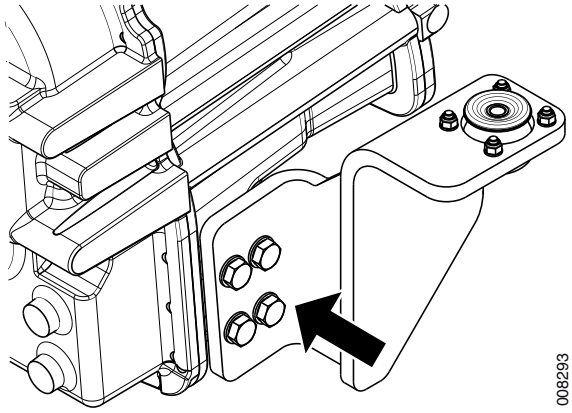
NOTE

If the flexible plates are damaged during an transmission change, they must also be replaced.

NOTE

Beware of balance before the transmission is lifted.

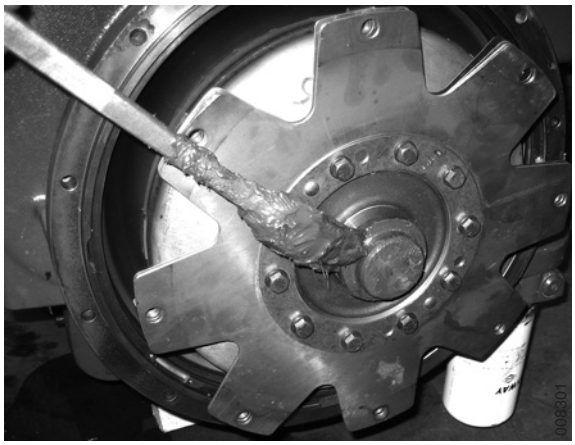
12 Remove the transmission.



Assembly

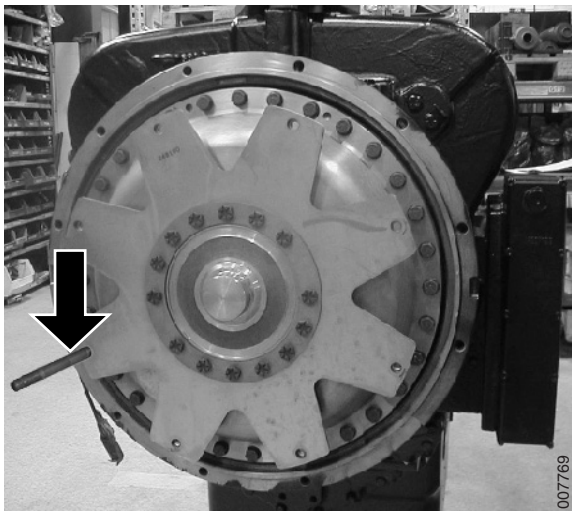
13 Move the transmission mounting over to the new transmission, tighten to a torque of **390 Nm**.

14 Transfer the hydraulic pumps from the old transmission to the new one, see section *10 Common hydraulics, group 10.4 pumps.*



15 Grease the torque converter connection, both on the Diesel engine and on the transmission.

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Ttransmissionransmission guide stud

16 Insert a stud into one of the nuts on the flexible plate as a guide when the transmission is installed.



Caterpillar C6.6

17 Lift the transmission into place. Guide the stud through the flywheel and out through the hole in the flywheel housing.



Cummins QSB6.7

18 Install the screws which fix the transmission and engine, and tighten the screws.

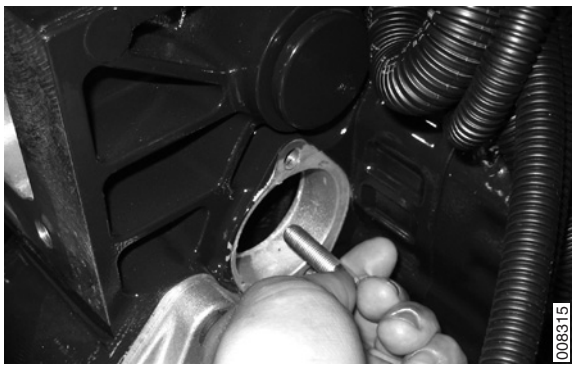
19 Remove the stud through the hole in the flywheel housing.

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Caterpillar C6.6

20 Install the screws which hold the flexible plate to the flywheel in two stages. Do not tighten the screws in the first stage. Then rotate the flywheel a further rotation and tighten the screws.



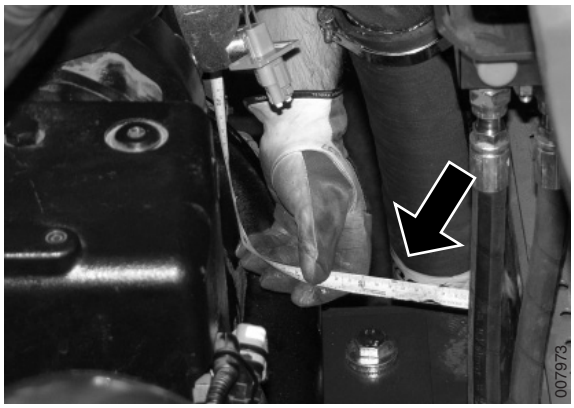
Cummins QSB6.7

NOTE

Turn the engine for each screw to be installed to the flex plate.

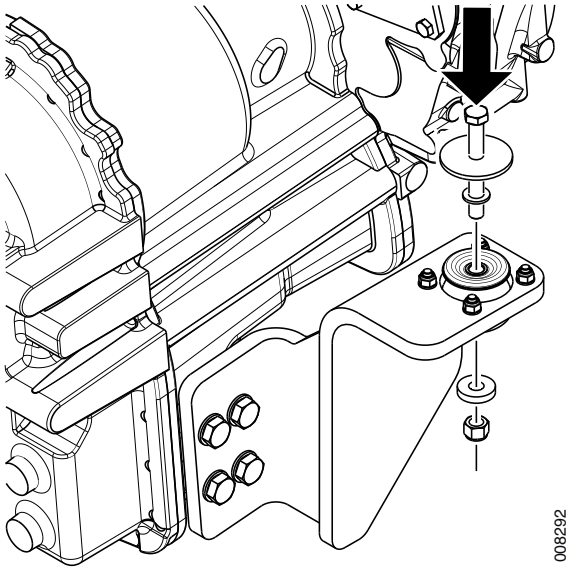
NOTE

The diesel engine must be undone from the engine mountings and from the transmission to remove a dropped screw. Secure the screw in the socket during installation.



21 Measure and check that the transmission is centred in the frame.

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22 Screw the transmission to the transmission mountings (Tighten to a torque of **135 Nm**), put the cover plate (Cummins) or rubber cover plug (CAT) and propeller shaft back.

23 Remove the hoisting equipment from the transmission.

24 Remove the jack from underneath the engine.

25 Put back the silencer and other equipment. Installation is in reverse order.

26 Attach relevant hoses and cables to the transmission. Check fluid levels and top up as necessary.

27 Calibrate the transmission, see *Calibration for Dana, description page 76*.

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Transmission ZF 3WG161, replacement (engine alternative Volvo TAD650VE and TAD660VE)

⚠ DANGER

The transmission is very heavy.

Risk of pinch injury!

It is forbidden to go under the transmission when it has been lifted by a jack or similar.

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

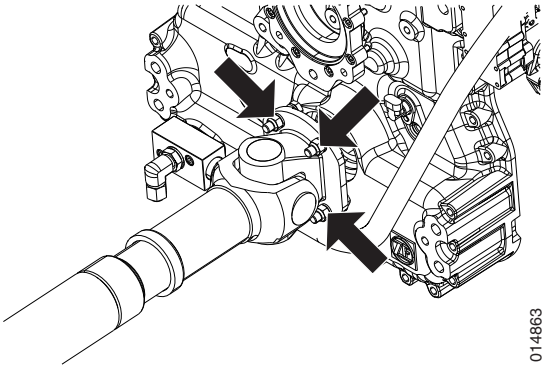
2 Remove the propeller shaft from the transmission.

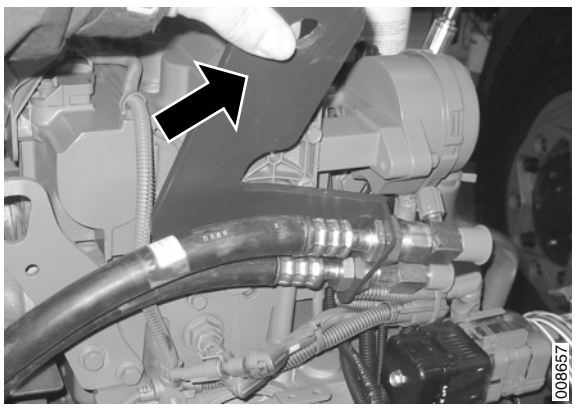
3 Depressurise the system, see section *B Safety*.

4 Detach relevant hoses and cables before separating engine and transmission.

NOTE

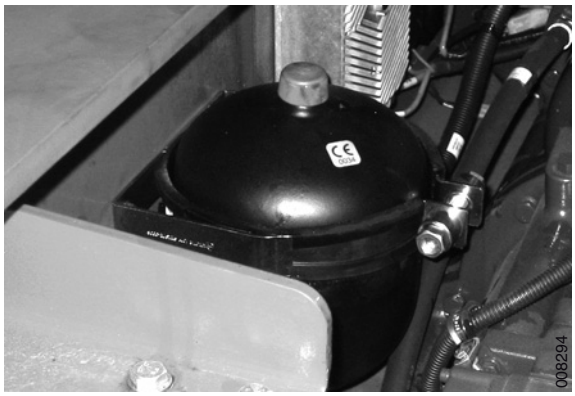
Drain and collect liquids before detaching hoses.



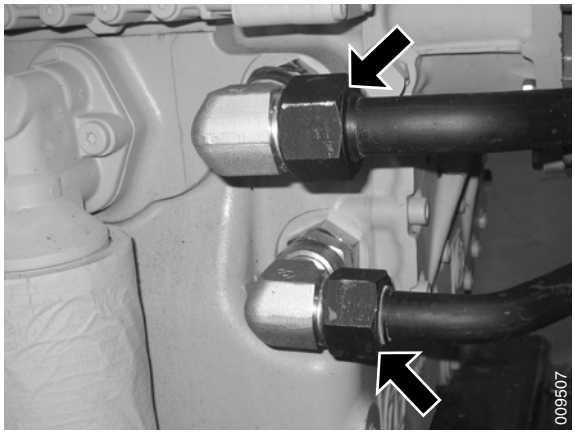


- Undo the hose bracket from the rear of the transmission, tie the bracket up so that the hoses are not damaged.

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- Undo the accumulator and hang it on one side without undoing the hoses.



- Undo the oil pipes to the bypass valve, from the transmission left- hand side without undoing the hoses from the valve.

NOTE

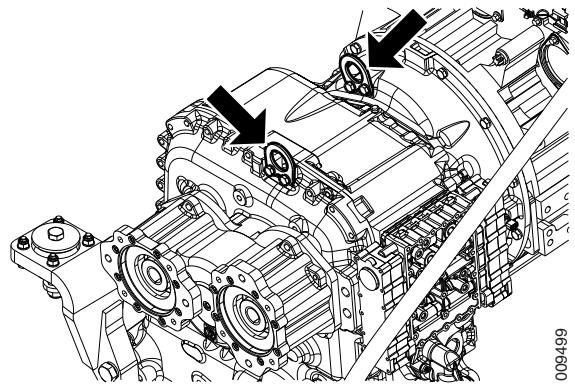
Plug all connections immediately to protect the hydraulic system from impurities.



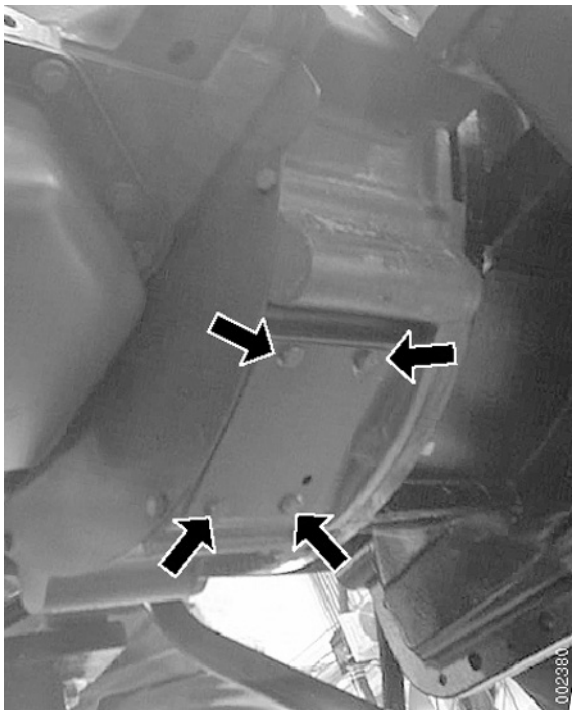
Silencer bracket

- Undo the silencer to make it possible to get access to the flexible plate.

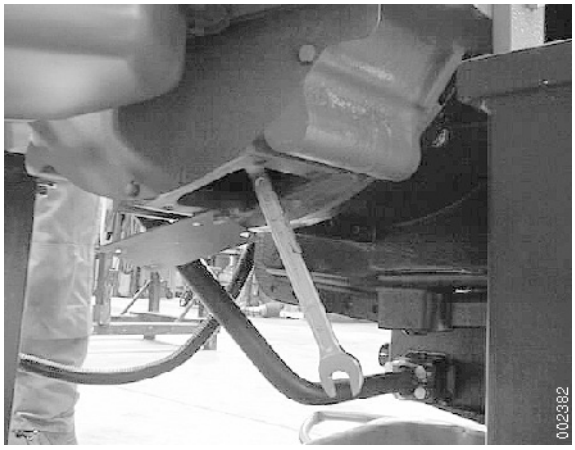
5 Fix the transmission to a lifting device.



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6 Remove the screws that holds the cover plate underneath the flywheel housing.



7 Remove the screws for the flexible plate through the hole under the cover plate.

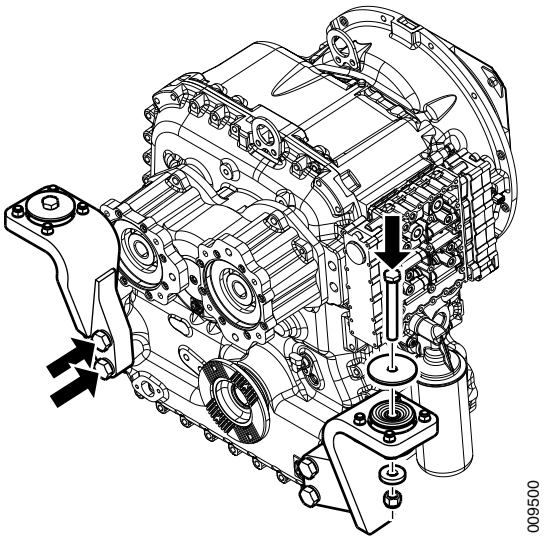
NOTE

Turn the engine for each screw to be removed from the flex plate.

8 Support the engine from underneath with a jack or equivalent.

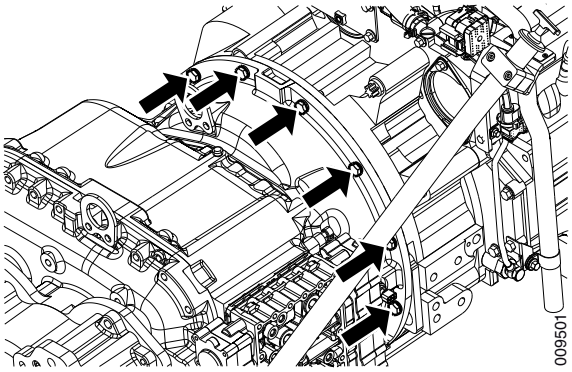
NOTE

Secure the diesel engine so that it does not tip over when the transmission is removed.

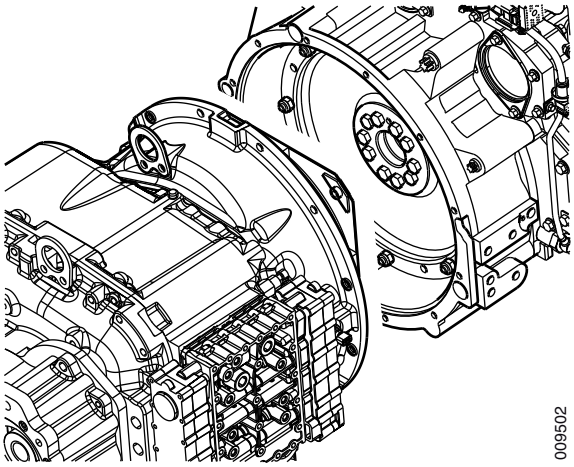


9 Undo the transmission mountings from the transmission on both sides, leave it in place on the right side of the frame and remove the left side.

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10 Remove the bolts holding the transmission and engine together.



11 Carefully separate the transmission and engine.

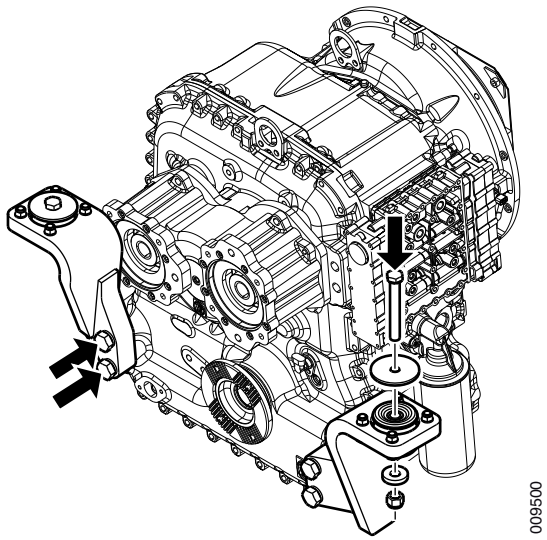
NOTE

If the flexible plates are damaged during an transmission change, they must also be replaced.

NOTE

Beware of balance before the transmission is lifted.

12 Remove the transmission.



Assembly

13 Move the transmission mounting over to the new transmission, tighten to a torque of **390 Nm**.

14 Transfer the hydraulic pumps from the old transmission to the new one, see section *10 Common hydraulics, group 10.4 pumps.*

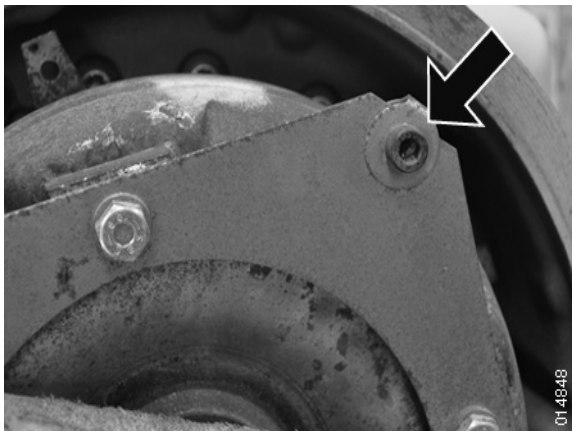
https://truckmanualshub.com/



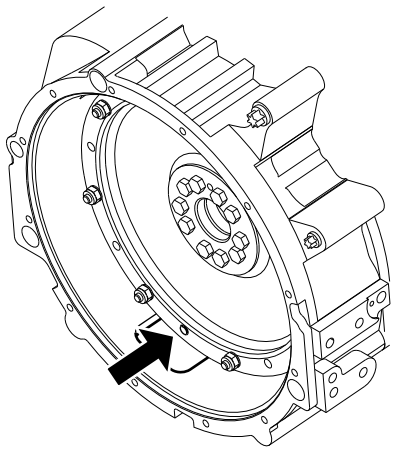
15 Put two studs into the flywheel housing as a guide when the transmission is installed.



16 Grease the torque converter connection, both on the Diesel engine and on the transmission.

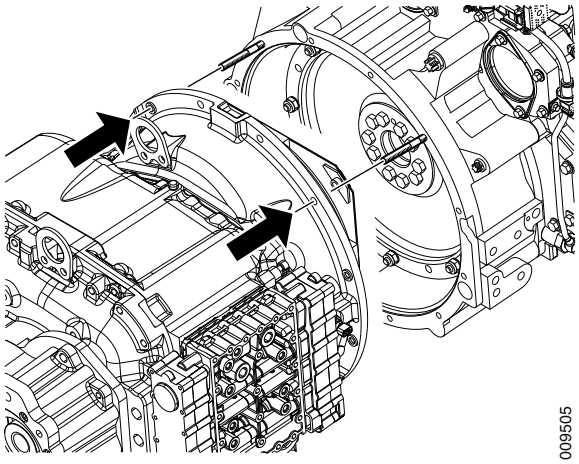


17 Check that the clips are aligned directly over the holes in the flex plate.



18 Align one of the holes on the flywheel so that it is centred on the hole in the flywheel housing

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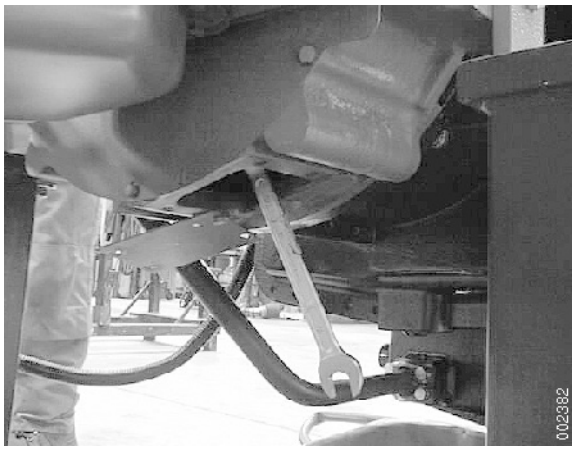

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19 Lift the transmission into place, make sure that the studs on the flywheel are aligned in the right position so that they do not damage the flex plate.

NOTE

If the flexible plates are damaged during an transmission change, they must also be replaced.

20 Install the screws which fix the transmission and engine, but do not tighten the screws fully. Leave about a millimetre between the engine and transmission, to facilitate installation of the screws for the flexible plate/flywheel.


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21 Install the screws which hold the flexible plate to the flywheel in two stages. Do not tighten the nuts in the first stage.

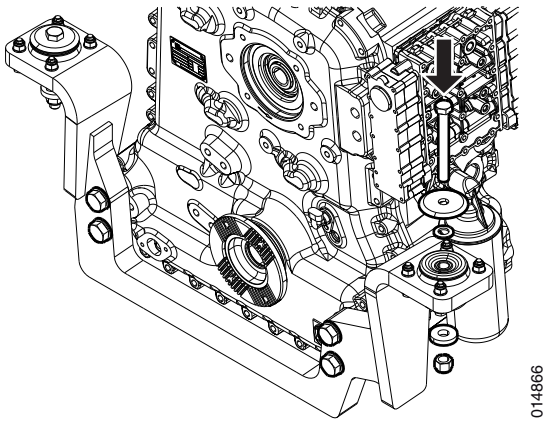
NOTE

The diesel engine must be undone from the engine mountings and from the transmission to remove a dropped nut. Secure the nut in the socket during installation.

22 Tighten the screws which fix the transmission and engine.

23 Rotate the flywheel a further rotation and torque the screws which hold the flexible plate to the flywheel to **46 Nm**.

24 Measure and check that the transmission is centred in the frame.


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25 Screw the transmission to the transmission mountings (Tighten to a torque of **135 Nm**), put the cover plate and propeller shaft back.

26 Remove the hoisting equipment from the transmission.

27 Remove the jack from underneath the engine.

28 Put back the silencer and other equipment. Installation is in reverse order.

29 Attach relevant hoses and cables to the transmission. Check fluid levels and top up as necessary.

30 Calibrate the transmission, see *Calibration for ZF, description page 77*.

NOTE

That clutch-linings will be destroyed if forklift is operated before calibration have been done.

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2.1 Controls and instruments

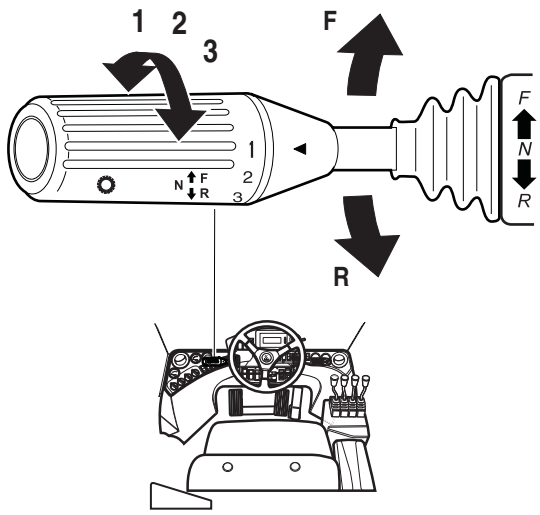
2.1.6 Gear and direction of travel selector

Gear and direction of travel selector, description

Main communication with the operator takes place with the gear selector. It makes it possible to select travel direction and shifting range. The gear selector's output signal functions as an input signal for ECU790.

ECU793 is receiving gear and travel direction via CAN bus from vehichle control system. The gear selector can be of other brands and combined with additional gear selectors on other location in the cabin depending on model and options selected. Same shift pattern and electrical interface must be fulfilled if change to other brand or model, please contact Cargotec for more info.

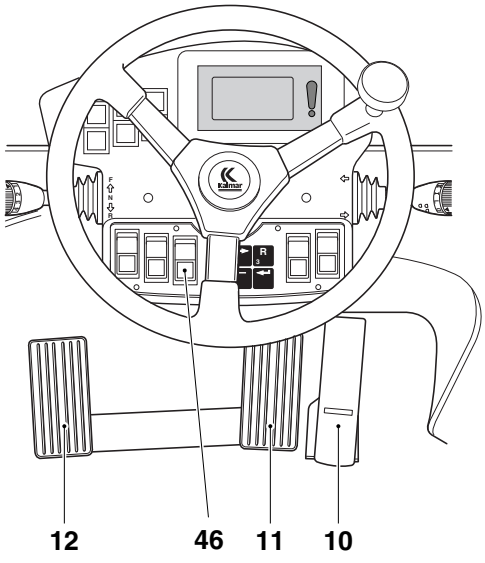
Note that ECU793 supports remote control via the CAN-bus, according to a proprietary CAN J1939 protocol.



Gear and direction of travel selector

2.1.7 Inching

Inching, description



10. Accelerator pedal
11. Brake pedal
12. Brake pedal

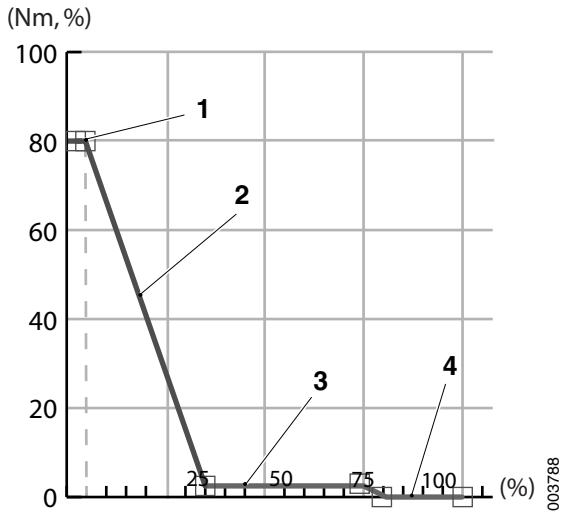
46. Inching enable switch (S1039) ⊞

The brake pedal (11 and 12) is equipped with a brake pedal angle sensor and a inching enable switch in the steering wheel panel (46).

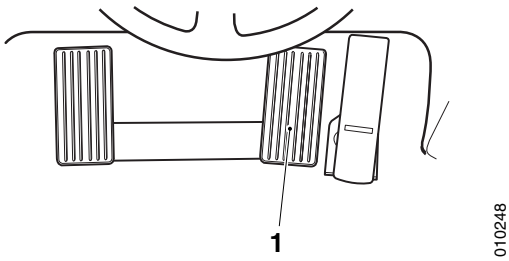
The brake pedal has a declutch function resulting in transmission neutral stand by mode if brake pedal is depressed around 50-60%. transmission controller ECU793 will maintain a standby clutch pressure on Fwd or Rev until brake pedal is released or gear lever is moved to neutral. This will speed up the engagement of gear Fwd or Rev and help the driver to work more efficient.

Inching involves a slipping mode which makes it possible to use the hydraulic functions with a gear engaged.

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Torque depends on pedal position
1. No inching
2. Variable speed
3. Lowest speed
4. Clutch release.



.
1. Inching Potentiometer brake pedal (R690) (behind brake pedal) ⊕.

When inching is activated and the brake pedal is depressed, transmission changes over to inching mode. Speed can be controlled by moving the brake pedal up and down in connection with high engine speed. This facilitates precision operation at low speed while power is released to the working hydraulics.

Inching potentiometer brake pedal, replacement

1. Machine in service position, see section *B Safety*.
2. Remove the two screws securing the bracket and potentiometer to the pedal rack.
3. Unplug the connector from the potentiometer.
4. Remove the two screws securing the potentiometer to the bracket.
5. Replace the potentiometer.
6. Fit the reverse order.
7. Calibrate the new potentiometer, for Dana see Section *8 Control system*, group *8.5.1 ETC-Electronic Throttle Control (electronic throttle) and for ZF group 8.5.2 Automatic shifting.*

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2.2 Torque converter/Clutch system

2.2.1 Flex plates

Flex plates (transmission alternative Dana TE13000/17000), replacement

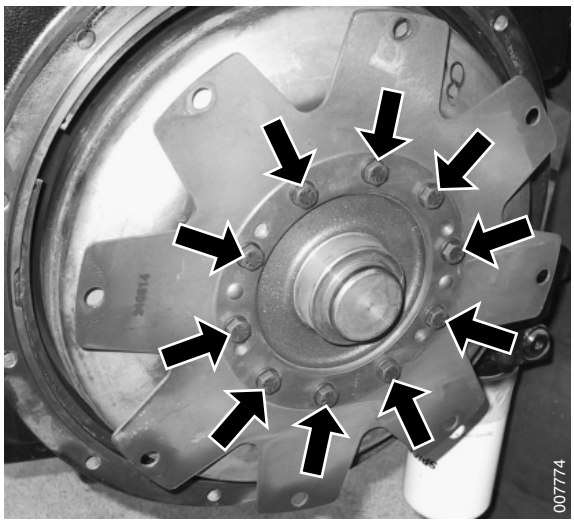
1 Machine in service position, see section *B safety*.

2 Remove the transmission, see *Transmission Dana TE13000 or TE17000, replacement (engine alternative Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE) page 14* or *Transmission Dana TE13000 or TE17000, replacement (engine alternative Caterpillar C6.6 and Cummins QSB6.7) page 21*.

3 Remove the bolts holding the flexible plate to the transmission.

4 Replace the flexible plate, torque the bolts holding the flexible plate to the transmission to **40 - 50 Nm**.

5 Reinstall the transmission, see *Transmission Dana TE13000 or TE17000, replacement (engine alternative Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE) page 14* or *Transmission Dana TE13000 or TE17000, replacement (engine alternative Caterpillar C6.6 and Cummins QSB6.7) page 21*.



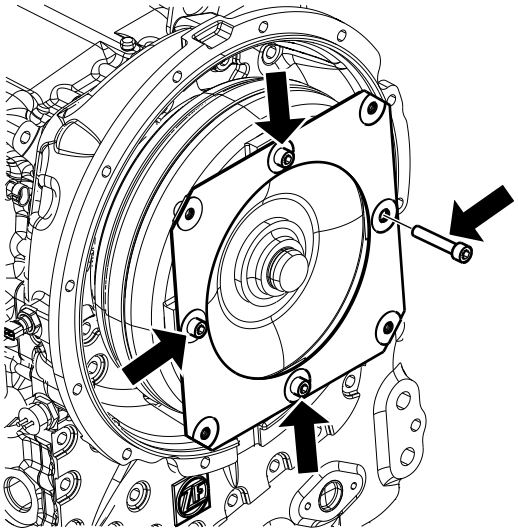
Attachment of flex plate.

Flex plates (transmission alternative ZF 3WG161), replacement

1 Machine in service position, see section *B safety*.

2 Remove the transmission, see *Transmission ZF 3WG161, replacement (engine alternative Volvo TAD650VE and TAD660VE) page 29*.

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Attachment of flex plate.

3 Remove the bolts holding the flexible plate to the transmission.

4 Replace the flexible plate, install washers between converter and flexplate under the hexagon screws.

NOTE

Lock the hexagon screws with Loctite (Type No. 262)!

Torque the hexagon screws holding the flexible plate to the converter to **115 Nm**.

5 Reinstall the transmission, see *Transmission ZF 3WG161, replacement (engine alternative Volvo TAD650VE and TAD660VE) page 29*.

6 Calibrate the transmission, see *Calibration for ZF, description page 77*.

2.2.6 Switch normally closed (NC), disengagement

Switch normally closed (NC), disengagement, description

See section *4 Brakes*, group *4.3.7 Switch normally closed (NC), disengagement*.

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2.6 Lubrication system

Lubrication system, description

The transmission lubricating system has the following function:

- Lubricate gear wheels and bearings
- Apply the clutches in the transmission
- Cool down the torque converter and transmission
- Clean the oil of any impurities with oil filter.

During operation of the engine, the oil pump draws oil from the transmission oil sump through a strainer, and then pumps it through the oil filter to a control valve.

The control valve provides oil at the correct pressure to the transmission valve housing to activate the clutch plates for FORWARD or REVERSE and gear 1, 2 or 3. The clutch plates require just a small amount of the oil flow supplied by the pump. The remaining oil flow is pumped through the torque converter circuit to the oil cooler and returns to the transmission for lubrication.

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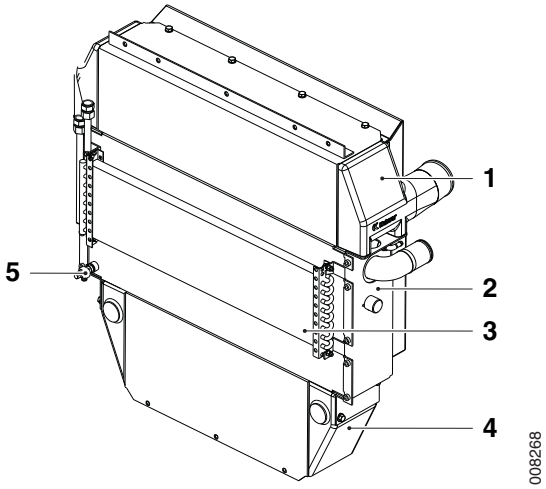
2.7 Cooling system

2.7.3 Oil cooler

Oil cooler, description

The transmission oil is cooled in the lower section of the cooler assembly.

A temperature controlled bypass valve, which only acts on the cooling circuit for transmission oil, is located on the transmission on the left-hand side. The valve closes when oil starts to reach operating temperature. In this way the oil reaches operating temperature more quickly.



1. Radiator intercooler
2. Radiator engine coolant
3. Fuel cooler
4. Cooler transmission oil
5. Drain nipple for coolant

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2.8 Transmission control system

Transmission Control system for Dana, description

Dana Spicer Off Highway TE13/17 is an electronic Powershift transmission that handles manual and automatic shifting modes in combination with inching or hydrostatic simulation, so called OptimumDrive that uses one pedal drive mode.

The transmission controller reads different sensors located on the transmission housing and valve block and receives information on CAN-bus from vehicle controller and controls the electric solenoid valves to give the vehicle a suitable tractive effort depending of driving situation.

ECU 793 is an advanced programmable control unit, with FLASH memory, used to control shifting in DANA TE series electronically modulated transmissions with torque converter, so-called ECM technology. ECM means “Electronic Controlled Modulation” and refers to a control technology which directs clutch engagement pressure via electronically controlled proportional valves to the gear packages in the transmission.

ECI means Electronic Controlled Inching and is a feature of ECM transmissions together with ECU793 that makes it possible for the vehicle to move at speeds independent of the engine's rpm.

ECU 793 handles all transmission-related functions to obtain high shifting quality and reliability. Also, it can control the engine's rpm and, in certain application, the service brake.

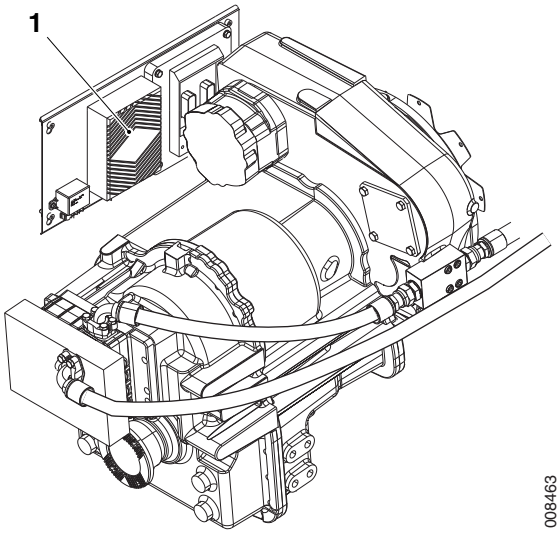
The integrated self-test and diagnostic functions make fast troubleshooting possible. Integration in the vehicle's electrical system is simple and consists mainly of connections between ECU793, power supply, CAN bus, rpm sensors, and the transmission.

ECU 793 contains software (programs) for manual and automatic shifting as well as electronic inching and hydrostatic simulation (OptimumDrive). Drive disengagement and reversing lock are standard on all TE13 and TE17 transmissions.

Transmission Control system for ZF, description

ZF 3WG161 is an electronic Powershift transmission and has 3 speed forwards and reverse, with electronically controlled clutch plates. The transmission has functions for manual shifting, automatic shifting and electronic inching via the brake pedal as an option. Monitoring and reverse interlock are standard.

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1. ECU 793

2.8.1 Transmission control unit (ECU 793)

Transmission control unit (ECU 793) for Dana, description

ECU 793 is an electronic unit for the TE13000 and TE17000 transmissions, which controls and monitors the shifting function.

ECU 793 is located in the engine compartment beside the transmission.

Functions of KCS:

- Manual shifting
- Automatic shifting
- Electronic inching
- OptimumDrive (hydrostatic simulation)

The control unit receives control values from:

1. Speed sensors such as engine speed, turbine speed, drum speed and output speed.
2. Temperature sensors from torque converter output to cooler and oil sump.
3. Oil pressure switch located in transmission valve block.
4. Vehicle controller information on CAN-bus

ECM valve /ECU793 safety implementation

The control valve concept guarantees fail to Neutral in case of loss of power through use of a redundant normal open Drive solenoid. A pressure switch that measures the system pressure after the Drive solenoid can monitor its function.

These properties are used in the ECU793/APC200 to implement the safety concept.

ECM requires that 2 clutches can be pressurised simultaneously. Normally the pressure in 1 clutch is increasing while the pressure in the other clutch is decreasing. If the overlap is not carefully monitored, one can achieve a situation in which clutch 1 is closed while clutch 2 is not opened yet. This situation is called “locking clutches.” The result is that the transmission stops instantly. The ECU793 software deals with potential problems related to this by continuously monitoring relations between and changes in various speed signals.

All faults described below refer to electrical connections. The ECU793/APC200 is in no way capable of detecting mechanical problems on its input and output devices except indirectly by analysing the speed signals.

The ECU793/APC200 monitors its inputs and outputs in order to detect internal and external faults.

Due to hardware limitations, fault monitoring is not always possible. The detection principles and their limitations are described wherever applicable.

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All detected faults are reported within 0.3 seconds, but only safety critical faults are acted upon.

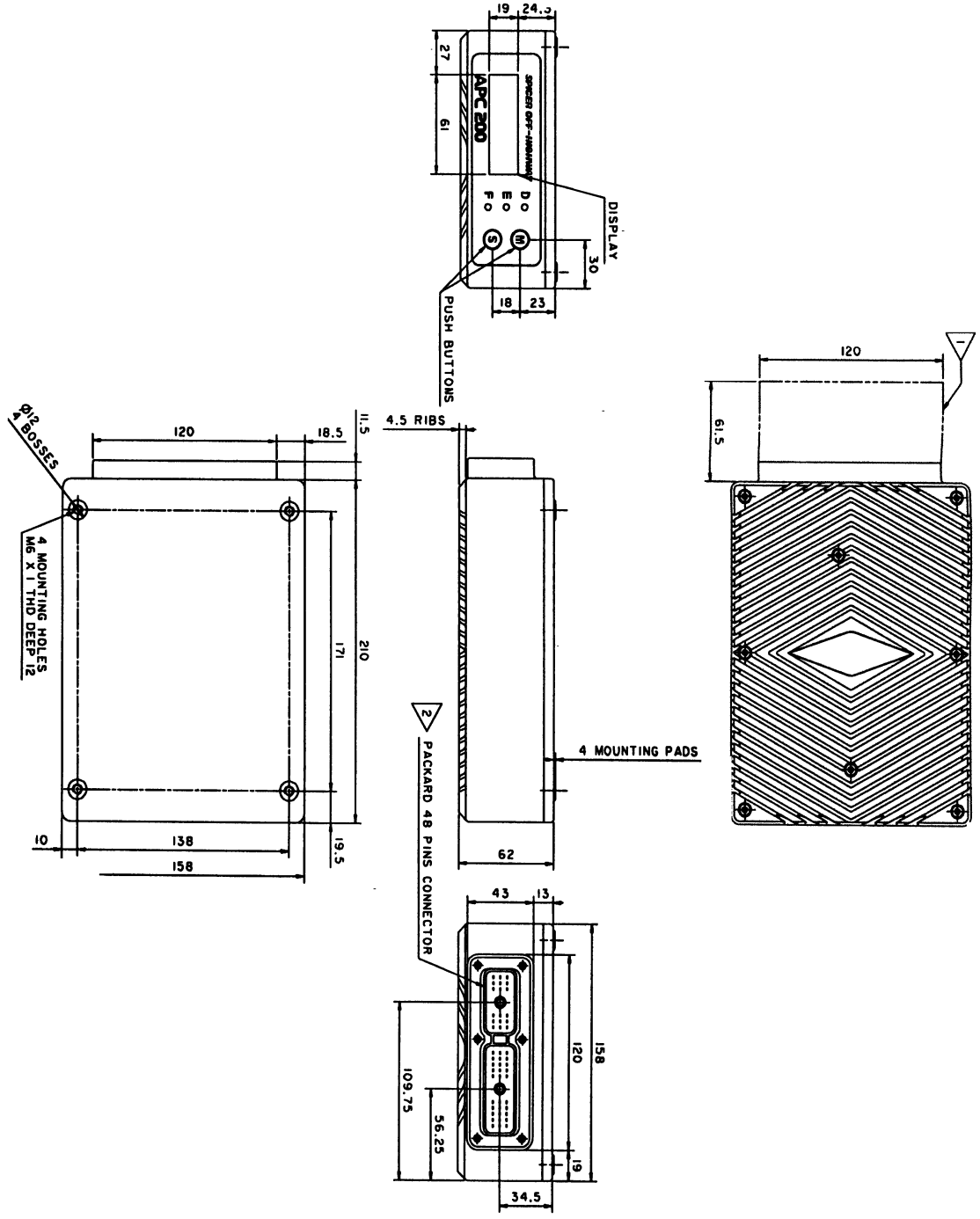
Faults resulting in loss of drive are tolerated.

Faults resulting in unwanted clutch engagement result in immediate selection of Neutral using one of two available redundant shutdown methods. Depending on the severity, this reaction can be permanent (until power is switched off) or last until the fault is removed.

Some faults are tolerated but the performance of the system is crippled when the fault persists.

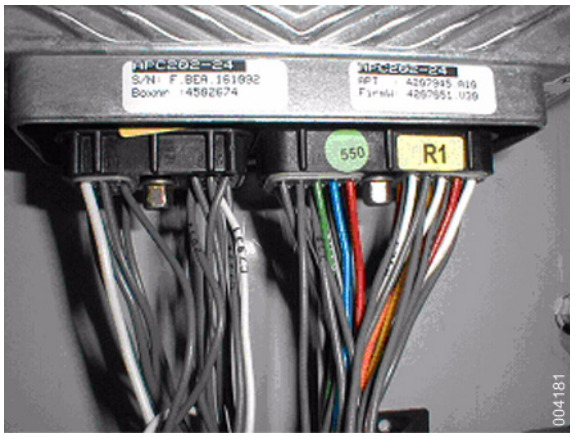
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Installation in machine



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ECU793 (APC200), replacement



1 Machine in service position.

2 Remove the ECU by:

- Unscrew connectors R1 and R2 from the ECU
- Lift the fixing plate away from the engine compartment and unscrew the 4 screws which hold the ECU. Please refer to the illustration.

3 Install the new ECU in the reverse order, in accordance with items 1-2.

NOTE

Make sure that the replacement ECU has the correct part number.

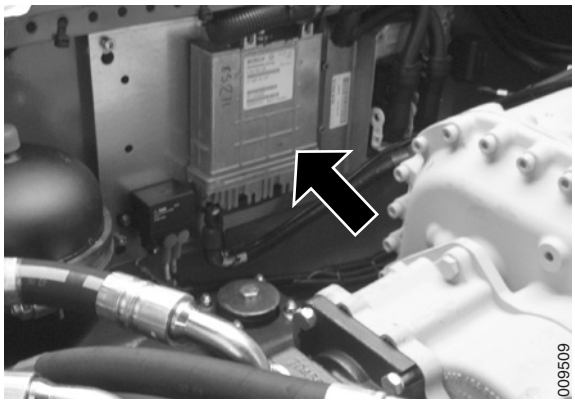


NOTE

Picture to the left shows a diagnostic connector located in the wiring harness in the chassis close to transmission controller that can be used for reprogramming the ECU793 unit if correct spare part controller is not available.

Contact Cargotec service dealer.

Transmission control unit (ECU 793) for ZF, description



ECU 793

ECU 793 is an electronic unit for the ZF transmission, which controls and monitors the shifting function.

ECU 793 is installed in the frame, inside the right frame rail next to Control unit engine (ECU794). The cables are connected to the transmission sensors and valve block, and directly up to the cab and distribution box. Since the CAN bus is largely used for signal transfer, the cable harness is relatively small, with few cables. A diagnostic plug (x201m) is prepared in the cable harness, for programming the ECU 793 if needed.

- The control unit has the following inputs and outputs:
  - 13 digital inputs, active high (ED)
  - 2 digital inputs, active high (EV)
  - 2 frequency inputs for active sensors (EF)
  - 3 frequency inputs for inductive sensors (EF)
  - 2 voltage inputs for power supply (EU)
  - 2 resistance / temperature inputs (ER)
  - 2 digital inputs, prepared for diagnostics (ER)

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- 8 digital outputs, sinking (ADM)
- 8 current outputs, PWM, sinking (AIP)
- 1 sensor, power supply (AU)
- 2 central valve supply outputs (VPS)
- 1 diagnostic channel ISO (SDDI)
- 2 CAN bus channels 2.0B (CAN1/2)
- 2 high-speed communications buses (SDI1-2)
- 1 speed output for the instrument (SD4)
- 1 programming input, voltage (EUPR)

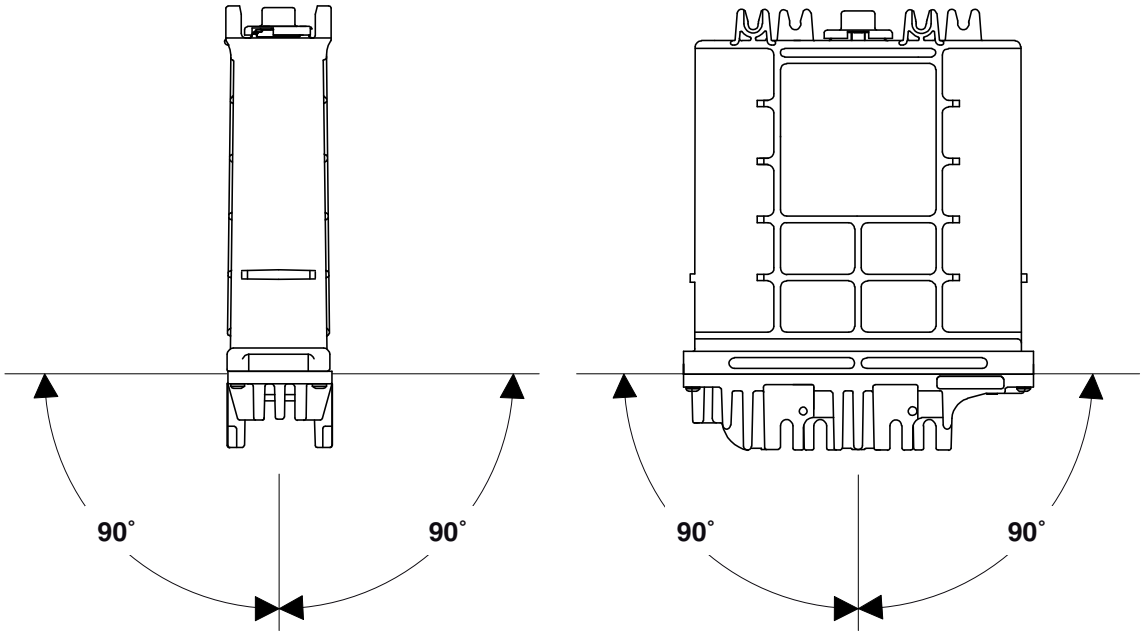
- The control unit
  - has been developed for working vehicles with a 24 V electrical system.
  - all inputs, outputs and interfaces are short-circuit proof to both ground and battery voltage.
  - have a safety and monitoring module with a microprocessor and “watchdog” circuit.
  - have a diagnostic facility (ISO compatible) for all inputs, outputs and power supplies, as per the system description.
  - have a non-volatile memory for diagnostics and adaptive functions.
  - Programming of data sets in a sealed control unit with encapsulation class IP66K, where the non-connected terminals in the connector are sealed.

The control unit receives control values from:

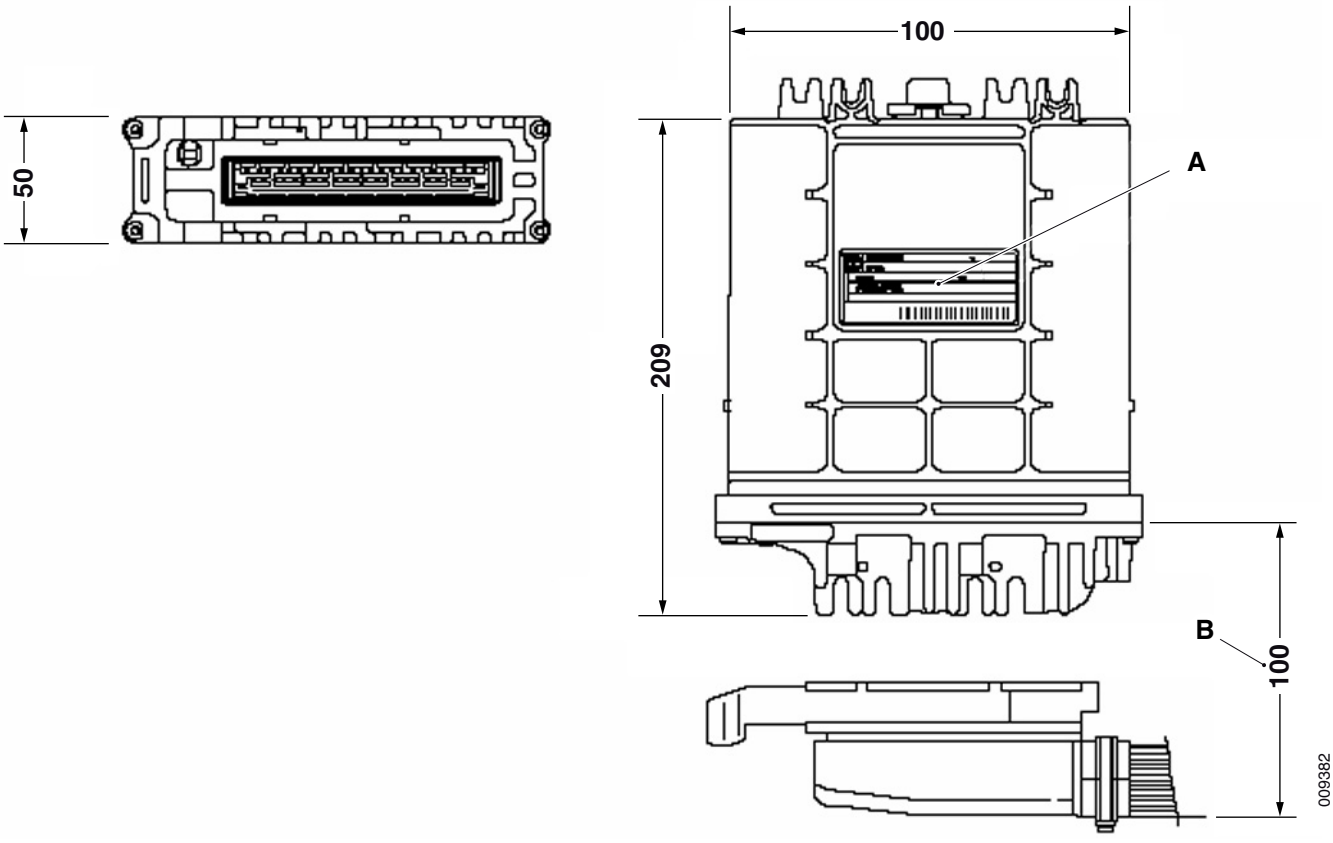
1. Gear selector on CAN-bus.
2. Functional configuration values on CAN-bus from vehicle controller.
3. Brake pedal with analogue position sensor (potentiometer) supplies control value (V) to the analogue input on ECU790 and sent to ECU793 on CAN-bus. The position sensor is active in inching mode for slow speed manoeuvre and when inching switch is off for declutch function at approx. 35% depressed brake pedal.

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Installation in machine



ECU793 installation position



ECU793 installation dimensions

A. ZF type plate

B. Minimum distance for disconnecting connector

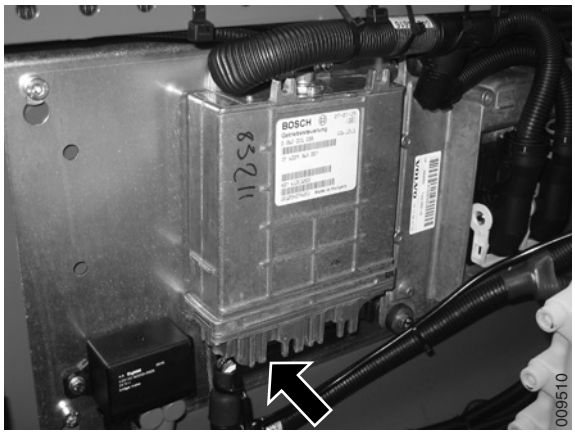
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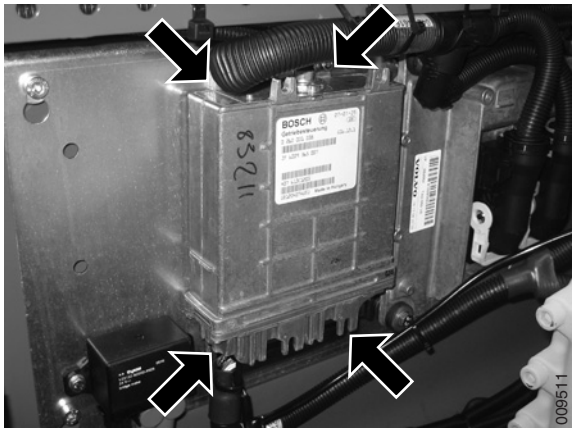
ECU793, replacement

1 Machine in service position.

2 Remove the ECU by:

– Disconnecting the connector from the ECU.





– Unscrew the 4 screws which hold the ECU and lift the ECU away.

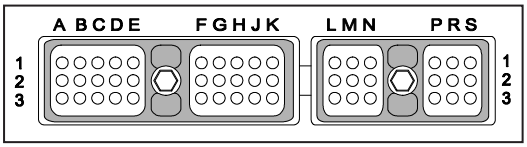
3 Install the new ECU in the reverse order, in accordance with items 1-2.

NOTE

Make sure that the replacement ECU has the correct part number.

2.8.1.1 Connectors

Connectors for Dana, description



Connectors, seen from the cable side.

Wire	Wire Dana	Pin	Name	Function
4404	A1	A1	PPWR	Supply voltage 18 - 32 V
P33	A2	B1	VFS0+	Analogue output 0 +/ Fwd VFS Hi
P34	A3	C1	VFS0-	Analogue output 0 -/ Fwd VFS Lo
P31	A4	D1	VFS1+	Analogue output 1 +/ 2nd VFS Hi
P32	A5	E1	VFS1-	Analogue output 1 -/ 2nd VFS Lo

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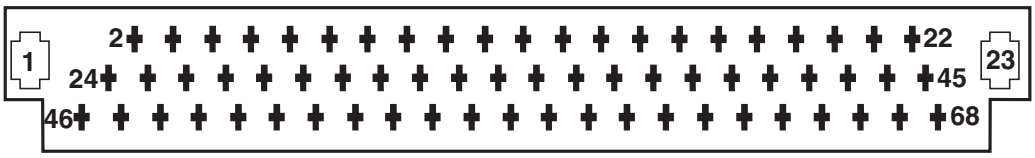
Wire	Wire Dana	Pin	Name	Function
P37	A6	F1	VFS2+	Analogue output 2 + /Rev VFS Hi
P38	A7	G1	VFS2-	Analogue output 2 -/ Rev VFS Lo
P35	A8	H1	VFS3+	Analogue output 3 +/ 1st/3rd VFS Hi
P36	A9	J1	VFS3-	Analogue output 3 -/ 1st/3rd VFS Lo
P39	A10	K1	DO0	Discrete high level output/ RSP Drive Solenoid +
P311	A11	A2	ANI0	Resistive input 0 – 5 kOhm
	A12	B2	DIGIN0	Discrete high side input/Shift lever 1-2
	A13	C2	DIGIN1	Discrete high side input
	A14	D2	DIGIN2	Discrete high side input
	A15	E2	DO1	Discrete high side output
P313	A16	F2	DO2	Discrete high side output/ Pressure feedback sensor
	A17	G2	DIGIN3	Discrete high side input
	A18	H2	DIGIN4	Discrete high side input
	A19	J2	DIGIN5	Discrete high side input
P310	A20	K2	DO3	Discrete low side output/RSP Drive Solenoid -
4401	A21	A3	GND	Battery negative
R1B3	A22	B3	SS0+	Speed sensor input 0 +/Drum speed
R1C3	A23	C3	SS0-	Speed sensor 0 Gnd/ Drum speed
R1D3	A24	D3	SS1+	Speed sensor input 1 +/ Output speed
R1E3	A25	E3	SS1-	Speed sensor 1 Gnd/ Output speed
R1F3	A26	F3	SS2+	Speed sensor input 2 +/ Engine speed
R1G3	A27	G3	SS2-	Speed sensor 2 Gnd/Engine speed

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Wire	Wire Dana	Pin	Name	Function
R1H3	A28	H3	ANI1	Resistive input 0 – 5 kOhm/ Transmission temp
R1J3	A29	J3	ANI2	Voltage input 0 – 5V/Converter out temp
R1K3	A30	K3	SGND	Signal ground
	B1	L1	PWM4 +	
R2M1	B2	M1	REF5V	Voltage reference output 5V
	B3	N1	PWM5 +	
	B4	P1	ANI5	Voltage input 0 - 5V
448A	B5	R1	PWM6 +	PWM output/Brake Valve
	B6	S1	ANI6	Voltage input 0 - 5V
C793 A	B7	L2	CANL	CAN High (+)
C793 B	B8	M2	CANH	CAN Low (-)
2012	B9	N2	RXD	RS232 RXD
2013	B10	P2	TXD	RS232 TXD / SPEEDO OUT
R2R2	B11	R2	SS3+	Speed sensor input 3 +/ Turbine speed
4402	B12	S2	SPWR	Switched battery plus
	B13	L3	DIGIN6	Discrete high level input/Declutch/Inching enable
	B14	M3	DIGIN7	Discrete high level input/ Manual/Auto
	B15	N3	DIGIN8	Discrete high level input/ Parking Brake
	B16	P3	DIGIN9	Discrete high level input/Max Speed 2
BK	B17	R3	ANI3	Voltage input 0 - 5 V/Lift pressure
4403 A	B18	S3	VFS-GND	Power ground (Battery minus)/VFS Ground

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Connectors for ZF, description



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Connectors, seen from the cable side.

Terminal	Function	Description	Connection machine
1	Supply ground 1	VM1	Battery 0V
2	Supply ground 2	VM2	Battery 0V
3	Supply ground sensor 1	VMG1	Speed sensor B2 and B3, 0V
4	Supply ground sensor 2	VMG2	Speed sensor B4, 0V
5	Output digital sink 4	ADM4	
6	Output digital sink 3	ADM3	
7	Output digital sink 2	ADM2	
8	Supply peripherals switchable 2	VPS2	
9	Output current 5, active low	AIP5	Current valve KR, reverse, max 532mA
10	Output current 2, active low	AIP2	Current valve KB, gear 2, max 532mA
11	Output digital sink 6	ADM6	
12	Supply peripherals switchable 1	VPS1	Digital out valves, max 5,5A
13	Supply peripherals switchable 1	VPS1	Digital out valves, max 5,5A
14	Communication interface 1	SD1	ZF display communication
15	Diagnosis interface communication	SDDK	Diagnostics switch
16	Input frequency 5	EF4	
17	Input resistance / switch diagn. 3	ER3	
18	Input programming voltage	EUPR	Programming/Calibration
19	Input frequency 1	EF1	
20	Input digital 3	ED3	
21	Input digital 10	ED10	
22	Input digital 7	ED7	
23	Supply positive “Term. 30" 1	VPE1	Battery 24V, “30” voltage
24	Supply ground analogue sensor 1	VMGA1	
25	Full CAN1 high	CAN1-H	CAN-H
26	Full CAN1 low	CAN1-I	CAN-I
27	Full CAN1 circuit termination resist.	CAN1-T	
28	Shield	VGS	
29	Input digital 11	ED11	

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Terminal	Function	Description	Connection machine
30	Input digital 12	ED12	
31	Input digital 13	ED13	
32	Output current 3	AIP3	
33	Output digital sink 8	ADM8	
34	Output digital sink 7	ADM7	
35	Input digital EV1	EV1	
36	Output speed signal	SD4	
37	Output sensor supply 1	AU1	
38	Input voltage 1	EU1	
39	Input resistance/temperature sensor 1	ER1	
40	Input resistance / switch diagn. 4	ER4	
41	Input frequency 2	EF2	Turbine speed
42	Input frequency 3	EF3	Internal gear ratio speed
43	Input digital 4	ED4	
44	Input digital 8	ED8	
45	Supply positive “Terminal 15"	VPI	24V ignition switch, “15” voltage
46	Supply ground analogue - sensor 2	VMGA2	Temperature sensor 0V
47	Full CAN2 high	CAN2-H	
48	Full CAN2 low	CAN2-L	
49	Input resistance/temperature sensor 2	ER2	Temperature sensor signal
50	Output current 7, active low	AIP7	Current brake valve, max 1,2A
51	Output current 6	AIP6	
52	Output digital sink 1	ADM1	
53	Supply peripherals switchable 2	VPS2	Digital out brake valve, max 5,5A
54	Output current 8	AIP8	
55	Output current 4	AIP4	Current valve KV forward, max 532mA
56	Output current 1	AIP1	Current valve KA gear 1, max 532mA
57	Output digital sink 5	ADM5	
58	Supply peripherals switchable 1	VPS1	
59	Input digital EV2	EV2	
60	Communication interface 2	SD2	
61	Input voltage 2	EU2	
62	Input frequency 4	EF4	Output shaft speed
63	Input digital 1	ED1	

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Terminal	Function	Description	Connection machine
64	Input digital 5	ED5	
65	Input digital 2	ED2	
66	Input digital 9	ED9	
67	Input digital 6	ED6	
68	Supply positive, “Terminal 30" 2	VPE2	Battery 24V, “30” voltage

2.8.1.3 Suitable connectors

Suitable connectors, description

See Spare parts catalogue.

2.8.2 Cable harness transmission

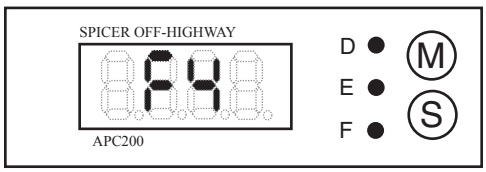
Cable harness transmission, description

The sensors located on the transmission sends signals to the control unit ECU 793 via a cable harness. The cable harness runs through a cable duct where the transmission and engine are jointed and on to ECU 793 (in engine compartment) along the frame.

See section *E Schematics*.

2.8.3 Display and menus

Display and menus for Dana, description



APC200 front panel display

The display us on the front panel of the APC200 and consists of:

- Four 7-segment red LED digits.
- Three LED status lights. D (yellow, indicates test mode), E (yellow, indicates error) and F (red, lights up when control unit restarts).
- Two scroll buttons (M, S) to navigate in the menu options.

After power up, the display defaults to the last display mode (if the display mode was not the error display) selected when the controller was last powered down. Typically, this will be the gear position mode. In this mode, the centre left digit shows the actually

engaged direction and the centre right digit shows the currently engaged range (gear).

Pressing the 'M' switch changes the displayed information group, while pressing the 'S' button selects the item within the group.

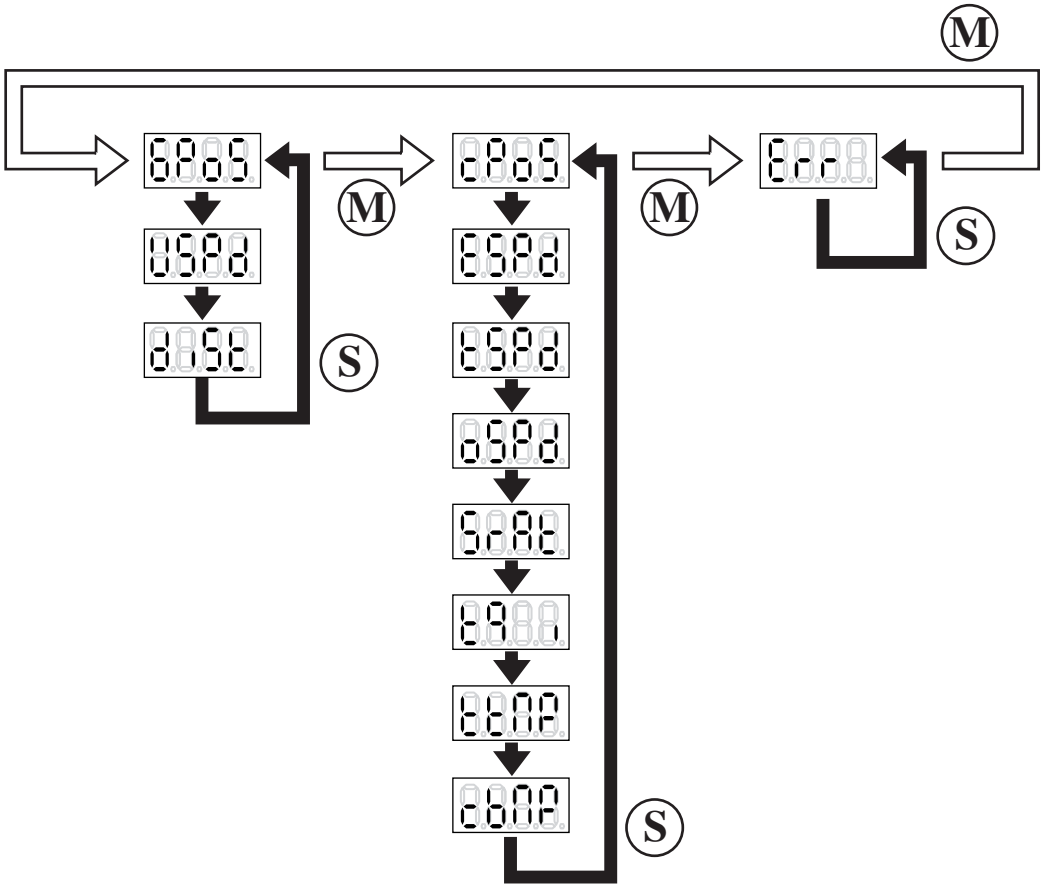
While pushing the switch (and about 0.5 seconds after it is released) the display shows which information is about to be displayed.

There are 3 display groups: the most commonly used one allows to switch between gear display, vehicle speed and travelled distance display.

The second group shows the shift lever position and some other less used but nevertheless quite relevant values (see below).

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The third display accessed with the M-button isn't actually a group of screens but is used to inform you about any current or previously active errors. The display normally shows '— — 'to indicate there are no faults, but if one or more faults are (or have been) detected, the most severe one is shown until you press the 'S' - button. Doing so reveals the next error until no more errors are present, at which time again the '— — 'sign is shown.



Menus

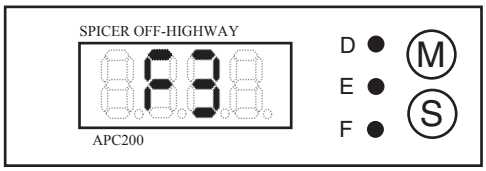
Select menu with "M" to scroll through the main menus, and "S" to scroll through the sub-menus.

GPOS	Reflects the actually engaged transmission direction and range.
VSPD	Shows vehicle speed in km/h or MPH (parameter setting). Speeds are shown with a 0.1km/h or 0.1 MPH resolution.
DIST	Shows the distance travelled in km or in miles (parameter setting). Distance is shown with a 0.1 km or 0.1 mile resolution. To reset this display, the "S" –button has to be pressed and keep it pressed during 3 seconds, when this display is selected.
CPOS	Reflects the current shift lever direction and position.

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TSPD	Shows measured turbine speed (RPM).
ESPD	Shows measured engine speed (RPM).
OSPD	Shows measured output speed (RPM).
SRAT	Reflects the current speed ratio (calculated as TSPD/ESPD [turbine speed /engine speed]) and is an important factor in automatic shifting.
TQ1	Measured torque at transmission input side (Nm)
TTMP	Shows transmission temperature in °C or °F (parameter setting).
CTMP	Shows cooler input temperature in °C or °F (parameter setting). **NOTE** *A temperature-controlled on/off switch is used as the sensor. 50 on the display means below 120 C (“Limp-home”, 50% speed). 150 on the display means over 120 C (“Stop”, 0 speed).*
ERR	Error display. When a malfunction occurs, the “E”-diode flashes on the display. From the “Err” main menu, it is possible to scroll through an error list with the “S”-key. Existing error codes (un-corrected errors) are displayed non-flashing. Old error codes (corrected errors) flash. When no errors remain, two dashes are shown on the display. Press “S” to return to the top of the error list.

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001111

Display and menus for ZF, description

Operation information and menus are shown in the display on the steering wheel panel.

Operating mode for Dana, description

Normal operating mode

Travel direction and gear position provide the control unit with input values. Travel direction and gear position are normally shown on the display.

The E-light on the display flashes in case an error occurs. For trouble-shooting, see *Troubleshooting and error codes, description page 58*.

Diagnostics

Diagnostics is activated by pressing the S-key on the unit's panel when the control unit becomes active (key in position I in the ignition switch).

For more information about the diagnostics, please refer to *Diagnostics for Dana, description page 71*

Limp-home

Limp-home occurs under the following conditions:

1. If an error is indicated for an output value from the control unit.
2. If an error is indicated for the engine speed sensor.
3. 1If two of three speed sensors do not function.

If any of the above conditions is in question, neutral gear is selected automatically.

To continue operating the machine, select neutral position and then a suitable gear position.

When the gear selector has been moved to neutral, the operator can once again select any direction. Under these conditions, the operator can operate the vehicle in both directions but only in 1st and 2nd gear. If the malfunction occurs in a higher gear, the operator can downshift manually.

For certain transmissions, functions that normally cannot be selected may be selected to replace those that no longer can be used.

In Limp home mode, the control unit uses standard values as compensation for the lost speed sensor; all gears use a standardised modulation curve. Inching is deactivated.



008453

The GPOS/CPOS display indicates the function with the letters “LH” on the left of the direction selection/gear position indicator.

Resetting the odometer.

When the odometer is displayed, this can be reset by pressing and holding the S-button for more than three seconds.

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Shut-down

The ECM transmission control valve has a built-in redundant shut-down solenoid and a pressure switch, pulls at about 13 bar and releases at about 9 bar, that monitors the pressure controlled by that solenoid. This solenoid is controlled by the ECU793 using both a high side and a low side switch (again redundant logic).

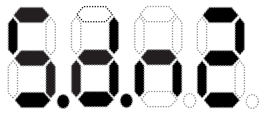
When the APC200 enters shut down mode, all four pressure modulators are put at zero pressure AND both controlling outputs of the redundant shutdown solenoid are switched off.

This mode is activated when a severe internal or external problem is detected. In this mode, the transmission is forced in Neutral because the redundant shutdown path cuts off the hydraulic power to the clutches.

This mode is selected only if an intolerable combination of faults exists. In case of an intermittent problem, SHUTDOWN mode is exited and the controller enters the LIMP HOME mode.

However, in case the error is related to the pressure feedback signal, SHUTDOWN mode remains selected until the controller is switched off.

Also when a fault related to the parameter settings located in FLASH memory is detected, the controller reverts to shutdown mode.



008454

The GPOS / CPOS display indicates the letters ‘Sd’ left of the direction/position indication.

If the problem is fixed, the control unit automatically reverts to limp-home mode. See *Troubleshooting and error codes, description page 58*.

In case of Stop, “S.d.” and the selected gear are shown in the control unit's display, and the E-light flashes.

Mode identification

Above modes are identified as follows:

Function	D-LED	E-LED	Display
Normal driving	Off	as per error	
Diagnostics	On	Off	*Diagnostics for Dana, description page 71*.
Limp home	Off	Blinking	 004162
Shut down	Off	Blinking	 004163

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Operating mode for ZF, description

There are five different operating modes for the transmission, one for normal operation: Normal, and four different modes with limited functionality to protect the transmission if severe problems occur: Substitute clutch control, Limp-home, Transmission-shutdown and ECU793-shutdown.

Troubleshooting and error codes, description

See section 8 Control system; D Error codes, group 2.8 Control system transmission.

Calibration, description

See *Calibration for Dana, description page 76*.

2.8.4 Reversing lock

Reversing lock for Dana, description

Forward to Reverse or visa versa

The behaviour of the transmission largely depends on the vehicle speed when the direction change is made.

If the vehicle speed is too high (3 km/h typically), the direction change will be postponed and neutral is selected.

If the engine speed is below the limit for direction changes, and the vehicle speed is sufficiently low, the direction change is made immediately without changing the transmission gear.

If the engine speed however exceeds the engine limit, the transmission will remain in neutral, and the warning lamp will be switched on until the limit is satisfied.

The engine speed limit is typically disabled but can be activated on request.

Neutral to Forward or Reverse (after standstill)

If an engine speed limit is used, neither forward nor reverse can be selected when the engine speed is too high.

The vehicle speed must be below e.g. 3 km/h.

Forward to Neutral to Forward

When driving in a certain direction and when putting the gear selector in neutral and back in the same direction, the direction will re-engage provided the engine speed has dropped below the limit for direction changes (if used).

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Function test, Reverse interlock

Forward to Reverse (or vice versa)

Accelerate the truck to about 10-15 km/h forwards, and select reverse with the gear selector.

The transmission should now select neutral and the warning lamp in the cab should light up. Allow the truck to roll until reverse gear is engaged. This should occur at about 3 km/h, depending on setting. If engine speed dependence is activated, you can repeat the procedure and rev the engine up to about 2000 rpm, and then reduce engine speed until the gear is engaged. This should occur at about 1500 rpm.

Neutral to Forward or Reverse (after standstill)

If engine speed dependence is activated, you can rev the engine up to about 2000 rpm, then engage forward or reverse gear.

Reduce engine speed progressively until the gear is engaged. This should occur at about 1500 rpm.

Forward to Neutral to Forward

During forwards or reverse driving, when you select neutral and then return to the same direction of travel, the transmission will engage the gear for the same direction of travel, if engine speed is below 1500 rpm.

Reversing lock for ZF, description

Forward to Reverse or visa versa

The behaviour of the transmission largely depends on the vehicle speed when the direction change is made.

If the vehicle speed is too high (3 km/h typically), the direction change will be postponed and neutral is selected. A warning lamp (if installed) is switched on.

If the engine speed is below 1600 rpm and the vehicle speed is sufficiently low, the direction change is made immediately without changing the transmission gear.

Neutral to Forward or Reverse (after standstill)

Transmission turbine speed must be below 1600 rpm to allow change of direction from neutral to forward or backward.

The vehicle speed must be below e.g. 3 km/h.

Forward to Neutral to Forward

When driving in a certain direction and when putting the gear selector in neutral and back in the same direction, the direction will re-engage provided the engine speed has dropped below the limit for direction changes (if used).

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Function test, Reverse interlock

Forward to Reverse (or vice versa)

Accelerate the truck to about 10-15 km/h forwards, and select reverse with the gear selector.

Allow the truck to roll until reverse gear is engaged. This should occur at about 3 km/h, depending on setting. If engine speed dependence is activated, you can repeat the procedure and rev the engine up to about 2000 rpm, and then reduce engine speed until the gear is engaged. This should occur at about 1600 rpm.

Neutral to Forward or Reverse (after standstill)

If engine speed dependence is activated, you can rev the engine up to about 2000 rpm, then engage forward or reverse gear.

Reduce engine speed progressively until the gear is engaged. This should occur at about 1600 rpm.

Forward to Neutral to Forward

During forwards or reverse driving, when you select neutral and then return to the same direction of travel, the transmission will engage the gear for the same direction of travel, if engine speed is below 1600 rpm.

2.8.5 Manual shifting

Manual shifting for Dana, description

The selected gear position normally follows the position of the gear selector. If the operator tries to change to a gear that is damaging to the machine, shifting is delayed until it can be performed safely and without damage. This means that if the driver starts in first gear, accelerates at the same time and selects third gear, gear shifts will be done in the same way as automatic gear shifting. On the other hand, if the driver is driving at high speed in third gear and selects first gear, the transmission will not downshift until the vehicle has reached a suitable speed.

Protection against change of direction of travel, so-called reverse interlock, please refer to *Reversing lock for Dana, description page 58*, is also activated during manual gear shifting. The gear selector control signals can either be obtained locally, via the distribution box, or via the CAN bus in accordance with Cargotec's CAN protocol (or via messages in accordance with the SAE/J1939 standard).

Function test, manual gear shift

It is a pre-requisite that the gear selector functions correctly.

Start by selecting gear F1 and accelerate the machine. Then select gear 2, followed by 3 later on. These should be engaged without delay. If top gear is engaged directly after a start in 1:st gear, there will be an automatic upshift to top gear in the same way as automatic gear shifting.

If the machine is driven in 3:rd gear at a higher speed, and 1:st gear is selected, it will downshift in the same way as automatic gear shifting.

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Manual shifting for ZF, description

The selected gear position normally follows the position of the gear selector. If the operator tries to change to a gear that is damaging to the machine, shifting is delayed until it can be performed safely and without damage. This means that if the driver starts in first gear, accelerates at the same time and selects third gear, gear shifts will be done in the same way as automatic gear shifting. On the other hand, if the driver is driving at high speed in third gear and selects first gear, the transmission will not downshift until the vehicle has reached a suitable speed.

Protection against change of direction of travel, so-called reverse interlock, please refer to *Reversing lock for ZF, description page 59*, is also activated during manual gear shifting.

Function test, manual gear shift

It is a pre-requisite that the gear selector functions correctly.

Start by selecting gear F1 and accelerate the machine. Then select gear 2, followed by 3 later on. These should be engaged without delay. If top gear is engaged directly after a start in 1:st gear, there will be an automatic upshift to top gear in the same way as automatic gear shifting.

If the machine is driven in 3:rd gear at a higher speed, and 1:st gear is selected, it will downshift in the same way as automatic gear shifting.

2.8.6 Automatic transmission

Automatic transmission for Dana, description

Automatic transmission is designed for a transmission with torque converter. The function handles shifting up and down, facilitates operation, and lengthens the service life of the drive equipment.

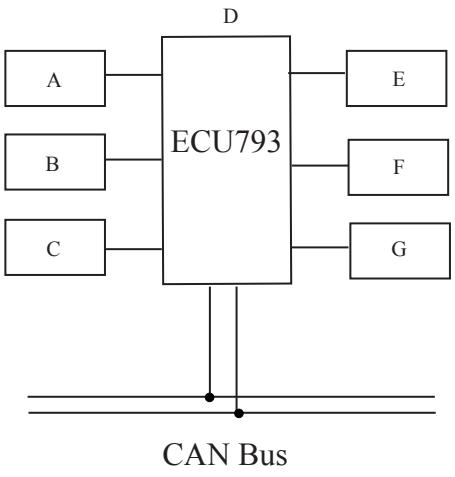
Automatic transmission consists of the following:

- Smooth engagement, changes at correct point from engine speed, the truck’s speed and current gear. In addition, with TE13000 and TE17000 turbine speed is measured as well as drum speed to further improve shifting.
- Current gear is indicated continuously on the display.

The following signals are monitored:

- gear selector lever
- speed sensors
- temp sensor
- pressure sensor
- throttle sensor
- servo motor sensor
- analogue output valves

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009624

A. Selector lever
B. Gas
C. Brake
D. Control unit
E. ECM, Electronic Controlled
F. Speed sensor (4 pcs)
G. Engine speed by CAN bus

ECU 793 is a unit that controls the gears in an electronically modulated transmission such as TE13000 and TE17000. ECU 793 handles all transmission related functions in order to ensure good shifting characteristics and high reliability. ECU 793 controls the engine speed by CAN bus. There is integrated self-testing and diagnostics to quickly locate and faults. Integration of the unit in the truck covers selector lever, speed sensor, valve block on the transmission and any different pedal position with position sensor.

The gear selector limits the highest gear that can be selected by automatic gear shifting. The gear selector control signals can be obtained on the CAN bus according to the Cargotec's CAN protocol (or through messages acc. to SAE/J1939 standard).

The standard algorithm uses all available ranges for automatic shifting.

Standard drive, description

Used when accelerator pedal >20% and when the speed ratio <1.0

Speed ratio = turbine speed / engine speed < 1.0

Automatic upshifting

An automatic shift to a higher gear is made when the accelerator pedal is pressed, the turbine speed exceeds a minimum speed, and the slip in the converter (speed ratio) has reached a certain value. This occurs when the tractive effort in the higher gear is higher than the tractive effort in the lower gear. The below table indicates for each gear the different limits.

Minimum turbine speed for automatic upshifting:

Shift	Accelerator > 20%	Accelerator > 80%
F1-F2	1400	1650
F2-F3	1450	1700

Automatic downshifting

Automatic shifting to a lower gear takes place when the drawbar pull (tractive force) of the lower gear is greater than that of the higher gear (rpm ratio drops below a certain level).

Brake position

This function is used when the throttle < 20% and the rpm ratio >= 1. That is, when the operator has let up the throttle pedal.

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Automatic upshifting

In principle, there's no upshifting when the machine is in brake mode. The exception is when the transmission's overspeed limit (depending on model) has been reached and the gear selector is in a higher gear than the gear that is being used.

Automatic downshifting

An automatic shift to a lower gear is made when the tractive effort in the lower gear exceeds the tractive effort in the higher gear (i.e. when the speed ratio drops below a certain limit).

Function test automatic gear shifting

Select gear 3 and engage forwards or reverse. During acceleration, gears will be engaged under certain criteria, such as accelerator position >20%, turbine speed and slip in the torque converter. This means that the tractive force in the next higher gear must be greater than the present gear, if an upshift is to be done.

If the machine is driven in top gear and the accelerator is released completely, a downshift will take place on the same principles as an upshift, but in the opposite way, i.e. that the accelerator position is <20% and the tractive force in the next lower gear is greater than the present gear.

As with manual shifting, you can change up manually, by moving the gear selector to any position between 1 and 3, but with the reservation that the transmission will always check whether it is suitable to engage the gear selected.

Automatic transmission for ZF, description

Automatic transmission is designed for a transmission with torque converter. The function handles shifting up and down, facilitates operation, and lengthens the service life of the drive equipment.

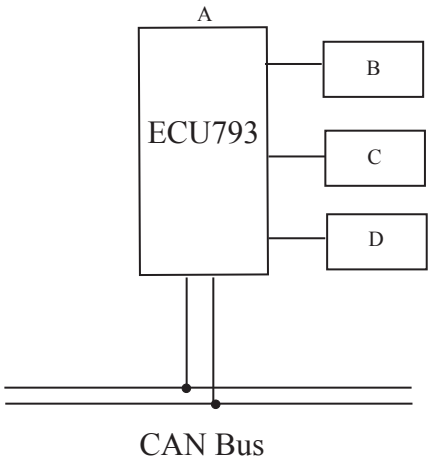
Automatic transmission consists of the following:

- Smooth engagement, changes at correct point from engine speed, the truck's speed and current gear.
- Current gear is indicated continuously on the display.

The following signals are monitored:

- gear selector (S160)
- sensor rpm turbine (B751)
- sensor rpm drum (B752)
- sensor engine speed (B753)
- sensor rpm output shaft (B758)
- sensor oil temperature converter (B766)
- sensor oil temperature sump (A3)
- solenoid valves for travel direction and gear position
- sensor oil filter contamination

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015729

A. Control unit
B. ECM, Electronic Controlled
C. Speed sensor (4 pcs)
D. Engine speed by CAN bus

ECU 793 is a unit that controls the gears in an electronically modulated transmission. ECU 793 handles all transmission related functions in order to ensure good shifting characteristics and high reliability. There is integrated self-testing and diagnostics to quickly locate faults. Integration of the unit in the truck covers selector lever, speed sensor, valve block on the transmission and any different pedal position with position sensor.

The gear selector limits the highest gear that can be selected by automatic gear shifting. The gear selector control signals can be obtained on the CAN bus according to the Cargotec's CAN protocol (or through messages acc. to SAE/J1939 standard).

The standard algorithm uses all available ranges for automatic shifting.

Automatic upshift takes place when the pulling power in the higher gear is greater than the pulling power in lower gear. Automatic downshift takes place when the lower gear's pulling power is greater than in the higher gear.

Function test automatic gear shifting

Select gear 3 and engage forwards or reverse. During acceleration, gears will be engaged depending on accelerator position, turbine speed and slip in the torque converter.

If the machine is driven in top gear and the accelerator is released completely, a downshift will take place on the same principles as an upshift, but in the opposite way.

As with manual shifting, you can change up manually, by moving the gear selector, the transmission will always check whether it is suitable to engage the gear selected.

2.8.7 Inching

Inching for Dana, description

The term 'inching' refers to the process of driving a vehicle at low speed while the engine runs at a high speed, independent from the vehicle speed. The target of inching is to temporarily reserve the engine power for controlling the hydraulics while still being able to precisely manoeuvre the vehicle.

The ECU793 implements this functionality by slipping the direction clutches, limiting the power that can be absorbed from the engine.

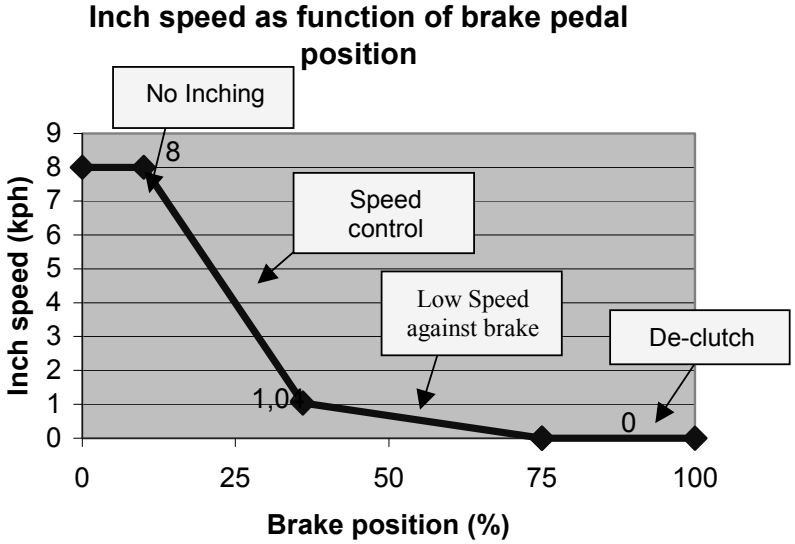
The inching system can be operated both in forward and in reverse and in any range. It will be most effective however in 1st range.

Automatic shift is typically disabled while inching.

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Operation

The inching system is controlled with the left brake pedal. The obtained effect depends on how deep you press the brake pedal.



008626

The 35% point in above graph is called the MID point and should correspond to the point where the brakes actually start braking.

If the brake pedal is measured locally by ECU793, the built-in calibration function can be used for calibrating the MID-point.

Activation of the inching system

Below conditions must be met simultaneously to start the inching function:

- In order to activate the inching system, you have to push the left brake pedal beyond 5%
- you must depress the ‘inching-enable’ switch (mounted on the left pedal) or depress the switch ‘inching-enable’ on the steering wheel panel.
- A certain minimum engine speed is required to provide the required torque, but apart from that, it doesn’t influence the vehicle speed – so the engine can be at full throttle to speed up the hydraulics or steering (typically no minimum engine speed limit is implemented).

The ECU793 will try to match the desired inching speed as close as possible. This speed depends on the current brake pedal position.

While inching, it is not necessary to keep the ‘inching enable’ switch pressed.

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Leaving inching mode

If either of below conditions is met, the inching function will be switched off and normal converter operation will be resumed.

- Release the brake pedal below 5% (i.e. release it completely for all practical purposes).

  Note that releasing the ‘inching enable’ switch will not stop the inching function.

- Select Neutral or the other direction.

  Note that when changing direction, if the change over is made while the ‘inching enable’ switch is still pressed, the inching mode will re-activate in the opposite direction.

- When the inching torque reaches the allowed maximum for longer than 1 second (parameter).

  When inching is stopped because of the 1second protection, the direction clutch gradually closes completely and inching is disabled until the brake pedal is completely released (below 5%).

Function of the brake pedal in relation with inching

Brake pedal position	Effect
0-4%	Inching is disabled
5-34%	Continuous inching speed control – no vehicle braking
35-69%	Fixed inching speed – gradually increasing brake force
70-100%	Transmission is disconnected – further increasing braking force

Function of the brake pedal without inching

When the (left or right) brake pedal is pressed without pressing the ‘Inch-Enable’ switch, the inching system remains off. This means you just get standard braking.

However once the vehicle speed is below 10 km/h (adjustable) and you press the brake pedal in the 55% - 100% range, the transmission is placed in neutral. This ‘standard’ de-clutch function improves vehicle braking. Additionally it prevents that you inadvertently overheat the transmission.

Releasing the brake pedal below 70% causes the transmission to re-engage smoothly.

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Inching and changing direction

If the operator wants to change direction during inching, the direction changes immediately, in principle without any consideration of normally applicable restrictions.

This means that it's possible to change direction without letting up the throttle pedal.

The "Inching enable" switch must be held down during the change of direction, otherwise the system will return to converter drive after the directional change.

Function test, electronic inching

Activate the inching function with the inching switch, accelerate the machine and slowly depress the left-hand brake pedal halfway. At the-same time, depress the accelerator pedal and rev up the engine to maximum speed. It should now be possible to check machine speed with the left-hand brake pedal by raising and lowering the brake pedal.

If the brake pedal is fully depressed, the machine should stop and engage neutral with minimum slipping in the transmission.

Inching for ZF, description

The term 'inching' refers to the process of driving a vehicle at low speed while the engine runs at a high speed, independent from the vehicle speed. The target of inching is to temporarily reserve the engine power for controlling the hydraulics while still being able to precisely manoeuvre the vehicle.

The ECU793 implements this functionality by slipping the direction clutches, limiting the power that can be absorbed from the engine.

The inching system can be operated both in forward and in reverse and in any range. It will be most effective however in 1st range.

Automatic shift is typically disabled while inching.

The inching system is controlled with the left brake pedal. The obtained effect depends on how deep you press the brake pedal.

Activation of the inching system

Below conditions must be met simultaneously to start the inching function:

- Left brake pedal depressed.
- The switch 'inching-enable' on the steering wheel panel acticvated.
- In some cases a minimum engine speed is required for the requisite torque. Engine speed does not affect vehicle speed - the engine can run at full throttle in order to speed up hydraulics and steering.

The ECU793 will try to match the desired inching speed as close as possible.

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Leaving inching mode

If either of below conditions is met, the inching function will be switched off :

- Release the brake pedal.
- Switch the inching enable switch to off position will disengage the inching function after pedal is released and leaving inching mode.
- Select Neutral or the other direction and inactivate ‘inching enable’ switch.

  Note that when changing direction, if the change over is made while the ‘inching enable’ switch is still activated, the inching mode will re-activate in the opposite direction.
- When the inching torque reaches the allowed maximum value.

  When inching is stopped, the direction clutch gradually closes and inching is disabled until the brake pedal is completely released.

Function of the brake pedal in relation with inching

Brake pedal position provides inching following functions:

1. Inching is disabled (brake pedal not depressed).
2. Continuous inching speed control - no vehicle braking.
3. Transmission is disconnected - further increasing braking force.

Function test, electronic inching

Activate the inching function with switch ‘inching-enable’. Accelerate the machine and and slowly depress the left-hand brake pedal halfway. At the same time, depress the accelerator pedal and rev up the engine to maximum speed. It should now be possible to control the speed of the machine with the left brake pedal by moving the brake pedal up and down.

If the brake pedal is completely depressed, the machine should stop and engage neutral with minimum slip in the transmission.

2.8.8 OptimumDrive

OptimumDrive for Dana, description

This system offers so-called hydrostatic simulation according to definition by Cargotec.

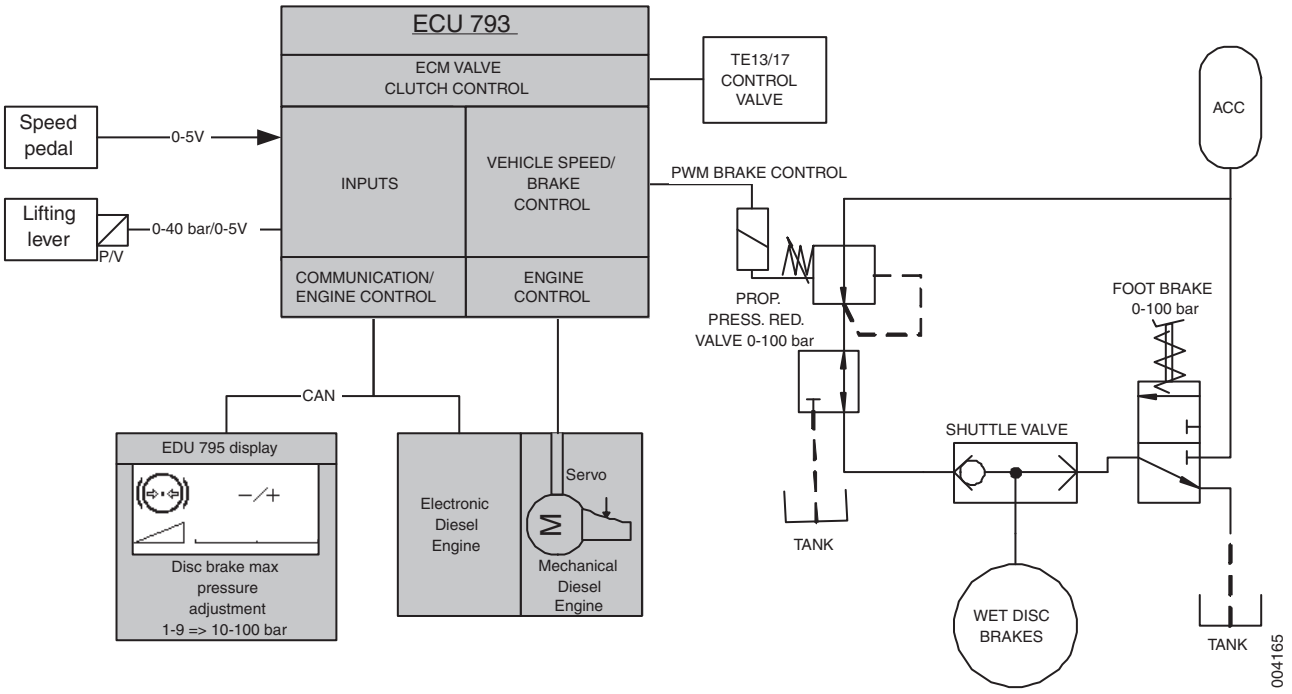
This system requires some optional equipment on the machine:

- Electro-hydraulic proportional brake coupled via a spool valve in parallel with the ordinary wet brakes.
- Engine speed control via a servo motor on a mechanical engine, or via the CAN bus on an electric motor.
- Pressure sensor via the lift function, which provides a proportional output signal when the lifting lever is activated, or if there is an electric servo, the lifting signal is sent via the CAN bus to the ECU793.

With this system, the vehicle can be operated using only one pedal. The throttle pedal changes to a speed pedal. The brake pedal is only intended for use in emergencies, but can be used as normal of course.

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ECU793 optimises use of the engine and brakes to give the vehicle the desired speed. The throttle pedal is no longer used to control the engine's rpm, instead it's used to give a desired value for vehicle speed. On uphill grades, the engine rpm increases automatically and on downhill grades the brakes are activated to limit the speed. When the lifting lever is activated, engine speed is increased automatically at the same time as ground speed is maintained. The driver can also change braking ability via the "+" and "-" buttons. Please refer to the block schedule.



Normal operation

To accelerate or retard the vehicle, the operator only needs to select speed with the accelerator. The control system then looks after engine speed control, braking force control and slip in the transmission, so-called inching.

The engine's rpm is changed automatically to ensure that there is sufficient traction force. Special consideration has been given to maintaining the advantages of traditional torque converter driving. If the throttle pedal is let up gradually, the vehicle behaves the same as during normal converter drive, that is, the vehicle free-wheels (rolls freely). It's only if the throttle pedal is released significantly that the brakes engage and brake the vehicle with a braking force that can be adjusted with the "+" and "-" buttons on the display. This break point between braking effect and no braking effect is located at about 50% of the angular movement of the brake pedal.

To ensure exact manoeuvring, even in the most demanding conditions, a special inching function has been developed (see above), offering operation with extremely high precision (even on 20% grades with considerable load). There's no longer any reason to use the brakes together with the throttle pedal – ECU793 takes care of this.

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Changing direction

When changing direction with the gear selector, the control unit (depending on the situation) will automatically reduce the engine's rpm and activate the brakes to retard the vehicle. When the speed is low enough, the brakes release and the vehicle accelerates again in the opposite direction.

Complete inching

ECU793 senses the lifting function output signal, either via a pressure sensor, 0-40 bar 0-5%, mounted on the main valve, directly through an analogue input or on the CAN-bus when an electric servo is used and uses it to decide if inching shall be activated. This means that the inching system is activated automatically when the forks are raised. The engine rpm increases in proportion to the lift movement, to give greater control of the lift.

When the lifting function is terminated, the control unit changes back to hydrostatic drive as smoothly as possible.

Calibration of lifting lever and brake pedal

Accurate calibration of the lifting function pressure sensor is needed to allow the system to manage speed control and transmission slip in the best manner (this does not apply if an electric servo is installed).

Start the engine and complete calibration.

In addition, pressure calibration of the brake valve has to be done. Connect a brake pressure gauge to the machine and check that the pressure ranges between 0 bar at full acceleration and about 100 bar with the machine stationary, brake pedal released and brake program 9 selected. Try setting the braking force 1-9 via the menu in the display.

Function test, OptimumDrive

The prerequisite for this test is that the transmission should maintain at least 60°C and the hydraulic oil should be at least 30°C. In other cases, undesirable effects can be obtained, such as heavy braking and jerking in the machine during lifting.

Connect a pressure gauge to measure brake pressure after the foot brake valve and the brake valve for the OptimumDrive.

When the parking brake has been activated, the brake valve should be released, and a residual pressure of about 1 bar may be left in the brake circuit, on condition that the brake pedal is not depressed.

When the parking brake is released, the OptimumDrive brake valve is activated and the pressure should then rise to the brake pressure set via the menu on the display, 15-100 bar.

Depress the accelerator slightly until the machine starts to move slowly forwards, about 1 km/h. Check the brake pressure, it should fall to 5-10 bar at the same time as the engine speed increases. Irrespective of the ground, the machine should maintain the same speed 1.0 km/h, i.e. either on an upward or a downward slope. If the test is done on a test track, you can drive through the ramp to check this.

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Retain the speed of 1 km/h and pull the lifting lever. At this point, the transmission will switch over to slipping, engine speed will increase proportionally with the lifting lever and it should maintain the same speed 1.0 km/h. When it changes over to slipping mode, the machine might give a slight jerk. This is normal, but it should not be too large, i.e. there should not be a risk that you drop the load. When the lifting lever is released, the engine speed should fall and the transmission will leave slip mode.

The next test is to see how well-behaved the machine is, by accelerating it to full speed and then releasing the accelerator. When the accelerator reaches half travel, the brakes begin to be activated gently and the machine should then brake softly. If the accelerator is released fully, the brakes will brake the machine harder, using the maximum set brake pressure.

Try alternately accelerating and releasing the accelerator, to see if the machine complies smoothly.

2.8.9 Diagnostics

Diagnostics for Dana, description

In principle, there are no specific devices required for first level troubleshooting as the ECU793 incorporates several self-test features assisting in this process. Nevertheless, use of digital multi-meters and simple tools such as an indicator lamp will be required to pinpoint exact causes of problems. More in depth troubleshooting and system tuning involves use of a WIN95 Compatible PC with appropriate software and FLASH parameter programming equipment. The ECU793 allows recall and modification of non-volatile parameters through RS232. This way, customers can, given the necessary equipment, choose to adapt certain parameters to suit their needs.

This function also makes it possible to download parameters (modified) together with serial numbers as well as change date, which may be relevant for maintenance and warranty matters.

Several PC hosted tools have been developed to ease the service and trouble shooting process. Kalmar Smart Link does not yet offer the possibility to check and calibrate ECU793, instead Dana’s own tools DanaFlash, APT32 and GDE Production/Engineering shall be used.

Self-test

The ECU793 has special circuitry to help verifying its operation.

Six self-test groups are built into the ECU793 control programs:

- Display test and version
- Digital input test
- Analogue input test
- Speed sensor test
- Output test
- Voltage test

The 'D' LED is on while operating the ECU793 in diagnostic mode.

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If during operation in a self-test mode a fault is detected, the E-led flashes to indicate the presence of the fault. Pressing S-button for a while however in this case will not reveal the fault code.

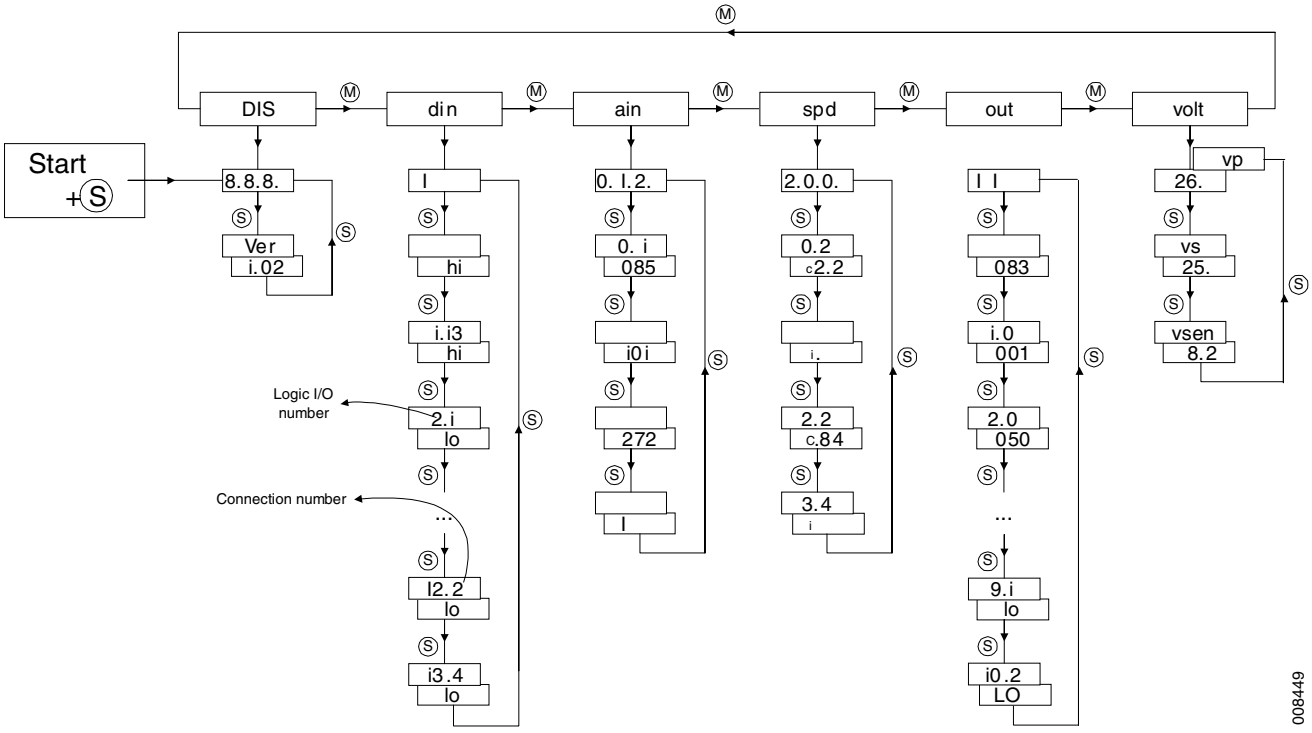
Self-test mode is activated by pressing the ‘S’-switch on the ECU793 front panel while powering up the ECU793. Switching off the power of the ECU793 is the only way to leave the self-test mode.

The available information is organized as groups of related displays Generally, each mode’s start display provides an overview of the status of all members of the group. For instance, the start display of the input test mode cryptically shows the level of each input and the speed sensor test mode shows the frequency of each sensor channel in kHz.

Pushing the ‘M’-switch selects the next group in the order listed. By pushing the ‘S’-switch a list of modes with more detailed information about the selected group can be looked through. When a new group is selected with the ‘M’-switch, the display always reverts to the overview display (i.e. the beginning of the mode-list).

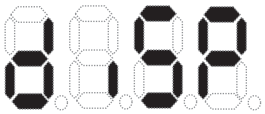
Pressing a switch (M or S) shortly re-selects the current group or mode. This feature is applicable in all diagnostic-groups.

Overview of test modes



Possible results:	lo	1234 (Ohm)	123 (Hz)	123 (mA)	24. (V)
	hi	open	open	lo	
			shrt	hi	
				open	
				shrt	

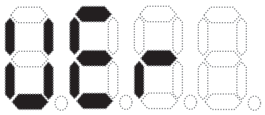
https://truckmanualshub.com/



004102



004103



004104

Display test and version

When selecting this group the display shows:

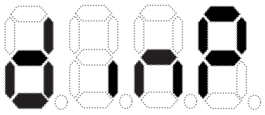
When pressing the S-switch, the display changes to;

Releasing the switch engages a scrolling text display showing the part number and the version.

When pushing the S-switch, the display switches back to the display test mode, showing.

Followed by the program identification string: ECM 3’0 r6.

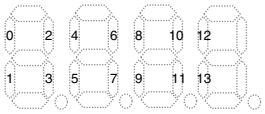
After releasing the S-button, the display again lightens up all segments.



004105

Digital input test

When selecting this group the display shows:

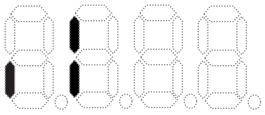


004106

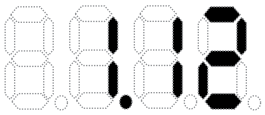
The display shows which inputs are active. Each segment of the display indicates a specific logical input. Different segments can be switched on simultaneously if different inputs are activated simultaneously. In total there are fourteen inputs: ten digital and four analogue inputs (in this group treated as if they were digital pull to ground inputs).

Digital inputs numbered 0 – 9 and analogue inputs 10 – 13 are shown on the segments as shown in figure.

The example indicates that input 1, 4 and 5 are on. All others are off.



004107



004108

By pressing the ‘S’- switch repeatedly, each individual input is shown in more detail.

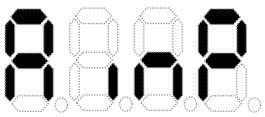
While pressing the ‘S’- switch, the display shows the logic-input number with the matching harness wire. – I.e. below display corresponds with input one connected to wire A12.

Releasing the switch displays the input’s state (hi or lo).

NOTE

The analogue inputs return ‘high’ when pulled to ground.

Pressing the S-switch at the last analogue input (13) brings back the overview on the display.



004109

Analogue input test

The ECU793 has 4 analogue resistance inputs. They measure the single-ended resistance of a sensor connected between the input and signal ground B18.

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004110

When selecting this group the display shows:.

Releasing the switch brings an overview of the 4 analogue inputs on the display. The values, displayed in kOhm, are separated by a dot.

Above display corresponds with a first input of 1 kOhm, a second of 2 kOhm and the last two of 0 kOhm.

Values that are more accurate can be found while running through the input specific displays (S-switch).

While pressing the switch, similar to the display of digital inputs, the left side of the display gives information about which input is tested; the right side gives the matching wire.

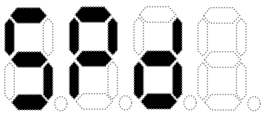
The displayed value when the S-switch is released is the resistance in kOhm.

NOTE

Although the ECU793 also has 4 current sense and 3 voltage sense inputs, these are not directly accessible through diagnostic displays.

The current sense inputs are treated in combination with analogue output test modes. The voltage sense inputs are not yet supported by the diagnostics modes.

Speed sensor test



004111

When selecting this mode the display shows:

When releasing the ‘M’-switch, again an overview appears on the display.

The four values, displayed in thousands of Hertz, are separated by a dot. Speeds below 1000 Hz are shown as 0.

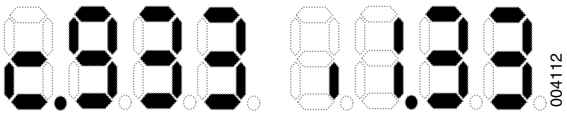
Using the ‘S’-switch more detailed information concerning the speeds is available.

While pressing the ‘S’-switch, the display shows the speed channel number on the left side of the display while the matching wire is shown right.

Once released, the left digit indicates what type of speed sensor should be connected to this channel:

c for a current sensor (Magneto Resistive Sensor).

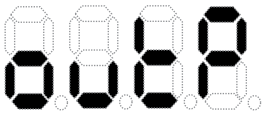
i for an inductive speed sensor.



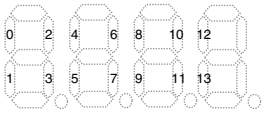
004112

The three other digits and the dot represent the matching speed in kHz for instance, in below examples the left display indicates a current speed sensor and a frequency of 933 Hz. The right one indicates an inductive sensor generating about 1330 Hz. After the last channel is shown, another press on the ‘S’ switch re-selects the speed sensor overview.

https://truckmanualshub.com/



004113



004106

Output test

When selecting this mode the display shows:

The display shows which outputs are active. Similar to the digital input test overview screen, each segment of the display indicates a specific input.

Different segments can be switched on simultaneously if different outputs are activated simultaneously.

A blinking segment indicates a fault at a certain output.

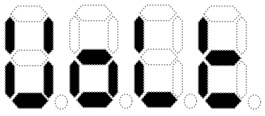
In total, there are 11 outputs.

- Outputs 0 – 6 are analogue
- Outputs 7 – 9 are STP (Switch to plus) digital outputs
- Output 10 is a STG (Switch to ground) digital output

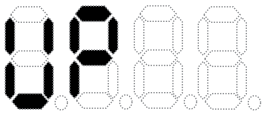
While pressing the switch, the left side of the display gives information about which output channel is tested; the right side gives the matching wire number.

When releasing the switch the display shows either the actual current in mA, or the logic state of the output (either ‘hi’ or 'lo').

If an output is currently in fault, its respective segment in the overview screen blinks slowly. On the output specific screen, the display alternates between the actual state (current value or logic state) and the fault type (open / short / curr / oor).



004114



004115

Voltage test

When selecting this mode the display shows:

The displayed value after the M-switch is released is the PERMANENT VOLTAGE Vp in Volts as measured on wire A1.

The two other modes of this group are switched voltage (Vs) and sensor voltage (Vsen), also expressed in Volts.

Vs is measured on wire B12. This power supply input is used to allow the ECU793 to control the power down process – allowing it to save statistical information in FLASH before actually shutting down.

Vsen is measured off an internally generated voltage regulator and should be near 8.0V.

It can be measured on any unloaded analogue input channel (e.g. ANI0 on A11). The Vsen voltage is used as a reference for the analogue inputs.

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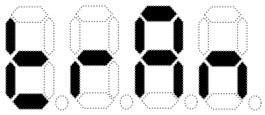
Diagnostics for ZF, description

Tools for advanced diagnostics are available from ZF dealers, for further information contact **Cargotec Sweden AB.**

2.8.10 Calibration

Calibration for Dana, description

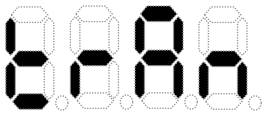
The calibration functions are activated by pressing and holding down the “S”-button for at least 15 seconds during start. When stand-alone calibration mode is entered the display shows:



004116

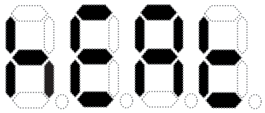
Switching off the power of the ECU793 is the only way to leave the calibration display mode.

By pressing the ‘M’-switch, the existing calibration modes are displayed, pushing the ‘S’-switch starts the calibration of the currently displayed mode. The following modes exist:



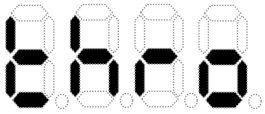
004116

Transmission (Clutch control) parameter calibration



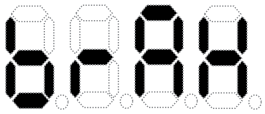
004366

Function for heating the transmission



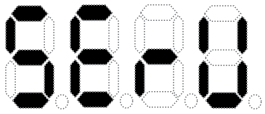
004117

Accelerator pedal calibration, Not used.



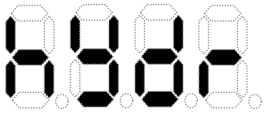
004118

Brake pedal calibration, Not used.



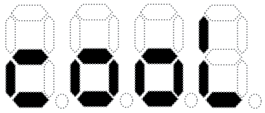
004119

Servo Motor calibration, Not used.



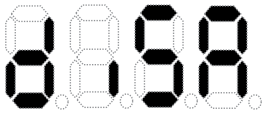
004120

Hydro Lever sensor calibration, Not used.



004121

Cooler In Temperature sensor calibration, Not used.



004122

Some calibration modes may be disabled by the controller software. In that case, when pressing the ‘S’-switch to start calibration the display shows:

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Calibration for ZF, description

After change of oil in the transmission it is recommended to calibrate the clutches for best driving comfort. The transmission needs first to be warmed up to at least 70 °C and there after perform an clutch fillings calibration using the display in the vehicle.

Optionally if inching system is available on the machine and there is changes on or the inching pedal sensor is replaced, the sensor needs to be calibrated using the display in the vehicle. See section *8 Control system*, group *8.5.2.2 Calibrate automatic gear shift* for more info.

NOTE

If a transmission has been changed it is a must to calibrate before start using.

⚠ DANGER

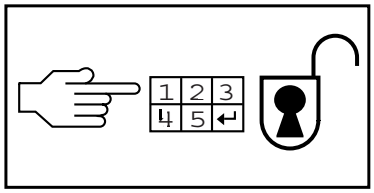
Do not leave the machine during calibration. The machine may start to move.

1 Park the machine on level ground, engage neutral position and apply the parking brake. Run the engine at idling speed, check the oil level and that the transmission oil temperature is between 70-90 °C.

2 To select the function to calibrate, first navigate to the service menu. Then press Enter.



000056



000060

3 Enter code for calibration.

The code is obtained via Cargotec Support.

NOTE

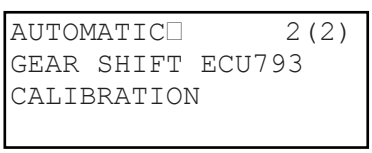
The code determines which service menu shall be activated (Diagnostics, Initiation or Calibration).

4 Select AUTOMATIC GEAR SHIFT ECU 793 by scrolling with the arrow keys (1 and 2) and confirm with Enter.



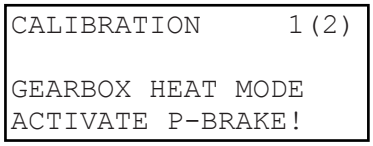
007741

5 Select CALIBRATION by scrolling with the arrow keys (1 and 2) and confirm with Enter.

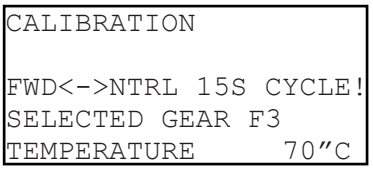


007742

https://truckmanualshub.com/



009098



009541

6 Only shown when the engine is running.

The signals for the parking brake and clutch disengagement have been temporarily disconnected to make it possible to run “Heat Mode”. The highest possible gear is always selected.

7 “Heat mode” is a function for heating the transmission with the machine stationary, by using the parking brake to brake the machine and let the torque converter heat the transmission oil.

Increase the oil temperature in the transmission as follows:

A. Apply the parking brake so that the machine is stationary.

B. Select direction of travel forward or backward and apply half to full throttle for 30 seconds.

C. Engage neutral position and apply half throttle for 10 seconds, run the engine at idle.

D. Repeat steps B and C until the oil is above 70 °C or maximum 90 °C. The temperature display starts to flash when calibration of the clutches can be started.

NOTE

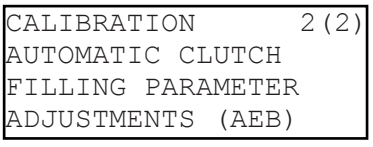
During this warm up procedure, it is possible that the converter out temperature of the transmission exceeds the maximum limit.This is a consequence of heating up the transmission using this quick procedure.

Put the transmission in neutral for a minute and throttle the engine to around 1300 rpm to cool the transmission. This will allow the heat in the converter to be evacuated.

After one or two minutes, you can resume the heating up procedure if the transmission temperature has not reached 70°C yet.

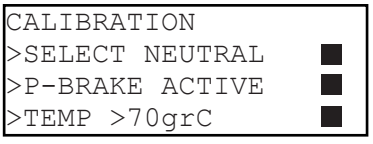
IMPORTANT

Calibration can be aborted at any time by return to higher menu level using “R” button. At which point the transmission's control unit will be reset and ignore the calibration results obtained so far.



009100

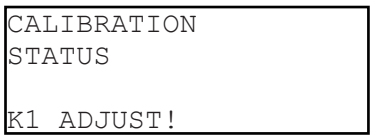
8 Only shown when the engine is running. Press “Enter” to come to the next menu.



009101

9 The following requirements must be complied with, to start calibration. Transmission in neutral and parking brake applied. Check that all requirements are complied with and that the oil temperature is 70° before you go on to the next menu by pressing Enter.

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009103

10 When the TCU has started calibration, the display shows information in plain language about the calibration procedure. Any fault messages are also displayed.

11 During calibration, engine speed is automatically regulated to the default value which suits each transmission.

After calibration is completed, the display will show the text: “ADJUSTMENT FINISHED SWITCH OFF IGNITION FOR 5 SECONDS!”, switch off ignition according to above text in display for saving the new parameters.



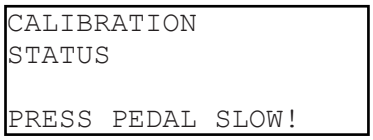
009104

12 This is only shown when the engine is switched off and inching is installed. This is an optional feature.

The requirement for seeing “CALIBRATION INCH PEDAL” is that the engine is already switched off. This will not be displayed at all otherwise.

--> Engine switched off = INCH PEDAL CALIBRATION

Engine running = AEB CLUTCH CALIBRATION



009105

13 When the TCU has started calibration, the display shows information in plain language about the calibration procedure. Any fault messages are also displayed.

14 Depress the pedal slowly and keep it depressed until the text shown on the display changes to “Release pedal slow!”. Release the pedal slowly.

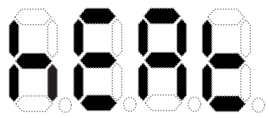
After successful calibration the displayshows: “ADJUSTMENT FINISHED SWITCH OFF IGNITION FOR 5 SECONDS!”

15 Switch off ignition for 5 seconds for saving the new parameters.

2.8.10.6 Calibration of transmission parameters

Calibration of transmission parameters for Dana, description

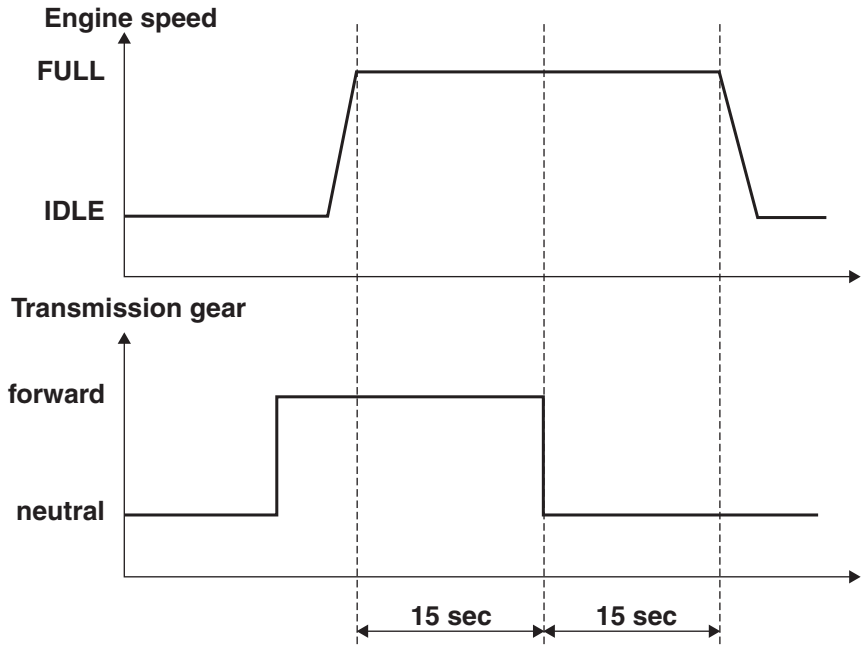
The transmission oil temperature must be at least 60°C (140°F) for calibration to be possible. Use the “Heat” function which is found in the menu after “trAn”.



004366

Select this with the “S” button, engage a gear, rev the engine for 30 seconds, and engage neutral at regular intervals to flush the oil round inside the transmission. Repeat this procedure until the temperature has risen above 60°C. See picture below.

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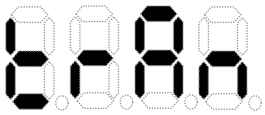
008452

NOTE

During this warm up procedure, it is possible that the converter out temperature of the transmission exceeds the maximum limit. This is a consequence of heating up the transmission using this quick procedure.

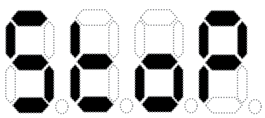
When this occurs, the engine speed will be limiting to the half throttle when the ECU793 has engine control or forcing neutral when the ECU793 has no engine control. To solve this, simply leave the transmission in neutral for a minute and throttle the engine to around 1300 rpm. This will allow the heat in the converter to be evacuated.

After one or two minutes, you can resume the heating up procedure if the transmission temperature has not reached 60°C yet.



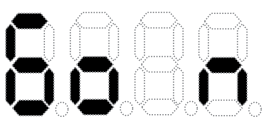
004116

Stop the vehicle, apply the parking-brake and enter the stand-alone calibration mode, the display shows:



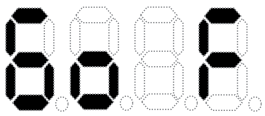
004144

Press the ‘S’-switch to start the servo sensor calibration. If vehicle is not standing still, the display shows:



004143

If the position of the shift lever is not neutral, the calibration process does not start and the following displays is shown:



004147

Now, the driver should select the forward shift lever position, as requested by the following display:

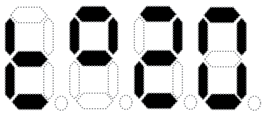
https://truckmanualshub.com/

NOTE

The transmission calibration process can be interrupted at all times by moving the shift lever into the reverse position. In that case, the transmission controller will reset and ignore the calibration results obtained so far.

Now, the transmission's temperature is checked against the minimum required temperature to calibrate, at present is the required temperature 60°C. If the actual temperature is too low, the driver should drive the vehicle until required temperature is reached. If the transmission temperature reaches the desired value, calibration proceeds automatically.

Meantime the display shows the actual temperature:



004148

If all conditions to start calibration are met, the calibration process starts. The following display is shown:



004149

The first two digits show the currently calibrated clutch. The third digit shows the actual calibration mode and the last digit shows the calibration algorithm's current step. During the calibration process, this information is continuously updated.

Depending on the actual calibration mode, a different engine speed may be required.

Whenever the actual engine speed is too low following display is shown:



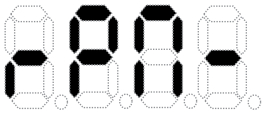
004150

Whenever the actual engine speed is too high, the display looks as follows:



004151

If the vehicle is equipped with throttle-by-wire, the engine speed will be automatically adapted. In the other case the driver has to change the throttle pedal position until the display looks as follows:

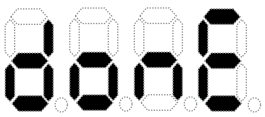


004152

After the engine speed has been within limits for about three seconds, the calibration process proceeds.

After successful completion of the calibration process, the calibration results are memorised in Flash memory and will become active at the next power-up of the controller.

The following display is showed:



004125

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When one or more errors were encountered during calibration the display shows vertical lines to indicate the calibration result of each clutch (the first line corresponds to clutch1, the second line to clutch2,…). A blinking line indicates the calibration of the corresponding clutch was not successful.

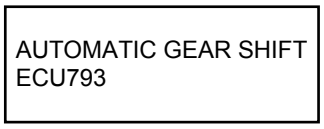
IMPORTANT

After successful calibration, switch off ignition key for 5 seconds for saving the new parameters.

2.8.11 Service menus

Settings and calibration

Level 3, automatic gear shift ECU 793

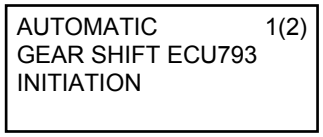


008455

Enter AUTOMATIC GEAR SHIFT ECU793 by stepping with the arrow keys (1 and 2). Confirm with Enter.

This display and the following shows only if ECU 793 is selected.

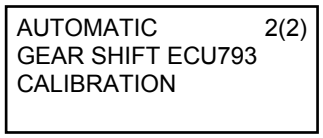
Level 4, automatic gear shift ECU793



008456

Enter AUTOMATIC GEAR SHIFT ECU793 INITIATION by stepping with the arrow keys (1 and 2). Confirm with Enter.

This display and the following shows only if A_GEAR_SHIFT_793 is selected.

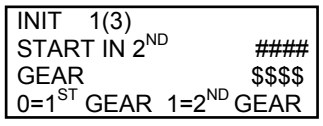


008457

Enter AUTOMATIC GEAR SHIFT ECU793 CALIBRATION by stepping with the arrow keys (1 and 2). Confirm with Enter.

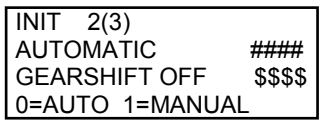
This display and the following shows only if ECU 793 is selected.

Level 4, initiation automatic gear shift ECU793



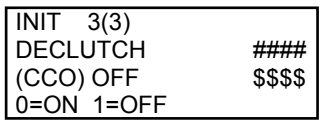
008458

Only shown if automatic shifting is selected in the machine configuration.



008459

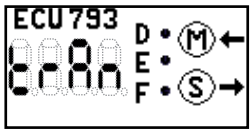
Only shown if automatic shifting is selected in setup.



008460

Only shown if automatic shifting and NOT inching is selected in setup.

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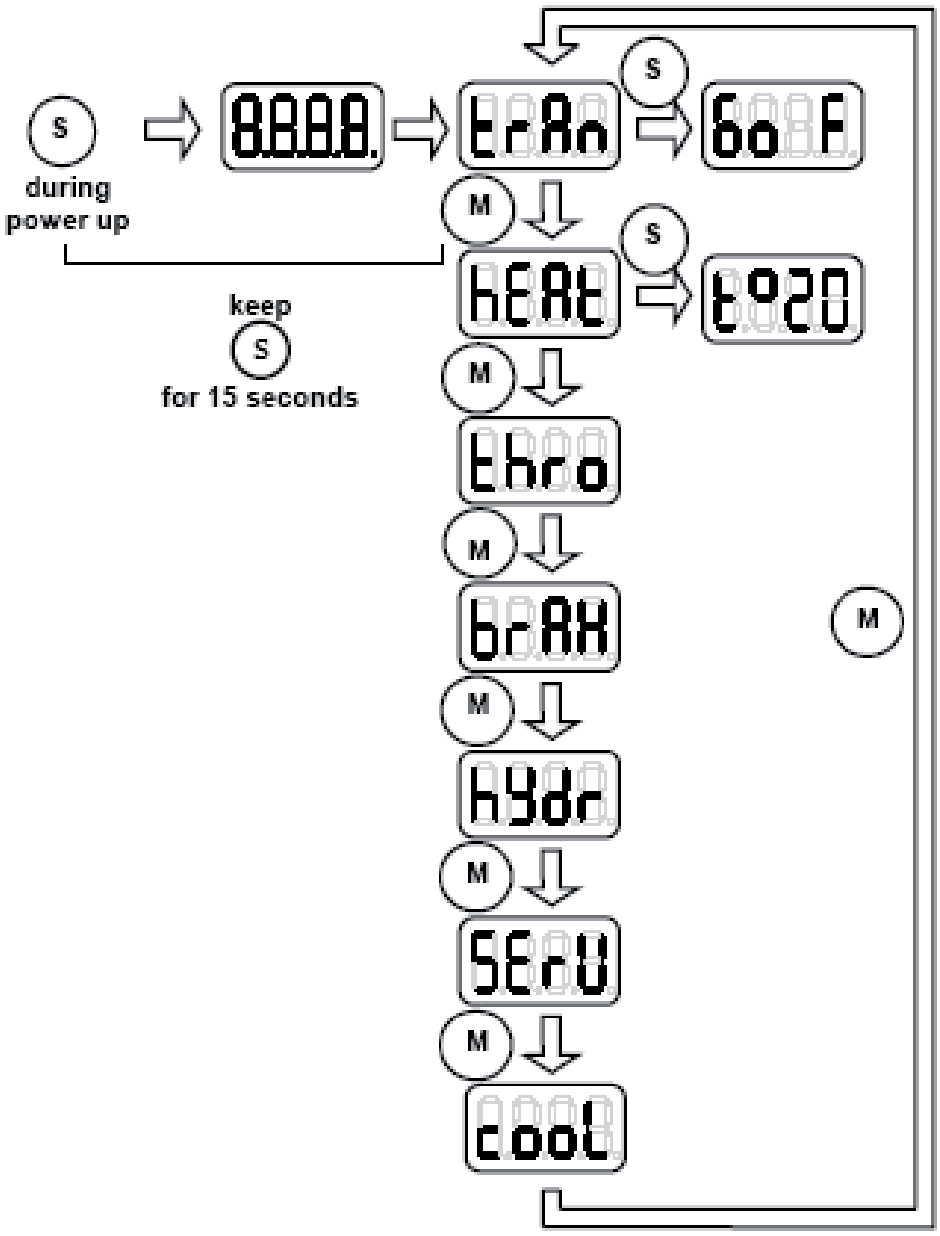


008461

Level 4, calibration, automatic gear shift ECU 793 (Dana TE)

Select transmission calibration, ECU793. This illustration is a copy of the display shown in APC200. Please refer to the figure below and the description further on.

If vehicle display and the diagnostic menus are used, the <- button is the same as M button and -> button is the same as S button on the ECU793 controller.



Overview display modes in calibration mode.

008462

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3.3 Drive axle 7

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3 Driveline/axle

Driveline/axle, general

Component supplier documentation

The workshop manual only describes components and job descriptions related to installation in the machine. Please refer to the component supplier documentation for descriptions and instructions of the driveline/axle components and systems.

References to component supplier documentation are only provided in exceptional cases. If information about a component is not found, the component supplier documentation should be used.

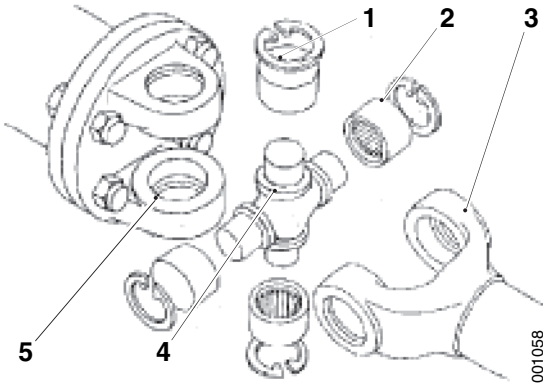
https://truckmanualshub.com/

3.2 Propeller shaft

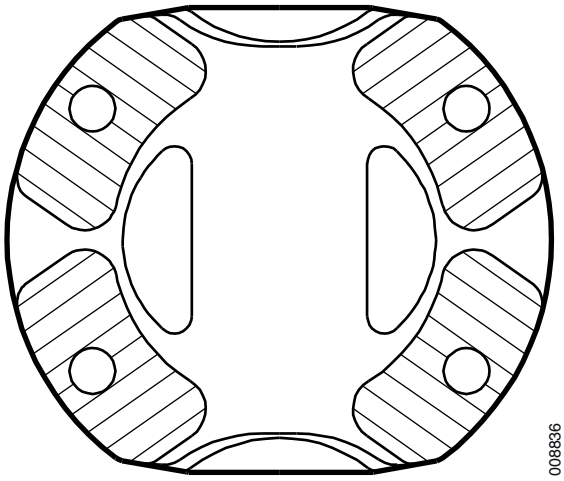
Propeller shaft, description

The propeller shaft transmits the engine power from the gearbox to the drive axle. Both universal joints on the propeller shaft make power transmission possible despite movements of transmission/engine and jolts due to road conditions (distance between transmission and drive axle varies).

Its possible to change the length of the propeller shaft since its divided in two parts, connected with a bolted joint and splines, as well as the universal joints, so-called spiders, at both ends. The propeller shaft connection is of the cross-tooth type to take stress off the mountings (attaching bolts). The universal joint needle bearings are pre-lubricated and are therefore maintenance free.

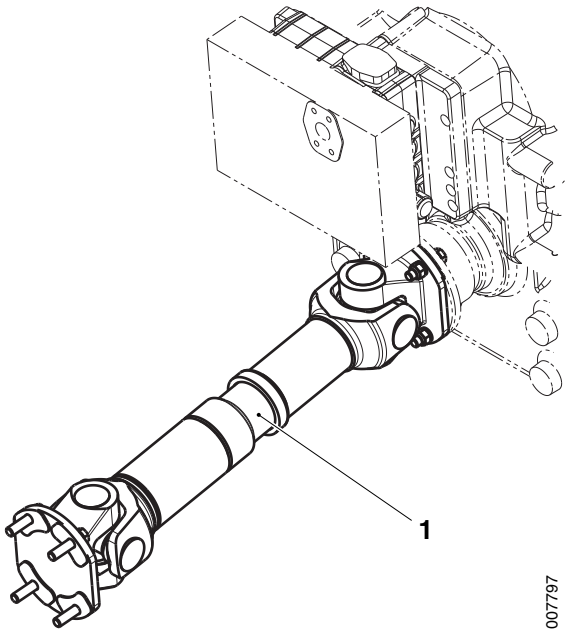


Principle figure, universal joint
1. Lock ring
2. Needle bearing
3. Drive flange fork
4. Spider
5. Drive flange

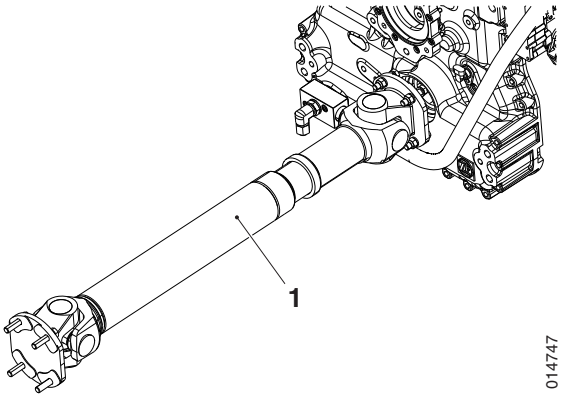


Cross-tooth propeller shaft connection

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Transmission alternative Dana
1. Propeller shaft



Transmission alternative ZF

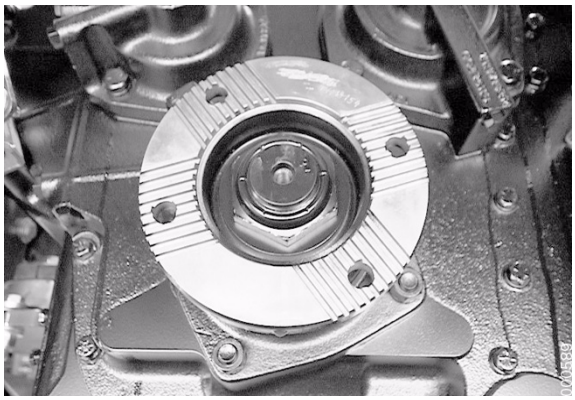
Propeller shaft, replacement

1 Machine in service position, see section *B Safety*.

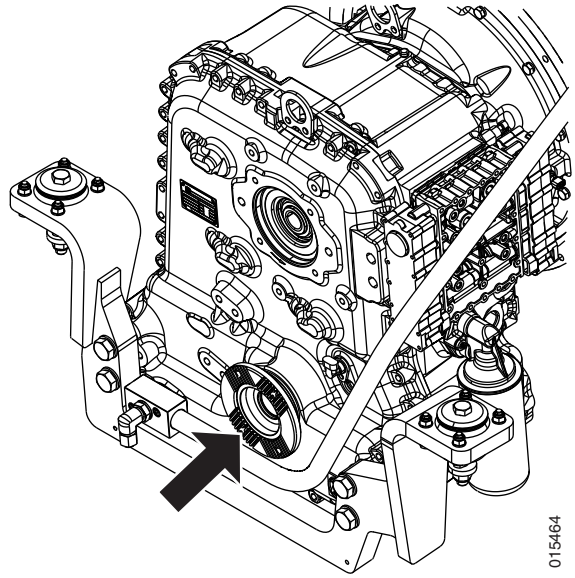
2 Remove the propeller shafts attaching bolts.

Remove the propeller shaft.

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Transmission alternative Dana



Transmission alternative ZF

3 Clean the contact surfaces (cross-toothed) on the drive axle and gearbox.

4 Fit the propeller shaft attaching bolts.

Tightening torque: **98 Nm (oil)**.

Re-tighten the attaching bolts after 50 hours operating time.

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3.3 Drive axle

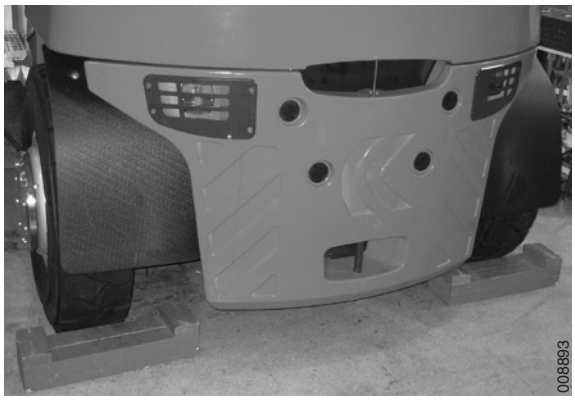
Drive axle, replacement

DANGER

The drive axle and the machine are very heavy.

Risk of pinch injury!

It is not permissible to go under a machine which has been lifted by a jack etc. For machine weights, please refer to section *F Technical data*.

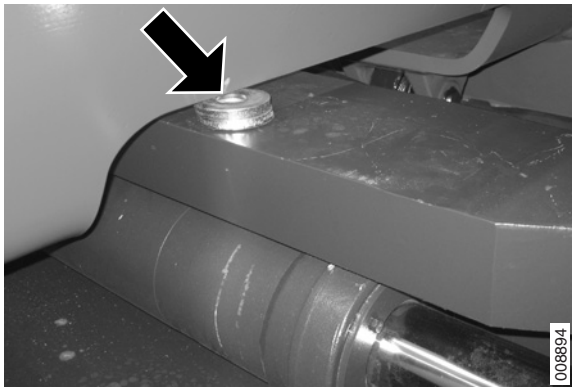


1 Park the machine with blocks behind the steering wheels.

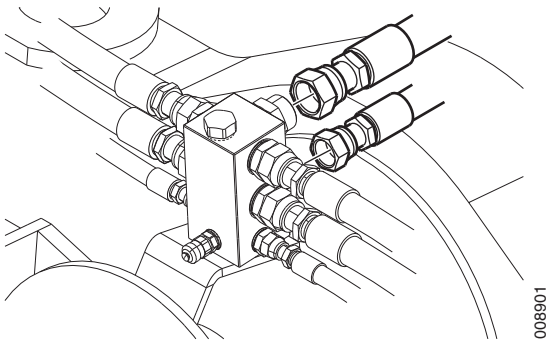
2 Stop the engine and turn the starter key to position I.

3 Depressurise and hydraulic system. Please refer to section *B Safety*.

4 Turn the starter key to position 0 and cut the main current.



5 Insert suitable support between steering axle and frame on both sides.

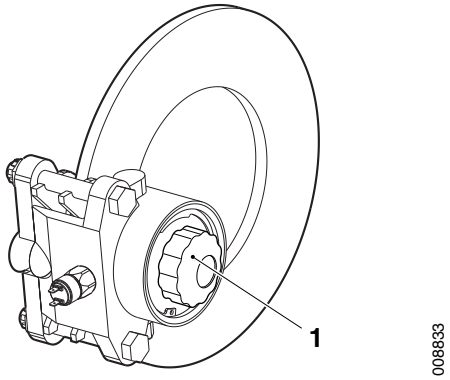


6 Undo the hydraulic hoses from the distribution block.

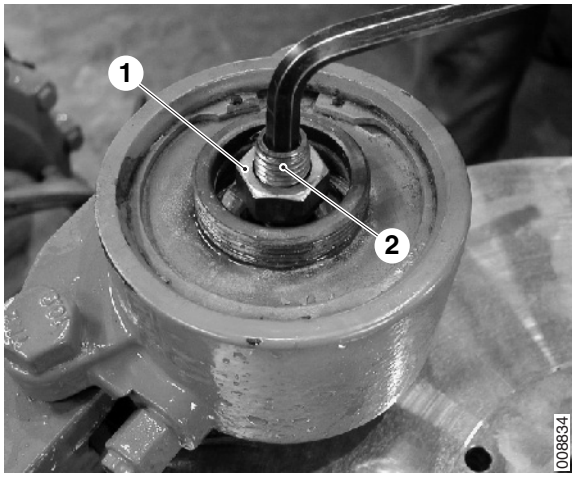
NOTE

Plug all unions at once to protect the hydraulic system from contamination.

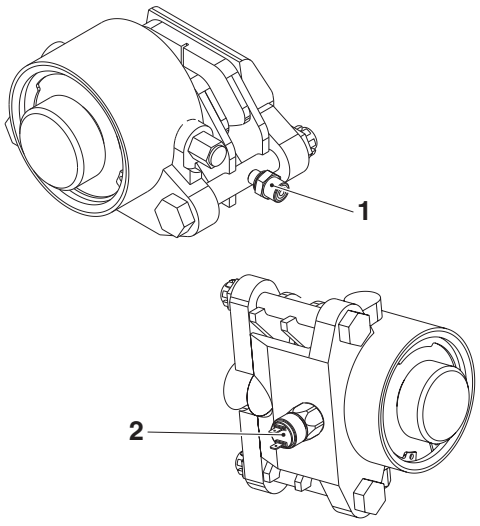
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7 Remove the cover (position 1) over the parking brake.



8 Undo the locknut (position 1) and tighten the screw (position 2). This compresses the brake spring. Tighten until the brake pads come loose from the brake discs. Put back the cover (position 1) over the parking brake.

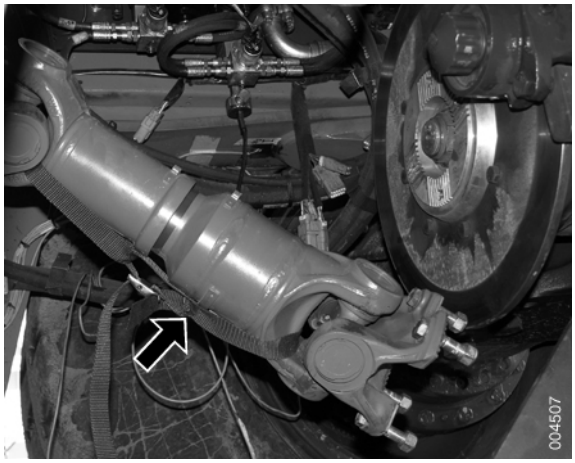


9 Undo the hydraulic hose (position 1) and unplug the switch (position 2) from the parking brake.

NOTE

Plug all unions at once to protect the hydraulic system from contamination.

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10 Undo the propeller shaft from the drive axle. Fix the propeller shaft. There is a risk that it would otherwise be pulled apart.



Lift the machine

11 Connect lifting equipment to the lifting lugs on the mast in a secure manner and lift the machine so the drive wheels are lifted from the ground.

12 Remove the drive wheels from the drive axle.

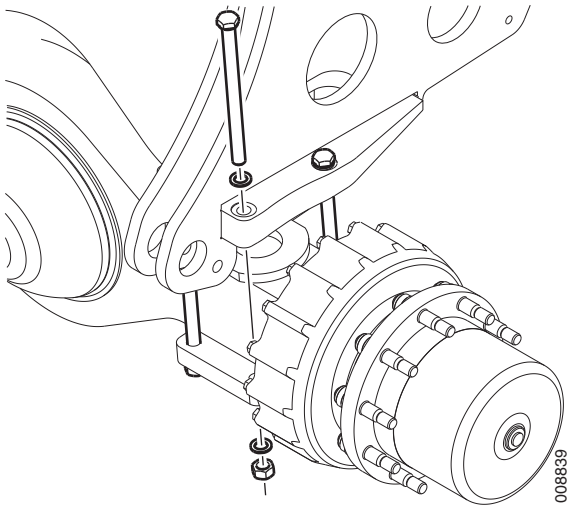
13 Block up the drive axle under the hubs.

⚠ CAUTION

The drive axle can start to roll away!

Pinch risk!

Make sure that the drive axle does not roll away when not under control.



14 Undo the screws which fix the drive axle to the frame.

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15 Lift the machine up so that the frame is lifted away from the axle.

NOTE

If the distribution block is released from the bracket the frame does not need to be lifted so high to get the drive axle out.

16 Lift out the drive axle.

⚠ CAUTION

The drive axle can start to roll away!

Pinch risk!

Make sure that the drive axle does not roll away when not under control.

17 Transfer the equipment from the old axle to the new axle.

18 Clean the mating surfaces on the driving axle and frame. Also clean the mating surfaces for the washers underneath the drive axle.

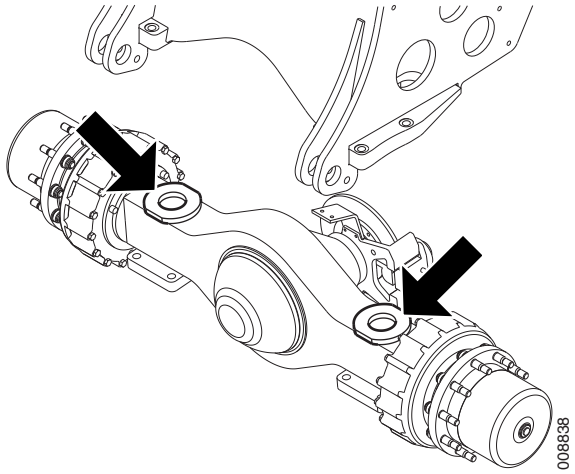
19 Lift the drive axle in under the frame.

⚠ CAUTION

The drive axle can start to roll away if not under control!

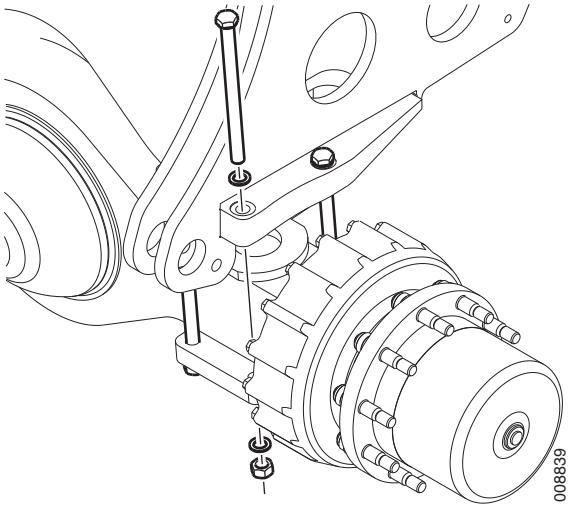
Pinch risk!

Make sure that the drive axle does not roll away when not under control.



20 Lower the frame down onto the drive axle. Check that the guides fit and that the drive axle is centred in the frame.

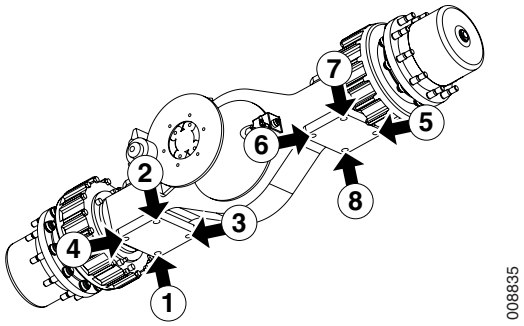
https://truckmanualshub.com/



21 Fix the new screws which fix the drive axle to the frame.

NOTE

Check that the threads are not damaged and that all dirt is removed. This is important to obtain the correct torque.



22 Start by tightening all nuts in number order (positions 1-8) tight enough to give metal contact between the drive axle and the chassis.

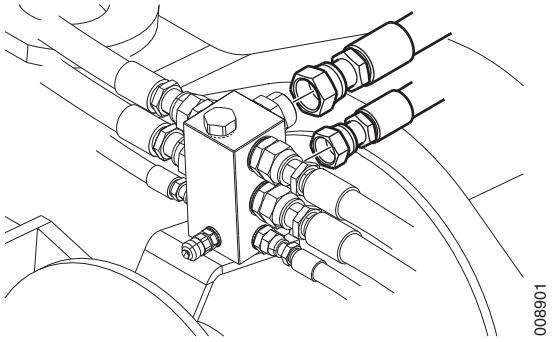
NOTE

Check that there is full contact between the drive axle and the chassis for all bolts.

Continue to tighten all nuts in number order (positions 1-8) to half torque **325 Nm** (oil).

Finish by tightening all nuts in number order (positions 1-8) to full torque **650 Nm** (oil), (Re-tighten the attaching bolts after 50 hours operating time).

23 Rust proof the new screws with suitable paint.



24 Connect the hydraulic hoses to the distribution block.

25 Connect the hydraulic hose and the cable for the switch to the parking brake, adjust the parking brake, see section *4 Brakes,* group *4.5.4 Parking brake unit*.

26 Connect the propeller shaft to the drive axle, torque the bolts to **98 Nm**. (Re-tighten the attaching bolts after 50 hours operating time).

27 Check the oil level in the drive axle.

28 Start the machine and bleed the brakes, see section *4 Brakes,* group *4.3.10 Wheel brake*.

29 Check carefully that no leakage occurs.

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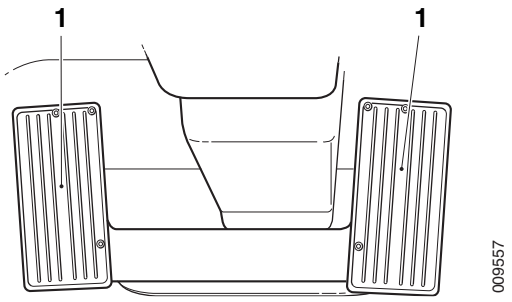
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1. Brake pedal

4 Brakes

4.1 Controls and instruments

4.1.1 Brake pedal

Brake pedal, description

The brake pedal (1) acts on the brake valve via a lever. A spring causes the pedal to return automatically to resting position. It is important to keep it clean around the pedal. Dust and rubbish can cause the pedal to bind, or prevent full depression. The inching pedal (2) is installed on the brake pedal, please refer to section *2 Transmission*, group *2.1.7 Inching*.

When the inching function is used (⊕), a potentiometer (R690) shows the position of the brake pedal. This signal is used by the control unit general (ECU790). When the pedal is depressed to approx. 55%, the transmission is put into neutral.

Brake pedal, reversible driver's seat, description

⊕

In the Spirit Delta cab, there are twin brake pedals when a reversible driver's seat is installed. Only the driving position facing the lifting mast has access to a separate inching pedal.

In the Spirit Delta Space cab, the brake pedals follow with the seat when it is turned round.

Customer specification determines the functions which are activated.

Also refer to section *9 Frame, cab, body and accessories*, group *9.3.9 Reversible driver's seat*.

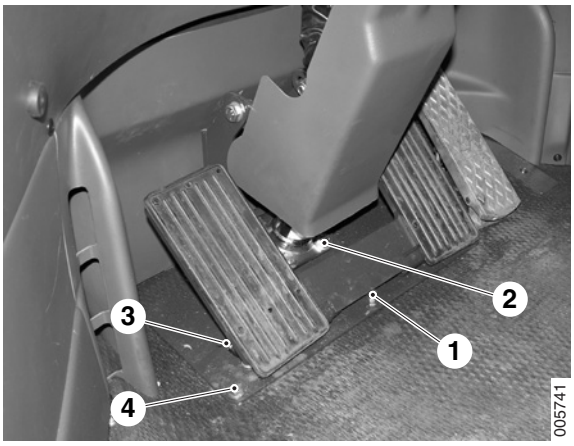
Brake pedal, replacement

1 Machine in service position, see section *B Safety*.

2 Depressurize the hydraulic system, see section *B Safety*.

3 Secure the brake valve and the steering valve on the cab's underside.

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4 Screw down the set screw (position 1) for the brake pedal all the way to facilitate access.

5 Detach the steering valve from the pedal bracket.

Remove the steering valve's attaching bolts (position 2). Pull the valve down slightly so that the steering shaft releases from the steering valve.

6 Detach the brake valve from the brake pedal

Remove the brake valve attaching bolts (position 3) securing the brake valve to the cab floor

7 Remove the four screws (position 4) securing the bracket to the cab floor.

8 Undo the splint pins and drive the shaft out.

9 Replace the brake pedal.

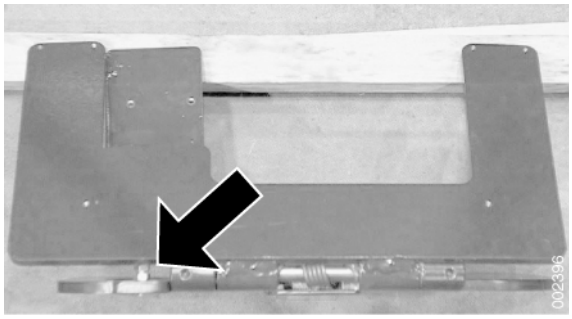
10 Fit in the reverse order.

Brake pedal, inspection and adjustment

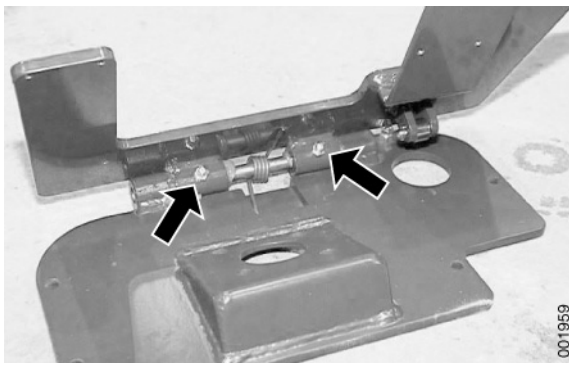
1 Clean the floor round the brake pedal and check that nothing is obstructing the movement of the brake pedal.

2 Check that the brake pedal springs back properly, and that the clearance between the brake pedal and the brake valve is 1-1.5 mm. If necessary, adjust the brake pedal stop screw to give the correct clearance.

3 Check that the pedal moves easily.



Stop screw for adjusting clearance between brake pedal and brake valve. (The illustration shows a loose brake pedal.)



Lubrication points, brake pedal. (The illustration shows a loose brake pedal.)

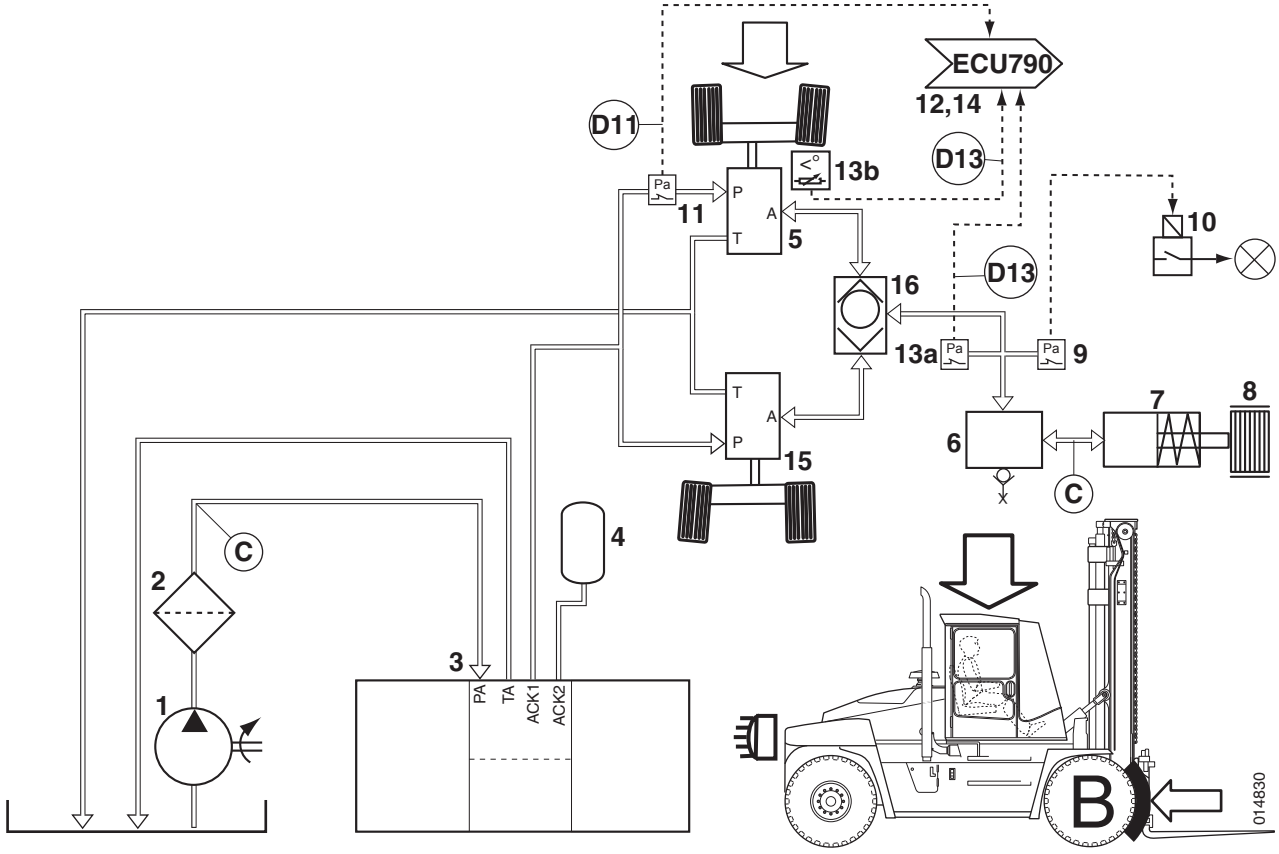
4 Lubricate the pedal hinge with “EP2” universal grease.

5 Check that the rubber pad on the brake pedal is intact and that the pattern is not worn away. Replace as necessary.

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4.3 Power-assisted brake system

Power assisted brake system, function description



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic oil tank.	P (when the accumulator is charged) = 13.0-16.5 MPa P (during cooling) = 1,0-1,5 MPa	Section *10 Common hydraulics*, group *10.3.1 Tank* Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	The high pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High pressure filter and return filter*
3	The accumulator charging valve directs oil to charging of accumulator or through the brake system's cooling circuit.	P (when the accumulator is charged) = 13.0-16.5 MPa P (during cooling) = < 0.1 MPa	Section *10 Common hydraulics,* group *10.5.2 Accumulator charging valve*
4	The accumulator store oil pressure.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*
5	The brake valve directs pressure from the accumulator to the brake cylinders proportional to pressing of the pedal.	-	*Brake valve, description page 10*

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Pos	Explanation	Signal description	Reference
6	The distribution block guides the oil to the brake cylinders.	-	*Distribution block, description page 13*
7	The brake cylinders compress the discs in the brake unit.	See pressure plate on left-hand front mudguard.	*Wheel brake, description page 18*
8	The wheel brakes brake the machine.	-	*Wheel brake, description page 18*
9	Switch (NO) brake lights (S216) closes the circuit when the brake cylinders are pressurized.	Brake pressure above 0.2 MPa: Conn 1, U = 24 V Conn 2, U = 24 V Brake pressure below 0.2 MPa: Conn 1, U = 24 V Conn 2, U = 0 V	*Switch normally open (NO), brake lights, description page 17*
10	Relay brake light (K308-1) supplies voltage to the brake lights (E411L and E411R).	U = 24 V	Section *9 Frame, body, cab and accessories*, group *9.6.4 Brake lights*
11	Switch (NC) brake pressure (S204) opens the circuit if the pressure in the accumulators is low.	Brake pressure above 11.5 MPa: Conn 1, U = 24 V Conn 2, U = 24 V Brake pressure below 11.5 MPa: Conn 1, U = 24 V Conn 2, U = 0 V	*Switch normally closed (NC), low brake pressure, description page 16* D11: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 2, ECU 790 input K1:22*
12	If the hydraulic brake pressure is too low Control unit general (ECU790) sends a warning of low brake pressure on the CAN bus.	Checked by control system, error shown with error code.	Section *11 Common electrics*, group *11.6 Communication*
13a	Switch (NC) disengagement (S220) opens the circuit if the brake pressure is above 2 MPa and sends a signal to the Control unit general (ECU 790).	U = 24 V	*Switch normally closed (NC), disengagement, description page 15* D13: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU 790 input K1:15*
13b ⊕	On machines equipped with inching, the inching potentiometer brake pedal (R690) opens the circuit if the brake pedal is pressed down to approx. 55% of full stroke and sends a signal to the Control unit general (ECU 790).	U = 0,5-4,5 V	Section *2 Transmission,* group *2.1.7 Inching*. D13: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 4, ECU 790 input K1:27*
14	Control unit general (ECU 790) disengage engine drive.	-	Section *11 Common electrics*, group *11.6 Communication*
15 ⊕	When one of the brake pedals is activated on a machine with reversible operator's position the pressure signal runs to the shuttle valve, double brake pedals.	-	*Shuttle valve dual brake pedals, description page 21*

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Pos	Explanation	Signal description	Reference
16 ⊕	Shuttle valve, double brake pedals sends the pressure signal on to the wheel brakes which are applied in the same way as pos 6–10.	-	*Shuttle valve dual brake pedals, description page 21*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

4.3.1 Pump 3 - accumulator charging, flushing/cooling system, brake and servo pressure control levers

Pump 3 - accumulator charging, flushing/cooling system, brake and servo pressure control levers, description

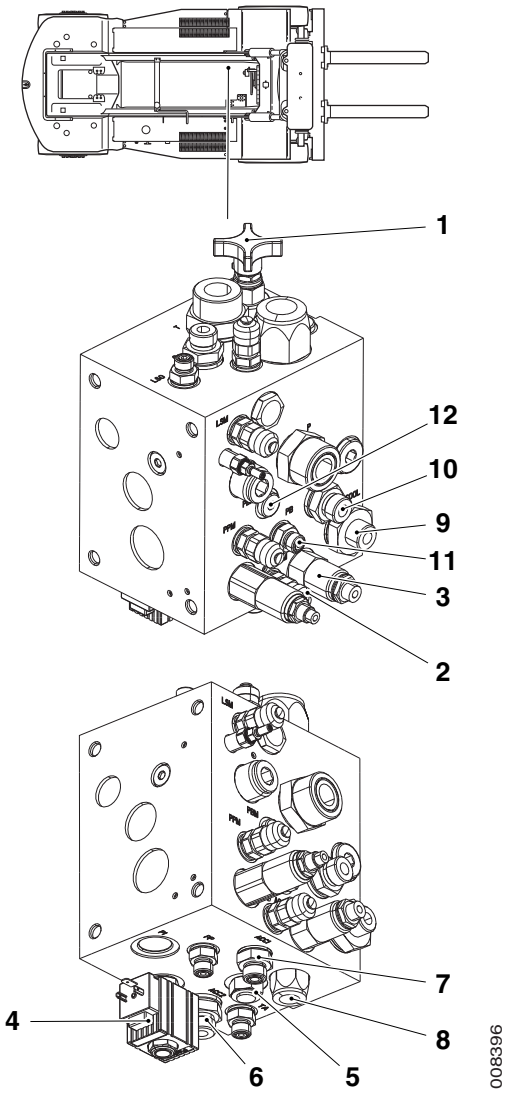
The brakes are fed by a hydraulic oil pump for the brakes and servo pressure. See section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

4.3.2 High-pressure filter

High-pressure filter, description

See *High pressure filter, description page 33*.

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Main valve block
1. Accumulator drain valve (TA)
2. Accumulator pressure measuring nipple (ACCM)
3. Accumulator charging valve
4. Parking brake valve (solenoid valve) (Y642)
5. Non-return valve, accumulator charging
6. Accumulator port (ACC2)
7. Port for brake valve (ACC1)
8. Priority valve for accumulator charging pressure
9. Flushing circuit (COOL)
10. Incoming pump pressure/feed (PA)
11. Parking brake calliper connection (PB)
12. Port for switch (NO), parking brake (S200) (PBM)

4.3.3 Main valve

Main valve, description

There are several different cartridges/valves grouped in the main valve block. This section only describes those that concern the service brake system. See section *10 Common Hydraulics*, group *10.5.2 Main valve* for further information.

The accumulator charging valve directs oil either to the accumulator or through the drive axle to the wheel brakes for cooling. Adjustable charge pressure.

The priority valve is controlled by the accumulator charging valve and gives priority to accumulator charging before cooling. A restriction for charging results in a small flow going to cooling also during accumulator charging.

There is a connection for measuring accumulator pressure. The port is stamped with the designation ACCM on the valve block.

The feed circuit connects to port PA in the valve block.

The accumulator drain valve is located in port TA on top of the valve block. This is where the hydraulic system pressure is released prior to all work on the brake system.

The accumulator connects to port ACC2 in the valve block.

The brake valve connects to ACC1 in the valve block, see *Brake valve, description page 10*.

The parking brake valve is located in port PB in the valve block and is a voltage-controlled solenoid valve (on/off). Voltage on releases the parking brake.

The Switch (NO), parking brake (S200) (50 bar) is located in port PBM in the valve block.

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4.3.3.1 Accumulator charging valve

Accumulator charging valve, description

See section *10 Common Hydraulics*, group *10.5.2 Main valve*.

4.3.3.2 Non-return valve

Non-return valve, description

The non-return valve prevents draining of the accumulator when the circulation is opened.

4.3.3.3 Priority valve

Priority valve, description

See section *10 Common Hydraulics*, group *10.5.2 Main valve*.

4.3.3.4 Accumulator drain valve

Accumulator drain valve, description

See section *10 Common Hydraulics*, group *10.5.2 Main valve*.

4.3.3.5 Parking brake valve

Parking brake valve, description

The parking brake valve opens a connection between the accumulator and the parking brake calliper. See also *Parking brake valve, description page 25*.

4.3.4 Accumulator

Accumulator, description

See section *10 Common Hydraulics*, group *10.3.2 Accumulator*.

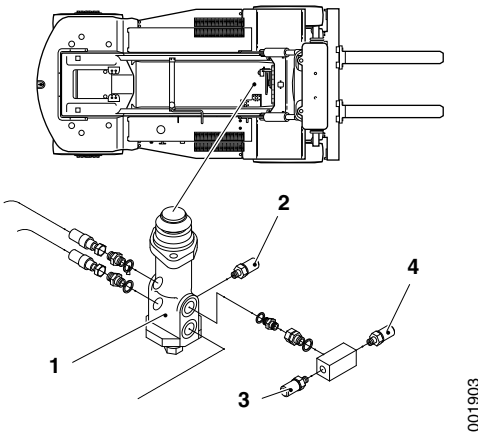
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4.3.5 Brake valve

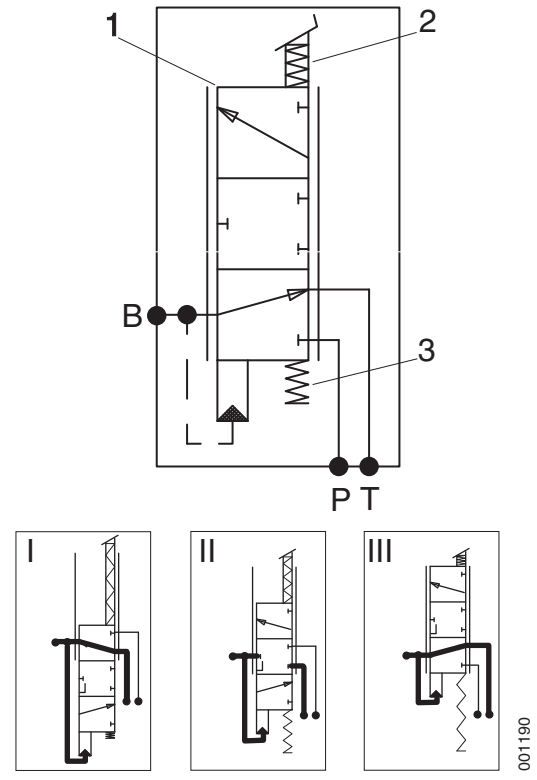
Brake valve, description

The brake valve controls the hydraulic pressure to the brakes. The valve is pressurized by the accumulator. The brake valve is mounted under the cab floor, a lever transmits the pedal force to the valve.

The foot brake valve is a mechanically activated pressure reducing valve. It is a two-step valve; depressing the brake pedal half way gives a pressure of 27 bar, and depressing it fully gives a pressure of 100 bar. This means that the feel of the pedal is good as well as increasing safety, since the operator can easily feel if no brake pressure builds up (no resistance in pedal).



1. Brake valve
2. Switch normally closed (NC), low brake pressure (S204) (white)
3. Switch normally closed (NC), disengagement (S220) (green)
4. Switch normally open (NO) brake lights (S216) (red)



1. Valve spool
2. Main pressure spring
3. Return spring

Braking

1. Position III

   With the brake pedal released, the valve spool (pos. 1 in figure) is held in place by springs (2 and 3). The inlet from the accumulator is closed and the connection between the brake circuit and tank is open.

2. Position I

   The pedal is depressed and the valve spool (1) opens the connection between the inlet from the accumulator (P) and the brake circuit (B).

3. Pressure builds up in the brake circuit. The pressure in the brake circuit is used as back-pressure on the underside of the valve spool (1), which acts against the main pressure spring (2).

4. The valve spool (1) is pressed upward until balance is obtained between pedal force and brake pressure.

5. Position II

   In the balanced position, the valve slide closes the connection between the accumulator and the brake circuit. The brake pressure is constant. This results in the brake pressure increasing proportionally to the force on the brake pedal.

6. The brake pedal is released, the return spring (3) and the control pressure on the underside of the piston press up the valve spool (1).

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7. Position III

   The valve spool (1) opens the connection between the brake circuit (B) and tank (T). The brake pressure is drained to the tank.

8. The control pressure on the underside of the valve spool (1) is reduced and the main pressure spring (2) presses the valve spool (1) downward.

9. The valve spool (pos. 1) closes the outlet to the tank (T).

Brake valve, checking

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Operate and warm up the machine so that the hydraulic oil reaches operating temperature, at least 50 °C.

2 Machine in service position, see section *B Safety*.

3 Connect a pressure gauge (0-25 MPa) to the measuring outlet for brake pressure on the distribution block.

4 Start the machine and run it at idling speed until the accumulator is charged and the accumulator charging valve changes to cooling.

5 Press the pedal to the bottom and read off the pressure. Compare it with the pressure plate on the left-hand front mudguard.

6 Turn off the engine.

7 Depress the pedal fully and keep it pressed down, check the pressure.

   The brake pressure must correspond with the value specified on the pressure plate and must not decrease from this value for 15 seconds.

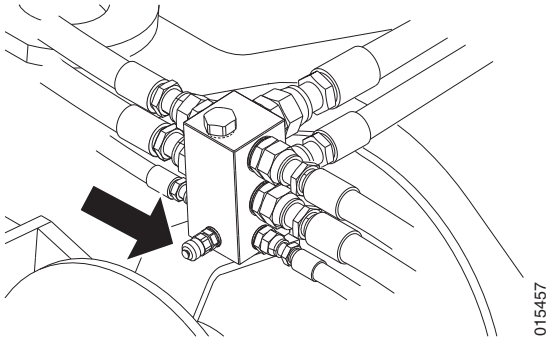
8 Release the pedal, the brake pressure must decrease to 0 MPa immediately.

   If the pressure does not fall fully to 0 MPa, the zero position of the pedal may need to be adjusted. The zero position of the pedal is adjusted with the screw under the pedal, please refer to *Brake pedal, inspection and adjustment page 4*.

   If the brake pedal is correctly adjusted and the pressure does not fall to 0 MPa, the brake valve is not sealed and can cause the brakes to remain applied and then overheat during operation.

   Replace the brake valve if it is not sealed.

9 Remove the pressure gauge and fit the protective cap on the measuring outlet.



Brake pressure measuring nipple on the distribution block

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Brake valve, replacement

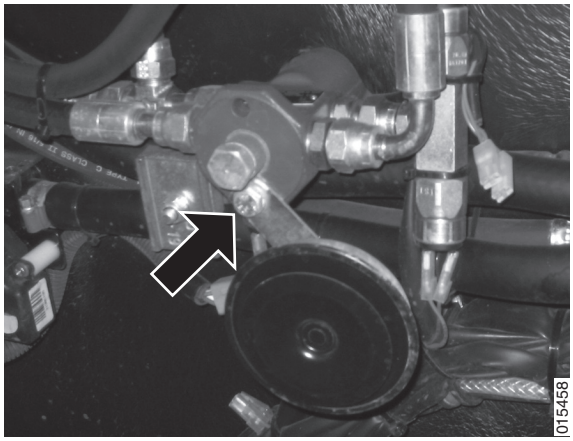
NOTE

Read the safety instructions for oil before working, see section B Safety.

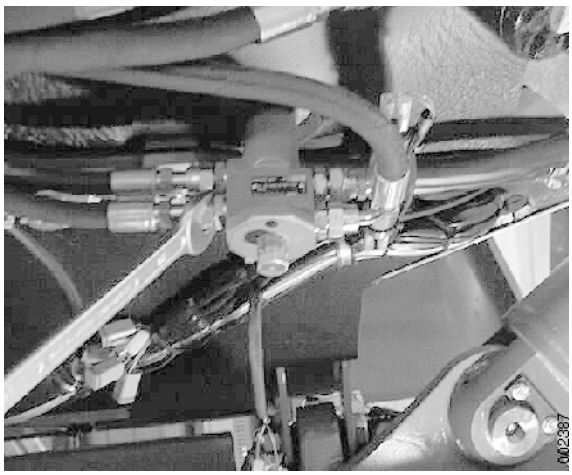
1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

3 Remove the horn from the brake valve. Fit the horn to the new brake valve.



Attachment of horn.

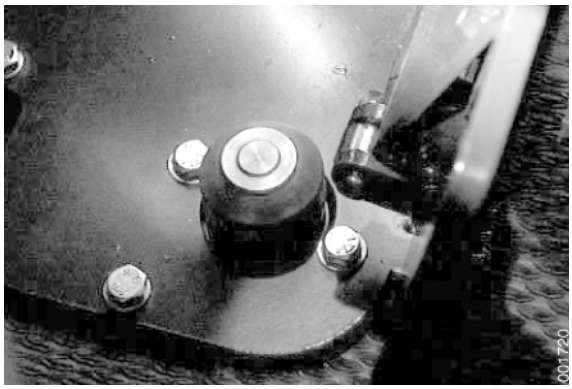


4 Mark up and detach the hydraulic hoses from the brake valve.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

5 Secure the brake valve under the cab.



6 Remove the brake valve attaching bolts.

7 Remove the brake valve by pulling it downward.

8 Transfer the connection adapters to the new brake valve.

9 Fit the new brake valve.

NOTE

Remember the spacer ring.

10 Connect the hydraulic hoses to the brake valve in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

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11 Grease and adjust the brake pedal, see *Brake pedal, inspection and adjustment page 4*.

12 Turn on the main electric power and start the engine. Run the engine at idling speed.

13 Test the brakes a couple of times.

14 Check that the brake valve's connections are sealed tightly.

15 Bleed the wheel brakes' brake cylinders, see *Wheel brakes, bleeding page 18*.

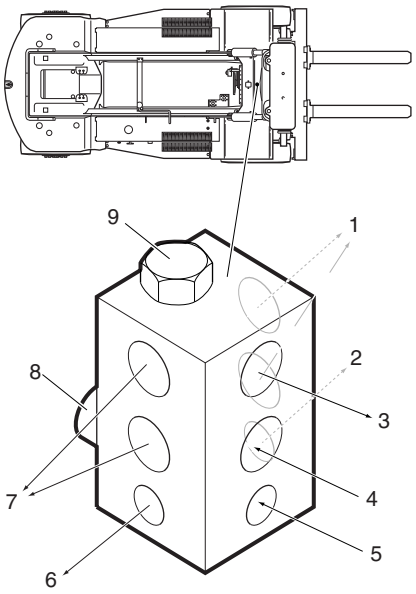
4.3.6 Distribution block

Distribution block, description

On top of the drive axle is a distribution block that divides oil flow and brake pressure between the right and left wheel brake.

The distribution block has measuring connections for brake pressure.

The distribution block has a by-pass valve (opens at pressure above 1 bar) that leads oil directly from the cooling circuit inlet to the cooling circuit return (oil back to tank) if the resistance in the axle becomes too high. This protects the wheel brake seals, for example, when the oil is viscous due to cold or incorrect viscosity.



1. Cooling circuit right brake
2. Brake pressure to right brake
3. Return to tank
4. Cooling circuit in, from valve block, port cool
5. Brake pressure from brake valve, port B
6. Brake pressure to left wheel housing
7. Cooling circuit left brake
8. Brake pressure measuring nipple
9. By-pass valve (1 bar)

Distribution block, replacement

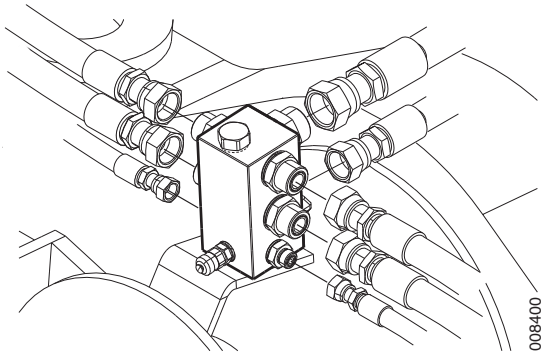
NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

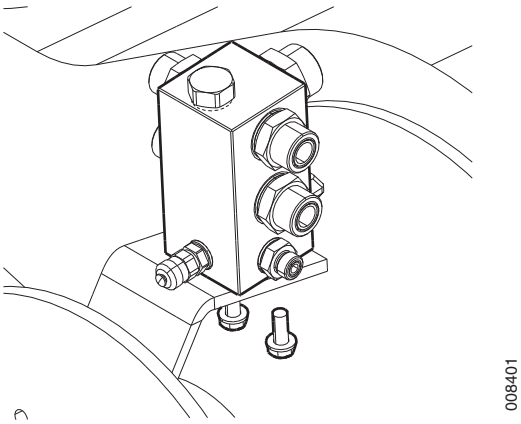
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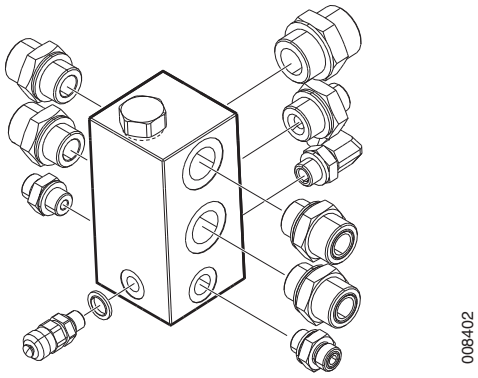
3 Mark up and detach the hydraulic hoses from the distribution block.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.



4 Remove the screws that hold the distribution block.



5 Transfer the connection adapters to the new distribution block.

6 Fit the new distribution block.

7 Connect the hydraulic hoses to the distribution block in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

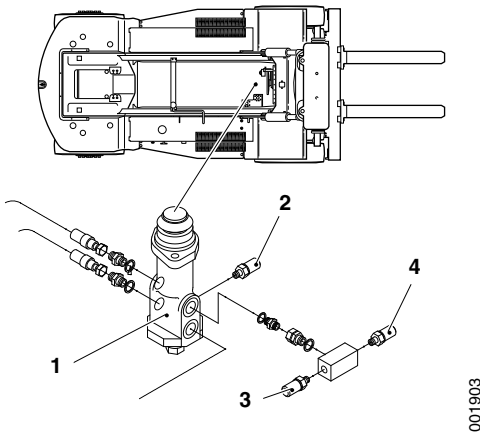
8 Turn on the main electric power and start the engine. Run the engine at idling speed.

9 Test the brakes a couple of times.

10 Check that the distribution block's connections are sealed tightly.

11 Bleed the wheel brakes' brake cylinders, see *Wheel brakes, bleeding page 18*.

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1. Brake valve
2. Switch normally closed (NC), low brake pressure (S204) (white)
3. Switch normally closed (NC), disengagement (S220) (green)
4. Switch normally open (NO) brake lights (S216) (red)

4.3.7 Switch normally closed (NC), disengagement

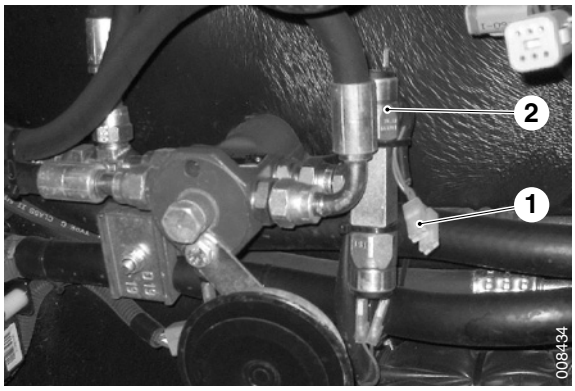
Switch normally closed (NC), disengagement, description

Switch normally closed (NC), disengagement (S220) opens the circuit if the brake pressure is above 2 MPa and sends a signal to the control unit general (ECU 790) to disengage engine drive (makes additional power available for working hydraulics).

See also *Brake valve, description page 10*.

On machines equipped with inching, the inching potentiometer in the brake pedal is used to sense pedal position. When it reaches 55% of full reading, forward driving of the machine is cut off, please refer to Section *2 Transmission,* group *2.1.7 Inching*.

Switch normally closed (NC), disengagement, replacement



NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*
2 Depressurize the hydraulic system, see section *B Safety*.
3 Detach the electrical connectors (position 1) from the contact.
4 Replace the contact (position 2).
5 Fit in the reverse order.

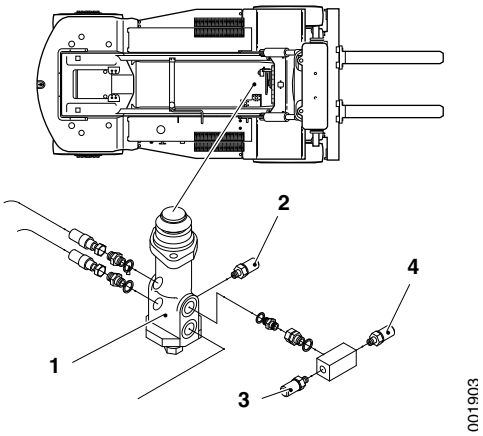
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4.3.8 Switch normally closed (NC), low brake pressure

Switch normally closed (NC), low brake pressure, description

The switch normally closed (NC) for low brake pressure (S204) warns if a drop in pressure occurs in the brake system. The switch is connected to the KCS and an error code is shown on the display if the brake pressure is low. (The sensor's final pressure is set so that there is pressure for another 6–8 brake applications without feed from the pump after the light has come on.)

See also *Brake valve, description page 10*.



1. Brake valve
2. Switch normally closed (NC), low brake pressure (S204) (white)
3. Switch normally closed (NC), disengagement (S220) (green)
4. Switch normally open (NO) brake lights (S216) (red)

Switch normally closed (NC), low brake pressure, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.

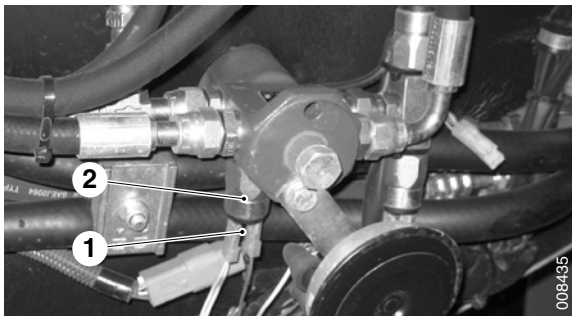
1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

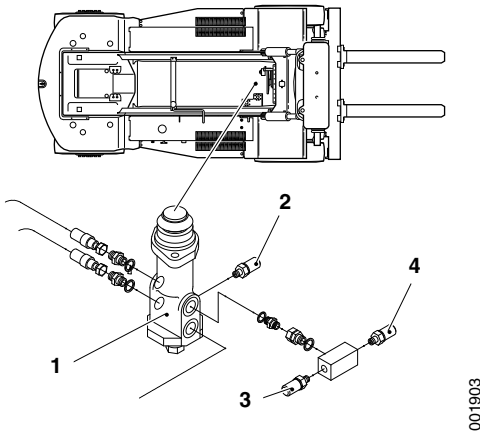
3 Detach the electrical connectors (position 1) from the contact.

4 Replace the contact (position 2).

5 Fit in the reverse order.



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1. Brake valve
2. Switch normally closed (NC), low brake pressure (S204) (white)
3. Switch normally closed (NC), disengagement (S220) (green)
4. Switch normally open (NO) brake lights (S216) (red)

4.3.9 Switch normally open (NO), brake lights

Switch normally open (NO), brake lights, description

Switch normally open (NO), brake lights (S216) activates the brake lights by closing the electric circuit for brake lights when the brake valve opens and pressurizes the wheel brake circuit.

See also *Brake valve, description page 10*.

Switch normally open (NO), brake lights, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.

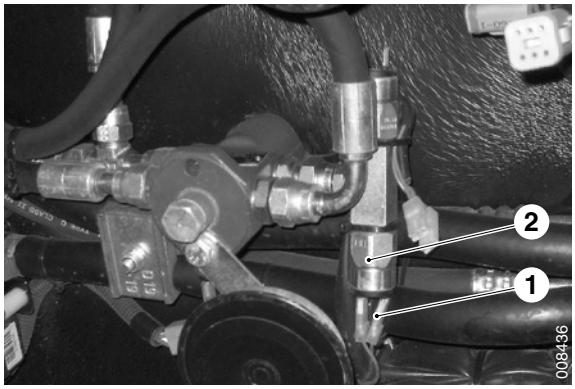
1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

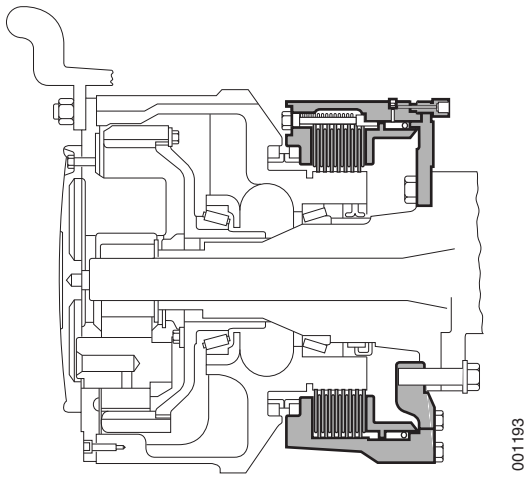
3 Detach the electrical connectors (position 1) from the contact.

4 Replace the switch (position 2).

5 Fit in the reverse order.



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Drive axle with wheel brake, cut-away view

4.3.10 Wheel brake

Wheel brake, description

The wheel brake consists of a disc pack and brake cylinder. It is mounted between the axle and hub reduction. The wheel brake housing is bolted to the axle and its inner part is connected with the hub reduction. The wheels are connected to the hub reduction.

The wheel brake uses wet disc brakes (WDB). Wet disc brakes require minimal maintenance and have long life due to the effective cooling. Maintenance requirements are minimized since the oil circulates in the brake system and counteracts corrosion.

Wheel brakes, bleeding

⚠ WARNING

Warm oil.

Burns, rashes and irritation!

Avoid skin contact with brake oil, use protective gloves.

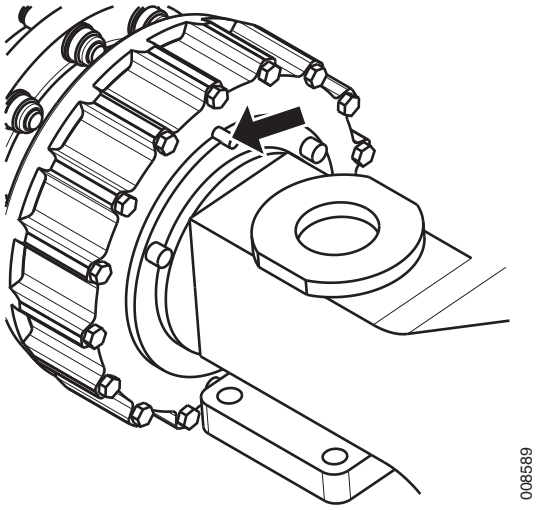
IMPORTANT

Both brake cylinder and disc brake must be bled after work where the brake system is opened or after work on the wheel brake.

Disc brake

1 Machine in service position, see section *B Safety*.

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Bleed nipple, brake cylinder, on top of the drive axle at the wheel hub's inner short side (left-hand side).

2 Place a ring spanner on the bleed nipple and connect a transparent hose to the bleed nipple.

Direct the other end of the hose down into a collection container.

3 Start the machine and press down on the brake pedal, keep the pedal pressed down.

4 Open the bleed nipple and allow oil to run out of it until the oil is free of air bubbles.

NOTE

The hydraulic hose between the brake pedal and brake is approx. 3 metres long. So allow at least two litres of oil to pass through the bleed nipple when bleeding to ensure that no air pockets remain in the system.

5 Close the bleed nipple.

6 Move the spanner and hose and repeat steps 1–5 on the other side.

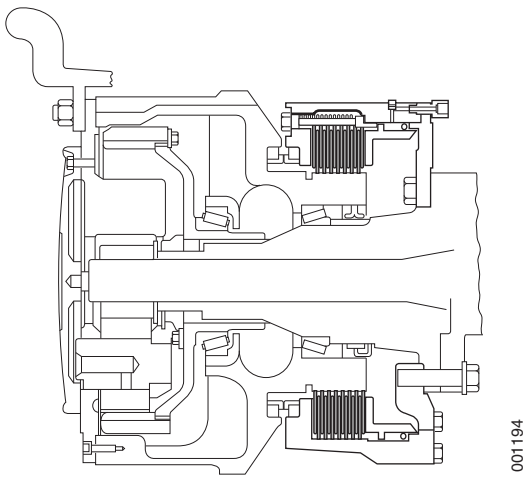
4.3.10.1 Disc pack

Disc pack, description

The disc pack consists of several thin metal discs fixed alternately to the wheel brake housing and to the hub reduction housing. The discs are mounted on splines, which allows them to move laterally.

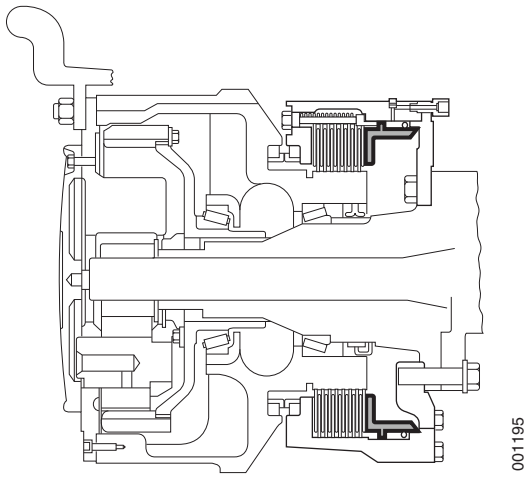
Oil circulates between the discs cooling them, thus the name wet disc brake. The oil is the same as in other parts of the brake system.

Braking is effected by the brake cylinder pressing together the discs. This creates friction between the discs that are fixed to the axle and those fixed to the hub reduction.



Cross section of disc pack

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Brake cylinder

4.3.10.2 Brake cylinder

Brake cylinder, description

The brake cylinder is integrated in the wheel brake and consists of a metal ring (cylinder) with two seal rings. The seals have lateral support from a bevel on the cylinder and a bevel on the wheel brake housing.

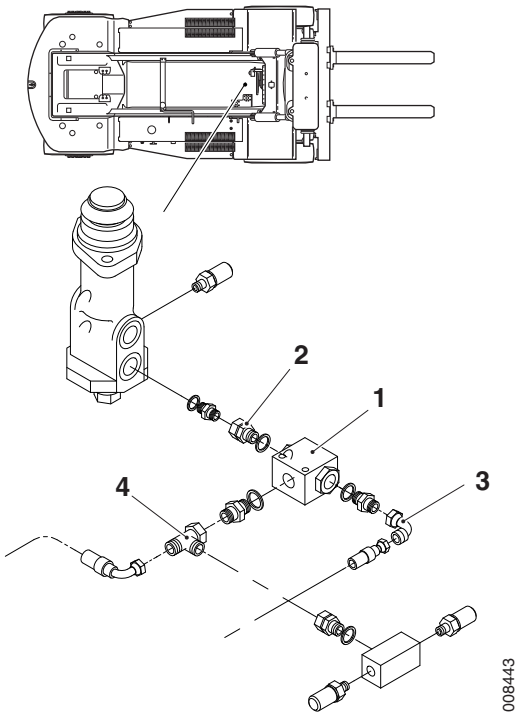
The space between the seal rings is pressurized through a channel in the wheel brake housing. The pressure moves the metal ring sideways and compresses the disc pack.

4.3.11 Pipes and hoses

Pipes and hoses, description

See section *10 Common Hydraulics*, group *10.5.1 Pipes and hoses*.

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1. Shuttle valve
2. Brake pressure from brake valve (driving forward)
3. Brake pressure from brake valve (driving backward)
4. Brake pressure to wheel brake

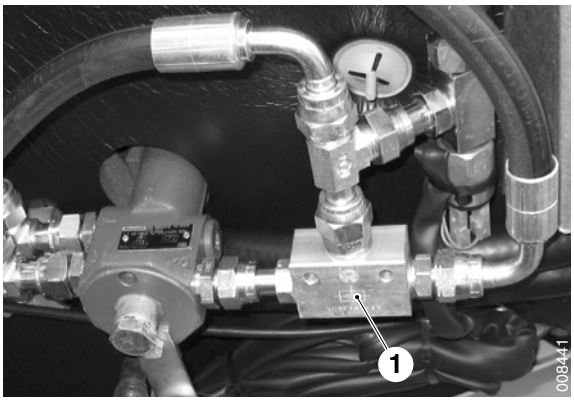
4.3.14 Shuttle valve dual brake pedals

Shuttle valve dual brake pedals, description

Machines with a reversible operator's position have an extra brake pedal and brake valve for driving with the position facing rearward. The shuttle valve selects the strongest brake signal and transmits this to the wheel brakes. The shuttle valve is located on the underside of the cab floor.

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Shuttle valve dual brake pedals, replacement



1. Shuttle valve

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

3 Mark up and detach the hydraulic hoses and fittings from the shuttle valve (position 1).

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

4 Remove the socket cap screws that hold the shuttle valve.

5 Transfer the connection adapters to the new shuttle valve.

6 Fit the new shuttle valve.

7 Connect the hydraulic hose and the fittings to the shuttle valve in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

8 Turn on the main electric power and start the engine. Run the engine at idling speed.

9 Test the brakes a couple of times.

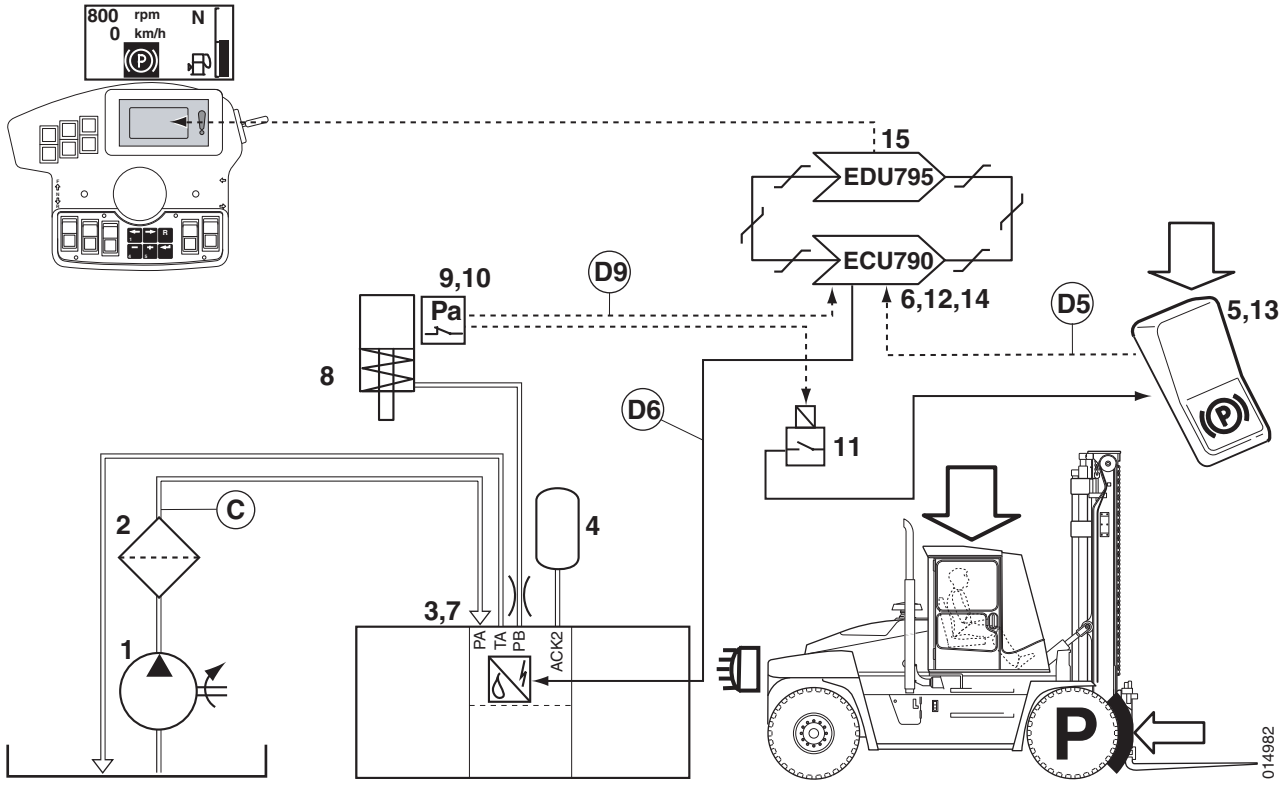
10 Check that the shuttle valve's connections are sealed tightly.

11 Bleed the wheel brakes' brake cylinders, see *Wheel brakes, bleeding page 18*.

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4.5 Parking brake system

Parking brake system, function description



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic oil tank.	P (when the accumulator is charged) = 13.0-16.5 MPa P (during cooling) = < 0.1 MPa	Section *10 Common hydraulics*, group *10.3.1 Tank* Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	The high pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High pressure filter*
3	The accumulator charging valve directs oil to charging of accumulator or through the brake system's cooling circuit.	P (when the accumulator is charged) = 13.0-16.5 MPa P (during cooling) = < 0.1 MPa	Section *10 Common hydraulics,* group *10.5.2 Accumulator charging valve*
4	The accumulator store oil pressure.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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Pos	Explanation	Signal description	Reference
5	Switch parking brake (S107) activates the parking brake by sending a voltage signal to Control unit general (ECU 790). The switch uses a signal with two levels, one for applied and one for released parking brake. Both levels must be correct to enable release of the parking brake.	Switch activated: Conn. 1, U = 22–28 V Conn. 7, U = 0 V Switch in resting position: Conn. 1, U = 0 V Conn. 7, U = 22–28 V	Section *9 Frame, body, cab and accessories,* group *9.1 Controls and instruments* D5: Diagnostic menu, see section *8 Control system*, group *8.4.1.2 View Inputs, menu 2, ECU 790 output K1:23*
6	Control unit general (ECU 790) activates Solenoid valve parking brake (Y642).	U = 24 V	*Parking brake valve, description page 25* D6: Diagnostic menu, see section *8 Control system*, group *8.4.1.2 View outputs, menu 3, ECU 790 output K2:14*
7	Solenoid valve parking brake (Y642) affects the valve slide which drains pressure in the parking brake calliper to tank.	Pump pressure	*Parking brake valve, description page 25*
8	The brake calliper is drained of pressure and the spring applies the parking brake.	0 MPa	*Parking brake unit, description page 27*
9	Switch (NO) parking brake (S200) closes the circuit when the pressure increases and sends a voltage signal to Control unit general (ECU 790).	Applied parking brake: Conn 1, U = 24 V Conn. 2, U= 0 V Released parking brake: Conn 1, U = 24 V Conn 2, U = 24 V	*Switch normally open (NO), parking brake, description page 30* D9: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 1, ECU 790 output K1:14*
10	Switch (NO) parking brake (S200) also sends a voltage signal to Relay parking brake (K314).	U = 24 V	*Parking brake valve, description page 25*
11	Relay parking brake (K314) closes Indicating lamp in switch parking brake (S107) to earth and sends a signal to Control unit general (ECU 790).	U = 24 V	Section *9 Frame, body, cab and accessories,* group *9.1 Controls and instruments*
12	Control unit general (ECU 790) sends a signal over CAN-bus to allow activating of inching ⊕ / declutching.	U = 24 V	Section *11 Common electrics*, group *11.5.3.2 Control unit ECU 790*
13	Indicating lamp in switch parking brake (S107) is activated and a signal is sent to Control unit general (ECU 790).	U = 24 V	Section *9 Frame, body, cab and accessories,* group *9.1 Controls and instruments*

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Pos	Explanation	Signal description	Reference
14	Control unit general (ECU 790) sends information over CAN-bus to Control unit terminal (EDU795).	Checked by control system, error shown with error code.	Section *11 Common electrics*, group *11.5.3.2 Control unit ECU 790*
15	Control unit terminal (EDU795) shows parking brake activated with a symbol in the display.	U = 24 V	Section *11 Common electrics*, group *11.5.3.1 Control unit EDU 795*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

4.5.1 Pump 3 - accumulator charging, flushing/cooling system, brake and servo pressure control levers

Pump 3 - accumulator charging, flushing/cooling system, brake and servo pressure control levers, description

The brakes are fed by a hydraulic oil pump for the brakes and servo pressure. See section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

4.5.2 High pressure filter

High pressure filter, description

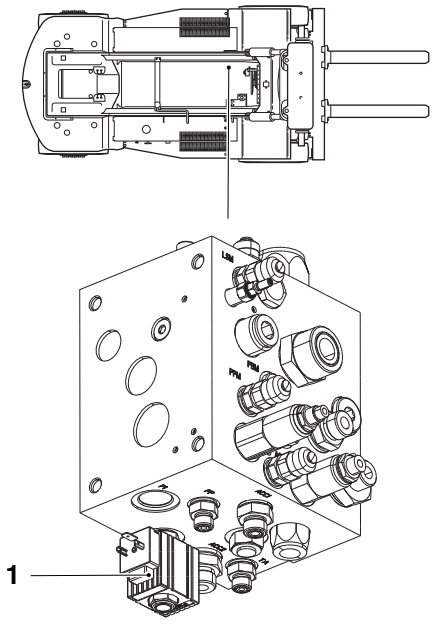
See *High pressure filter, description page 33*.

4.5.3 Parking brake valve

Parking brake valve, description

The parking brake valve (Y642) is an electrically controlled solenoid valve that is integrated in the valve block. See also *Main valve, description page 8*. When voltage is supplied to the valve, it opens to pressure on the condition that the accumulator is charged. The oil passes on and compresses the spring assembly in the parking brake calliper. The parking brake is released.

If the parking brake circuit pressure is released (below 50 bar), the oil drains to the tank and the spring assembly applies the brake calliper.



1. Parking brake valve (solenoid valve) (Y642)

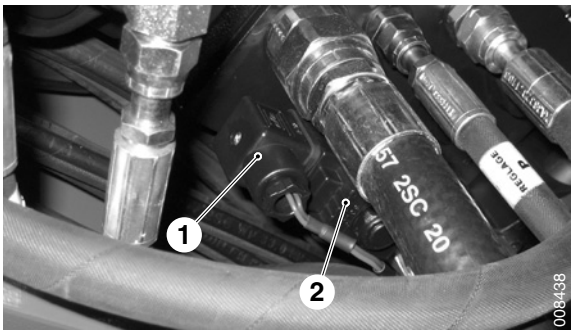
Apply parking brake

1. Position I, inactive

   The valve spool opens a connection between the parking brake calliper and tank.
2. The parking brake solenoid is supplied with voltage.
3. The solenoid valve changes the position of the valve spool.
4. Position II, activated

   The valve spool opens a connection between the parking brake circuit's brake calliper and the accumulator. The pressure releases the parking brake.

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1. Connector
2. Valve

Parking brake valve, replacement

1 Machine in service position, see section *B Safety*.
2 Depressurize the hydraulic system, see section *B Safety*.
3 Unplug the connector from the valve.
4 Remove the nut securing the spool.
5 Remove the spool from the valve.
6 Remove the valve from the valve block.
7 Replace the valve.
8 Fit in the reverse order.
9 Turn on the main electric power and start the engine. Run the engine at idling speed.
10 Test the parking brake a couple of times.

Parking brake valve, check

⚠ DANGER

The machine may start to roll.

Risk of crushing.

Block the wheels so that the machine cannot start to roll when the parking brake is released.

1 Start the engine and run the engine at idle until the warning lam for brake pressure goes out and the accumulator charging valve changes to cooling.
2 Switch off the engine and turn the starter key to position I.
3 Release the parking brake with the switch for the parking brake and check that the parking brake's brake caliper releases. The brake caliper should be able to move.
4 Activate the parking brake with the switch for the parking brake and check that the parking brake's brake caliper is applied.

NOTE

As long as there is oil pressure in the accumulator system it is possible to disable the parking brake with switch parking brake when the engine is off.

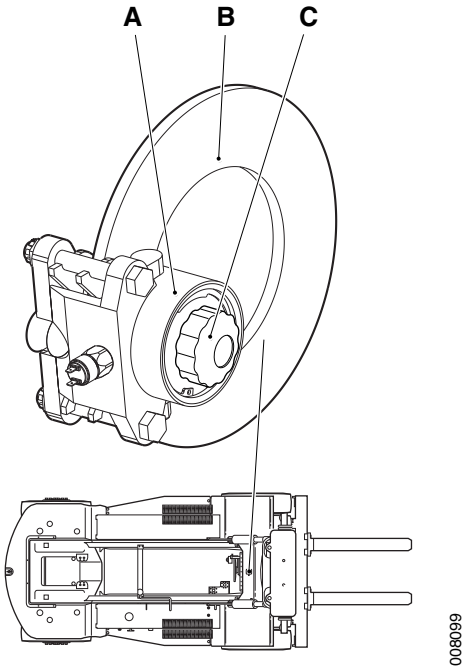
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4.5.4 Parking brake unit

Parking brake unit, description

The parking brake unit keeps the machine stationary when parking. The parking brake unit is located on the drive axle input shaft between the propeller shaft and drive axle.

The parking brake acts on the propeller shaft via a disc mounted on the drive axle input shaft and a brake calliper with dry brake pads mounted in a bracket on the drive axle.



A. Parking brake unit
B. Brake disc for parking brake
C. Protective cover over adjustment screw

NOTE

If the hydraulic pressure in the feed circuit drops, a warning is activated before the pressure drops so low that the parking brake is applied. If the parking brake is applied while the machine is on the move, the brake pads must be checked and brake pads must possibly be replaced.

Parking brake unit, replacement

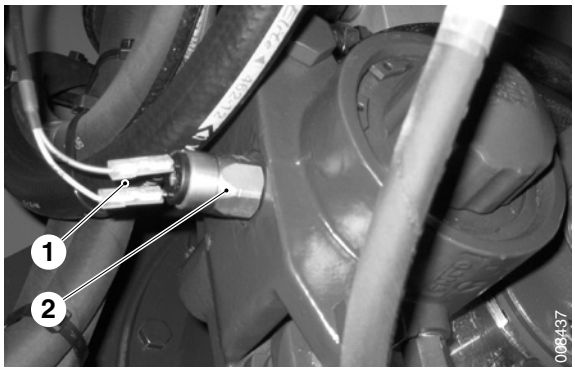
NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

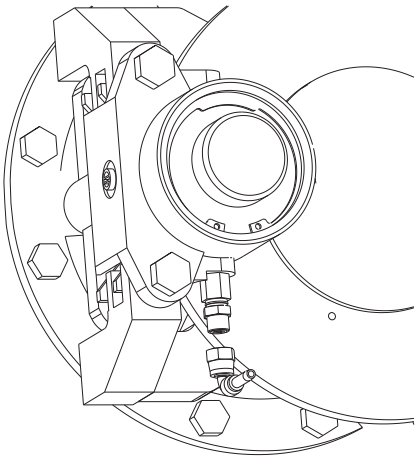
2 Depressurize the hydraulic system, see section *B Safety*.

3 Unplug the connector (position 1) from the switch.



1. Connector
2. Switch

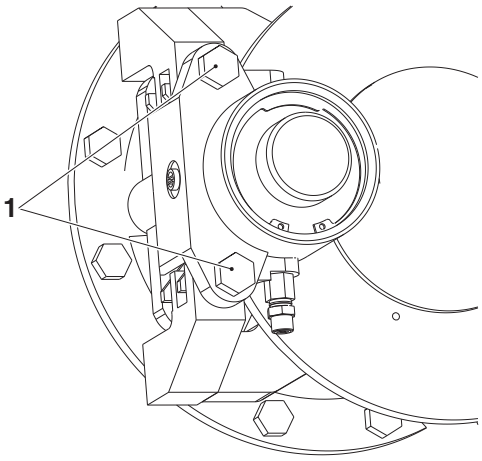
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4 Detach the hydraulic hose from the parking brake unit.

NOTE

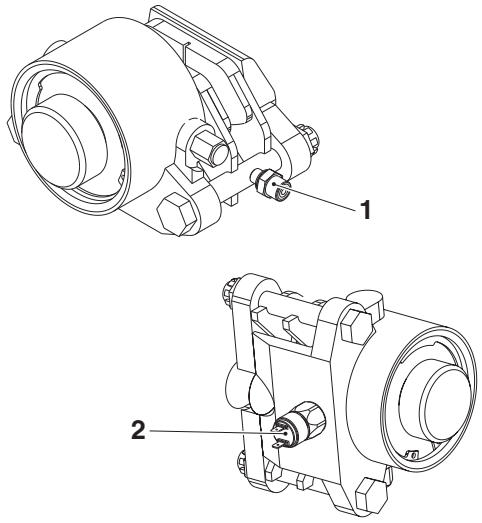
Plug the connection immediately to protect the hydraulic system from impurities.



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5 Remove the parking brake unit attaching bolts (position 1).

6 Remove the parking brake unit.



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7 Transfer the connection adapter (position 1) and switch parking brake (position 2) to the new parking brake unit.

8 Fit the new parking brake unit.

9 Connect the hydraulic hose to the parking brake unit.

NOTE

Check that the O-rings are intact and fitted correctly.

10 Connect the connector to the switch parking brake (position 2).

11 Turn on the main electric power and start the engine. Run the engine at idling speed.

12 Release the parking brake.

1. Connection adapter
2. Switch parking brake

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13 Adjust the adjustment screw so that the brakes are applied.

14 Back off the adjustment screw 0.5±0.1 mm.

15 Tighten the lock nut.

NOTE

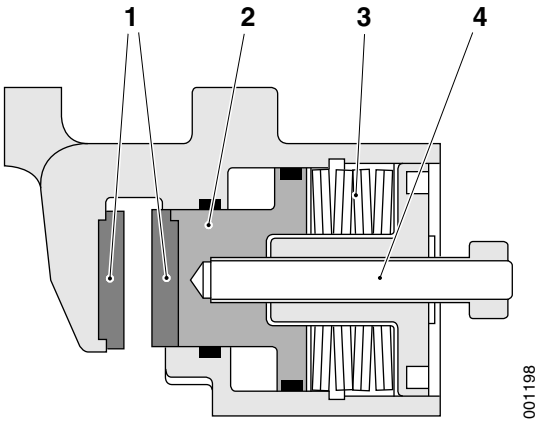
To avoid turning the adjustment screw as well it must be held still when tightening the lock nut.

16 Refit the cover to the calliper.

17 Test the parking brake a couple of times.

18 Check that the hydraulic connections are sealed tightly.

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1. Brake pads
2. Release cylinder
3. Application spring
4. Release screw

4.5.4.1 Parking brake calliper

Parking brake calliper, description

The brake calliper has a spring part and a hydraulic part. The spring part attempts to apply the brake, the hydraulic part is used to release the brake. This results in application of the parking brake if the brake system loses pressure, which in turn means that the machine brakes if a serious malfunction occurs.

4.5.4.2 Parking brake pads

Parking brake pads, description

The brake pads consist of a metal plate with friction material (lining).

4.5.4.3 Parking brake disc

Parking brake disc, description

The brake disc is mounted on the drive axle's input shaft. The drive axle's reduction ratio amplifies the braking force.

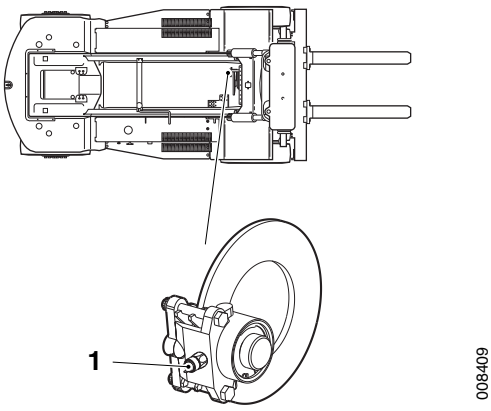
4.5.5 Switch normally open (NO), parking brake

Switch normally open (NO), parking brake, description

Switch (NO), parking brake (S200) senses if the parking brake is applied or released.

Switch (NO), parking brake (S200) senses the pressure in the parking brake circuit. When the pressure is sufficiently high that the parking brake is released, the sensor closes and completes an electric circuit. This is used to indicate that the parking brake has been released.

When the pressure exceeds the make pressure, the Switch (NO), parking brake (S200) sends a voltage signal to Relay parking brake (K314).



1. Switch (NO), parking brake (S200)

NOTE

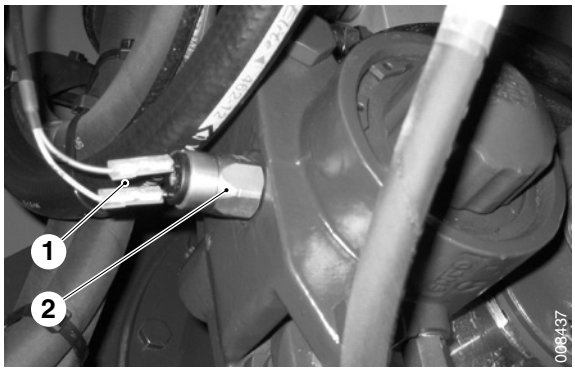
Direction cannot be engaged when the parking brake is applied.

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Switch normally open (NO), parking brake, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.



1 Machine in service position, see section *B Safety*
2 Depressurize the hydraulic system, see section *B Safety*.
3 Unplug the connector (position 1) from the switch.
4 Remove the switch (position 2) from the parking brake unit.
5 Replace the switch.
6 Fit in the reverse order.

4.5.6 Pipes and hoses

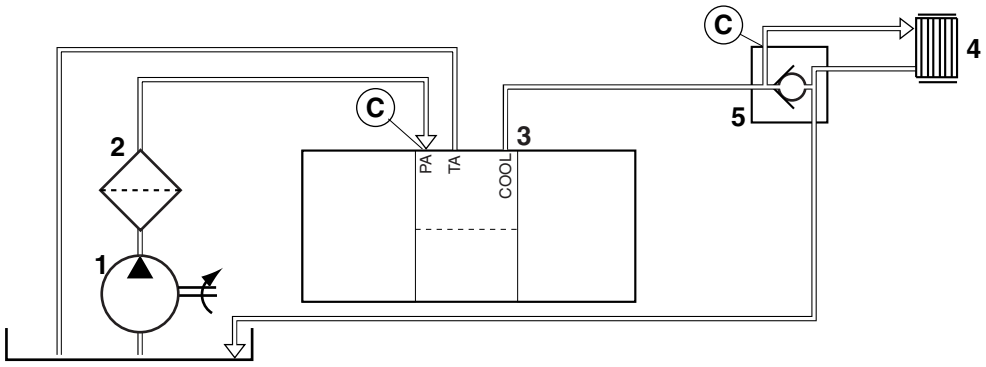
Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

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4.8 Temperature control, cleaning and brake oil

Temperature control, cleaning and brake oil, function description



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic oil tank.	P (when the accumulator is charged) = 13.0-16.5 MPa P (during cooling) = < 0.1 MPa	Section *10 Common hydraulics*, group *10.3.1 Tank* Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	The high pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High pressure filter and return filter*
3	The accumulator charging valve directs oil to charging of accumulators or through the brake system's cooling circuit.	P (when the accumulator is charged) = 13.0-16.5 MPa P (during cooling) = < 0.1 MPa	Section *10 Common hydraulics,* group *10.5.2 Accumulator charging valve*
4	The oil cools the wheel brake.	-	*Wheel brake, description page 18*
5	The by-pass valve in the distribution block leads oil past the drive axle if the back pressure through the wheel brake is too high.	-	*Distribution block, description page 33*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

4.8.1 Hydraulic oil tank

Hydraulic oil tank, description

See section *10 Common Hydraulics*, group *10.3.1 Tank*.

4.8.2 Tank heater

Tank heater, description



See section *10 Common Hydraulics*, group *10.6.1 Tank heater*.

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4.8.3 Pump 3 - accumulator charging, flushing-/ cooling system brake and servo pressure control levers

Pump 3 – accumulator charging, flushing/cooling system and control lever servo pressure, description

See section *10 Common Hydraulics*, group *10.4.1.3 Pump 3 – accumulator charging, flushing/cooling system and control lever servo pressure*.

4.8.4 Accumulator charging valve

Accumulator charging valve, description

See section *10 Common Hydraulics*, group *10.5.2 Main valve*.

4.8.5 Distribution block

Distribution block, description

See *Distribution block, description page 13*.

4.8.6 Wheel brake

Wheel brake, description

See *Wheel brake, description page 18*.

4.8.7 Oil cooler

Oil cooler, description

See section *10 Common Hydraulics*, group *10.6.2 Hydraulic oil cooler*.

4.8.12 High pressure filter

High pressure filter, description

See section *10 Common hydraulics*, group *10.6.8 High-pressure filter*.

4.8.13 Pipes and hoses

Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

4.8.14 Hydraulic oil

Hydraulic oil, description

The brake system uses the same hydraulic oil as the machine's other hydraulic systems, see section *10 Common hydraulics*, group *10.6.9 Hydraulic oil*.

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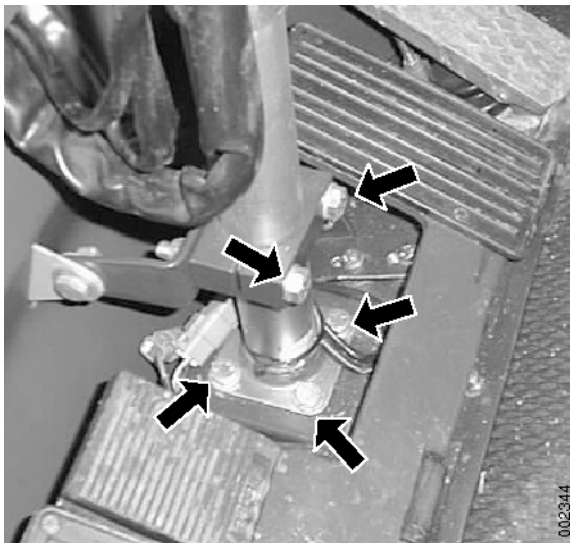
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5 Steering

5.1 Controls and instruments

5.1.1 Steering wheel and steering column

Steering wheel and steering column, replacement



1 Machine in service position, see *B Safety*.

2 Remove the steering wheel, steering panel covers, direction indicators and the covers for the steering column, please refer to section *9 Frame, body, cab and accessories, Group 9.1.1 Multi-function lever, replacement.*

3 Remove the six bolts securing the steering column.

4 Replace the steering column.

5 Fit in the reverse order.

NOTE

Torque the socket cap screws that hold the multi-function lever to the steering column to ***2.5-3.0 Nm.***

Torque the nut in the centre of the steering wheel to ***40 Nm (±5 Nm).***

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5.1.2 Mini-wheel

Mini-wheel, description

The mini-wheel is an electro-hydraulic function for comfortable steering with the arm resting on the left-hand arm rest. The wheels always follow the position of the mini-wheel. If the mini-wheel is released then both steering wheel and wheels remain in set position.

Otherwise the same characteristics and settings apply as for lever steering, see *Feedback lever steering, description page 8*. Amplification factor setting in main loop, see *Feedback lever steering, description page 8*.

The control valve is electrically controlled with one magnet (solenoid) for right and one for left. It controls the oil flow to the steering cylinder. The magnets obtain analogue signals from ECU 792.

The standard steering wheel is equipped with a sensor that checks any steering wheel movements in an emergency situation. As soon as steering with the standard steering wheel is started the mini-wheel is disconnected and the lamp in the switch for forward/reverse goes out.

The following signals are monitored:

- 2-channel, 2-axis potentiometer in left-hand arm rest
- steering valve (impedance and current)

See also *Lever steering/mini-wheel, function description page 18*.

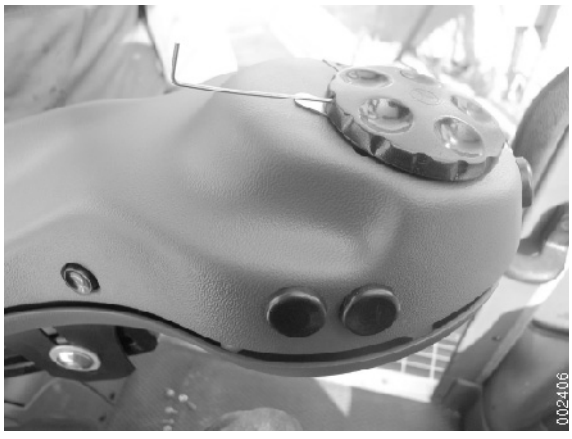
Function test

See *Function test page 9*.

Trouble shooting

See *Trouble shooting page 9*.

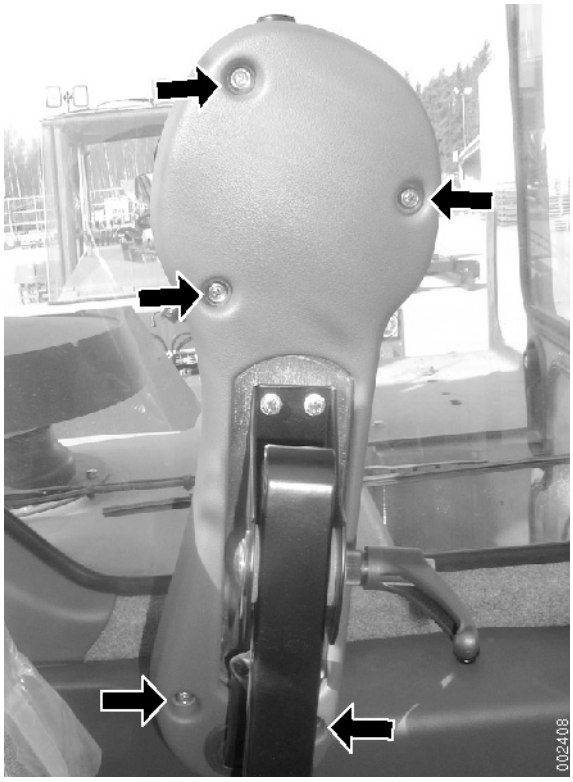
Mini-wheel, replacement



1 Machine in service position.
2 Remove the mini-wheel by undoing the socket cap screw.
3 Replace the mini-wheel.

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Mini-wheel travel direction selector, replacement



1 Machine in service position.

2 Remove the screws securing the top of the plastic panel for the mini-wheel.



3 Unplug the connector from the travel direction selector.

4 Replace the switch.

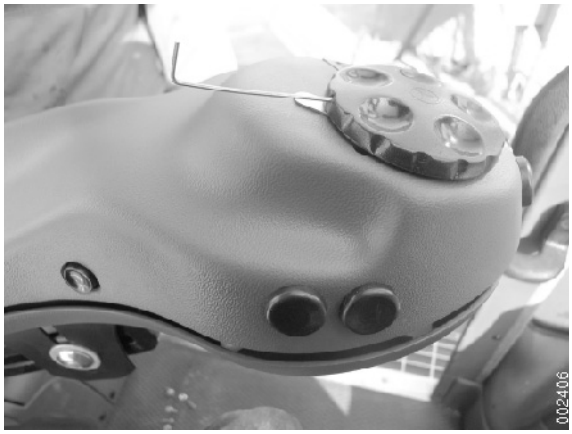
5 Fit in the reverse order.

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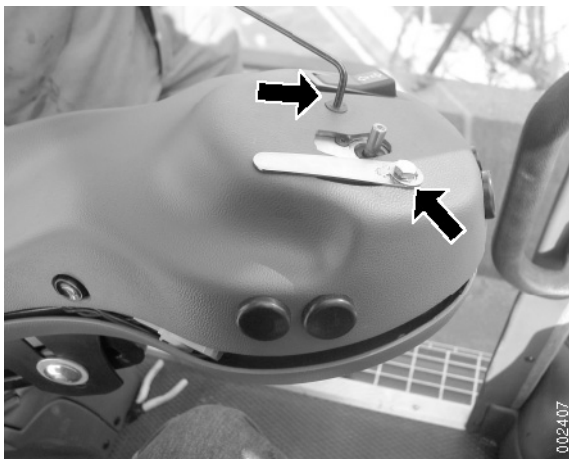
Mini-wheel potentiometer, replacement

1 Machine in service position.

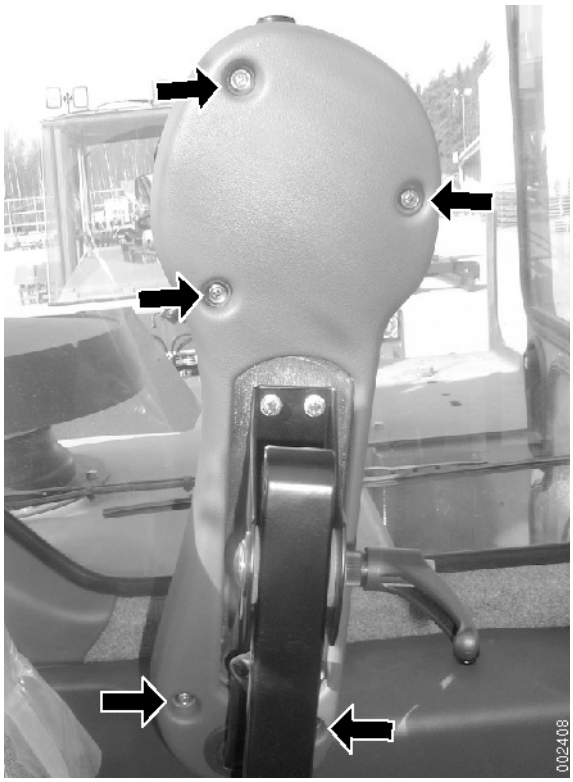
2 Remove the steering wheel by undoing the Allen screw.



3 Remove the Allen screw and nut.



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4 Remove the screws securing the top of the plastic panel for the mini-wheel.



5 Unplug the connectors from the potentiometer.

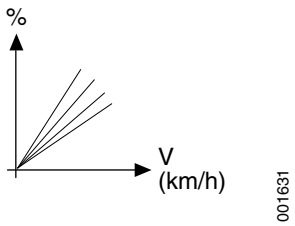
6 Replace the potentiometer.

7 Fit in the reverse order.

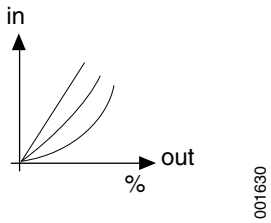
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5.1.3 Lever steering

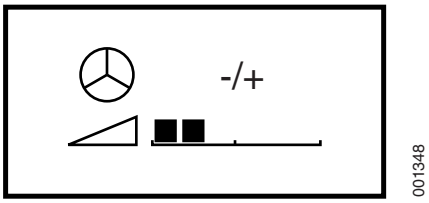
Feedback lever steering, description



Lever steering is an electrically controlled function to steer the machine with a joystick on the left-hand arm rest. The steering angle is inversely proportional to the machine's speed, i.e. low speed gives large angle and vice versa.



The steering angle can also be set in 10 steps from linear (step 0) to maximum exponential (step 10). In this way better response is achieved with small steering angles.



In the menu figure in the main loop there's a setting for the amplification factor from 1 to 9 that the operator can set. It's possible to set which start-up factor that the system should start up with.

The function can be delivered with or without feedback of the wheels' positions. A feedback function means that when the driver releases the lever the wheels return to the centre position, i.e. the wheels always follow the lever. For the function without feedback the wheels remain in the position they are steered to (therefore require steering to the centre position).

The control valve is electrically controlled with one magnet (solenoid) for right and one for left. It controls the oil flow to the steering cylinder. The magnets obtain analogue signals from ECU 792.

The standard steering wheel is equipped with an inductive sensor that recognises any steering wheel movements. The sensor is used to disconnect the lever steering if the driver encounters an emergency situation. As soon as the standard steering wheel is used the lever steering is disconnected and the lamp in the switch for forward/reverse goes out. The arrangement fulfils the safety requirements for a feedback system.

The sensor that recognises and feeds back steering axle angle is located under a cover by the steering axle's left-hand king pin.

The following signals are monitored:

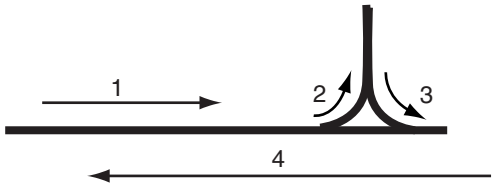
- joystick in left-hand arm rest
- position sensor in wheel axle (feedback lever steering)
- steering valve (impedance and current). Switches off steering in the event of open circuit or short-circuit. Error code is activated.

See also *Lever steering/mini-wheel, function description page 18*

No feedback lever steering, description

See *Feedback lever steering, description page 8*.

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Function test

All test-running with the lever steering or mini-wheel should be performed without load. That's when the steering axle is loaded the most and any problems are felt distinctly.

Check that the lever steering/mini-wheel disengages when the steering wheel is turned. If the steering wheel is turned slowly, steering shall not disengage. Internal leakage in the Orbitrol can turn the steering wheel.

The mini-wheel shall have 6-8 turns from one lock (end-position) to the other. This shall be tested when the machine is rolling slowly (below 5 km/h) and applies when "Sensitivity" is set to 10.

If the machine is operated slowly (below 5 km/h), a small deflection of the lever (or slow turning of the steering wheel) shall result in the steering axle changing position slowly, without jerking or delay. Test both to the right and left.

Test-run in a realistic work operation, for example:

1. Run at full speed forward.
2. Slow down and turn 90 degrees left.
3. Stop and reverse with 90 degree right turn.
4. Run back in the direction you came from.

Does the machine follow the intended path? Place cones to indicate the intended path.

Trouble shooting

All alarms are saved and can be read out according to "Last alarms", see section 8 Control system group 8.4.5 Last alarms. This may be of great value when troubleshooting a machine that, according to the operator/test, has had problems, but that aren't triggered when troubleshooting.

For error code tables, see section *D Error codes*.

A number of fault tracing examples are shown below.

Steering feels good at low speed, but uncontrollable at high speed

Check the following:

1. Setting of start current. See section *8 Control system group 8.5.4.1 Initiating Feedback lever steering, Adjusting lever steering*.
2. Setting of linearity (only applies to lever steering). Can be set in 10 steps from linear (step 0) to maximal gear down sensitivity of lever movements (step 10). This gives improved feel for small steering movements. See section *8 Control system group 8.5.4.1 Initiating Feedback lever steering*.
3. Setting of speed dependence. See section *8 Control system group 8.5.4.1 Initiating Feedback lever steering, Adjusting lever steering*.

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Steering is shut off while operating

This occurs if one of the alarms for lever steering/mini wheel is generated. Steering is shut off for safety reasons.

Steering can also be shut off by the inductive sensor that senses movements of the standard steering wheel.

Check the following:

1. Cause of alarm, see section *D Error codes*.
2. Cabling and inductive sensor for standard steering wheel.

Steering is not shut off when the standard steering wheel is turned

Use diagnostic menus to view input K1:3. Shall give signal 4 times/ steering wheel turn.

Steering can also be shut off by the inductive sensor that senses movements of the standard steering wheel.

Check the following:

1. Inductive sensor for standard steering wheel may be squeezed too hard in its bracket. Replace sensor.
2. Steering wheel console mounted too loosely on steering column. It slides down and sensors are placed incorrectly on the steering column.

Steering cannot be turned on

Conditions for turning on steering:

1. No alarms active
2. Speed below 3 km/h

Wheels goes to end position when lever steering is turned on (only applies to feedback lever steering)

Cause:

1. The wheels have been turned in the wrong direction during calibration, right – left.
2. Electrical connection right – left valve incorrect. K1:6 shall be for steering right. K1:7 shall be for steering left.
3. Valve – steering cylinder, incorrect hydraulic connection. Shift hoses.
4. For reversible operator's seat:

   If steering steers to lock (end-position) only when the seat is reversed. In setup (see section *8 Control system group 8.6 Software*), it's indicated if steering shall switch right/left when the seat is reversed. This depends on if the steering valve is located before or after the valve that changes the Orbitrol's flow to the steering cylinder. Different for DCE50-90 and DCE90-180/DCD200-300.

NOTE

The steering lever's polarity (if value increases or decreases when one steers, i.e. to the right) doesn't matter. Calibration takes care of this.

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Wheels steer in opposite direction of the steering lever.

1. Steering lever has been deflected in the wrong direction when calibrating.
2. Electrical connection right – left valve incorrect. K1:6 shall be for steering right. K1:7 shall be for steering left.
3. Valve – steering cylinder, incorrect hydraulic connection. Shift hoses.
4. For reversible operator's seat: If steering steers to lock (end-position) only when the seat is reversed. In setup (see section *8 Control system group 8.6 Software*) it's indicated if steering shall switch right/left when the seat is reversed. This depends on if the steering valve is located before or after the valve that changes the Orbitrol's flow to the steering cylinder. Different for DCE50-90 and DCE90-180/DCD200-300.

Machine does not run straight ahead (only applies to feedback lever steering)

Check the following:

1. Calibration of steering axle. See section *8 Control system group 8.5.4.2 Calibrating Feedback lever steering*.
2. Calibration of steering lever. See section *8 Control system group 8.5.4.2 Calibrating Feedback lever steering*.
3. Setting of dead zone too high. See section *8 Control system group 8.5.4.1 Initiating Feedback lever steering*.

If this doesn't help, one has to check if some part is loose/has poor connection. This can be done in diagnostics (see section *8 Control system group 8.4.2 ECU 792*) for the steering lever's signal, K1:31 or the steering axle's signal, K1:32.

The value shall remain in the same position if the lever / steering axle comes from right or left.

1. Steering axle. Potentiometer is located under a cover by the steering axle's left spindle bolt (king pin). There must not be any clearance in the mounting between the spindle bolt and potentiometer. Make sure that the spacer in the spindle is fixed and that the stop bolt is tightened against the potentiometer's shaft.
2. Steering lever shall remain in the same position if it comes from the right or left. The top of the steering lever must move freely (not jam/bind against plastic parts in armrest).

Also check that the value from the lever and steering axle changes in linear manner (without skipping) when one steers slowly from lock to lock. This is easiest to see using a "bar graph". This is a graphic bar that changes length depending on the voltage value. Available in "Kalmar Smart Link" (see section *8 Control system group 8.6 Software*) and in some measuring instruments.

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Steering feels jerky or slow (harsh)

Check the following:

1. Setting of min. current for steering valve. If steering is jerky, min. current is too high. If steering is slow (big angle before anything happens), min. current is too low. For adjusting, See section *8 Control system group 8.5.4.1 Initiating Feedback lever steering, Adjusting lever steering*.
2. Valve binds. Impurities in hydraulic system?

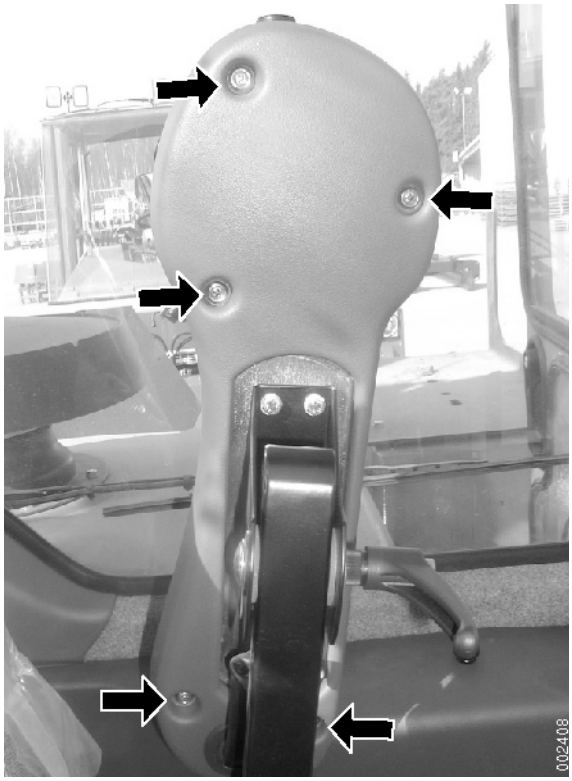
Start-up of new steering

1. Download program and setup.
2. Set basic values for “Initiation”. Can be done with PC or menu.
3. Calibrate steering.
4. Fine-tune start currents for right and left, respectively.
5. Test-run and adjust. See section *8 Control system group 8.5.4.1 Initiating Feedback lever steering, Adjusting lever steering*.

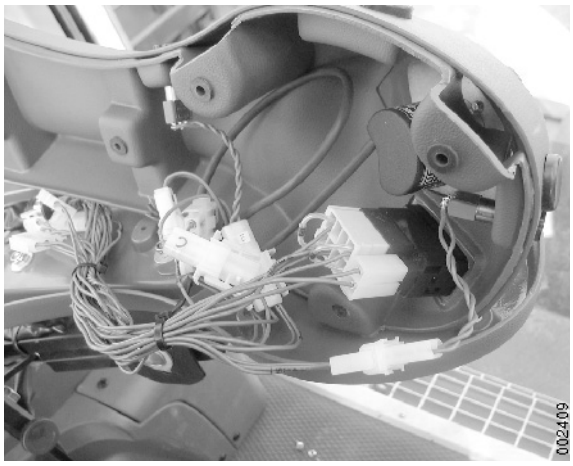
Steering lever, replacement

1 Machine in service position.

2 Remove the screws securing the top of the plastic panel for the mini-wheel.



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3 Unplug the connector from the steering lever.

4 Replace the steering lever.

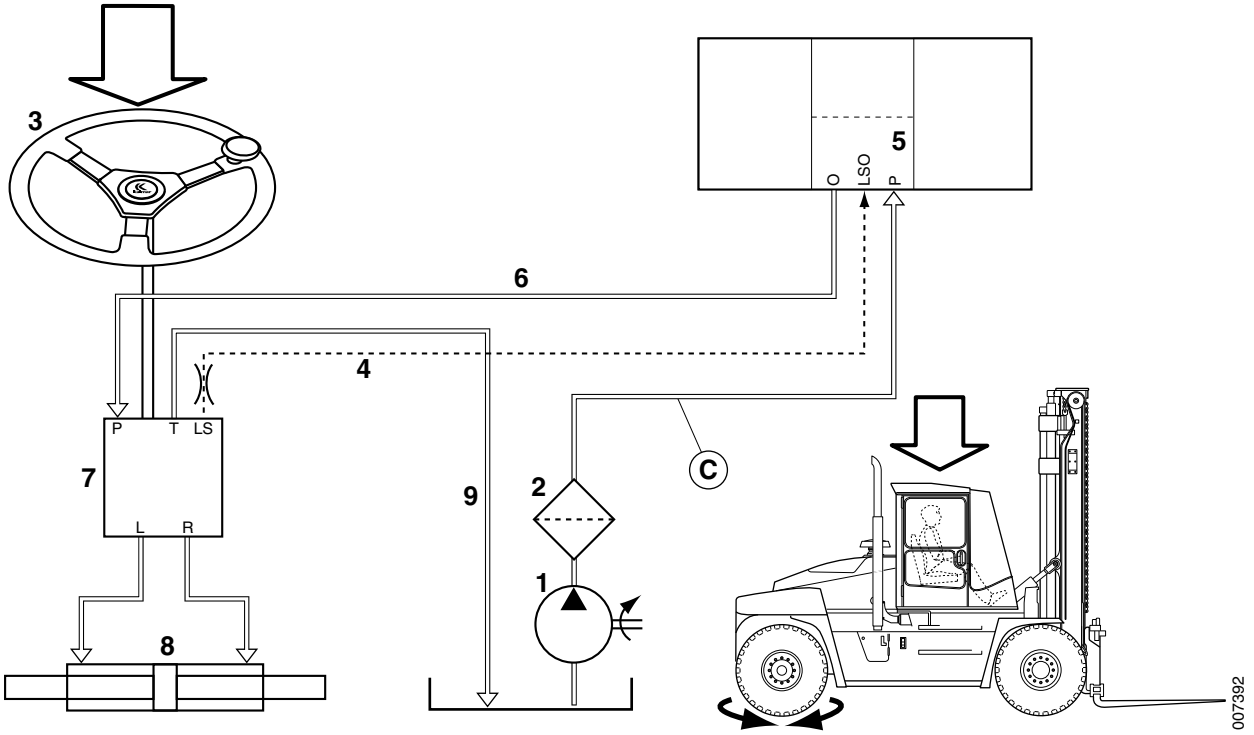
5 Fit in the reverse order.

6 Calibrate the steering lever, see section *8 Control system group 8.5.4.2 Calibrating Feedback lever steering*.

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5.2 Power assisted system

Power assisted steering system, function description



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	The high pressure filter cleans the oil	-	Section *10 Common hydraulics,* group *10.6.8 High pressure filter*
3	When the steering wheel is turned, this activates the steering valve.	-	*Steering valve, description page 22*
4	The control valve sends a load signal (a small flow of oil) to the pressure relief valve, priority valve and pressure reduction valve, which are all integrated into the main valve block.	-	*Steering valve, description page 22*

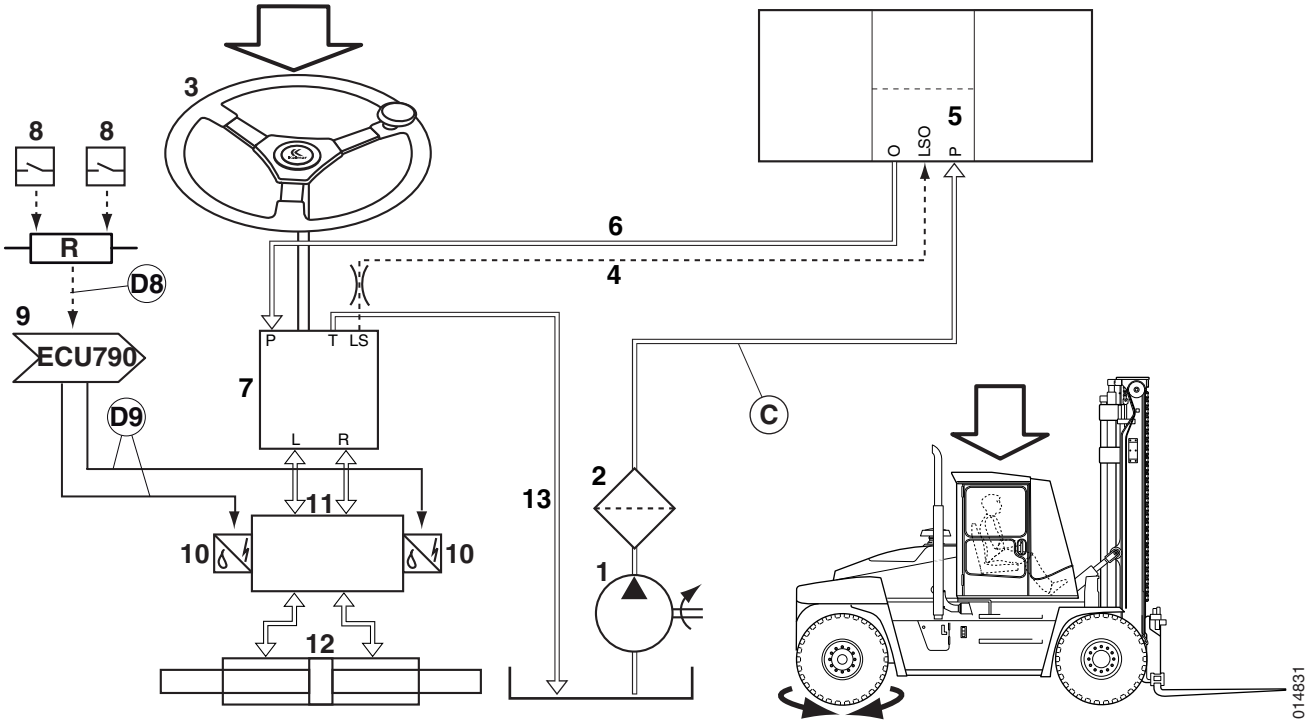
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Pos	Explanation	Signal description	Reference
5	The following activities take place in the valve block: The pressure relief valve ensures that the incoming load signal from the control valve is maximised to 17.5 MPa. The priority valve ensures that oil pressure for steering is given priority before working hydraulics. The pressure reduction valve checks that the pressure supplied back to the steering valve never becomes more than 1.1 MPa higher than the load signal.	-	Section *5 Steering,* group *5.2.2 Main valve* Section *5 Steering,* group *5.2.14 Pressure limiting valve* Section *5 Steering,* group *5.2.13 Pressure reducing valve*
6	After processing in the valve block, the oil flow continues on to the steering valve.	-	*Steering valve, description page 22*
7	When the oil reaches the steering valve, it makes sure that oil is pumped into the appropriate side of the piston in the steering cylinder (exact quantity of oil per revolution).	-	*Steering cylinder, description page 25*
8	Oil is pressed into one side of the steering cylinder, on the side needed to change direction. On the other side of the piston in the steering cylinder, oil has to be evacuated back to the steering cylinder.	-	*Steering cylinder, description page 25*
9	The steering valve ensures that returned oil from the steering cylinder is transported back to the hydraulic tank.	-	*Steering valve, description page 22*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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Power assisted steering system, reversible operator's seat, function description



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	The high pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High pressure filter*
3	When the steering wheel is turned, this activates the steering valve.	-	*Steering valve, description page 22*
4	The control valve sends a load signal (a small flow of oil) to the pressure relief valve, priority valve and pressure reduction valve, which are all integrated into the main valve block.	-	*Steering valve, description page 22*

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Pos	Explanation	Signal description	Reference
5	The following activities take place in the valve block: The pressure relief valve ensures that the incoming load signal from the control valve is maximised to 17.5 MPa. This pressure is reached only with steering wheels in end-positions. The priority valve ensures that oil pressure for steering is given priority before working hydraulics. The pressure reduction valve checks that the pressure supplied back to the steering valve never becomes more than 1.1 MPa higher than the load signal.	-	Section *5 Steering,* group *5.2.2 Main valve* Section *5 Steering,* group *5.2.14 Pressure limiting valve* Section *5 Steering,* group *5.2.13 Pressure reducing valve*
6	After processing in the valve block, the oil flow continues on to the steering valve.	-	*Steering valve, description page 22*
7	When the oil reaches the steering valve, it makes sure that oil is pumped into the appropriate side of the piston in the steering cylinder (exact quantity of oil per revolution).	-	*Steering cylinder, description page 25*
8	The sensor for reversible operator´s seatforward (S720-1) or the sensor for reversible operator´s seat rearward (S720-2) controls a resistor network which generates various voltages to the general control unit (ECU 790) depending on which direction the driver's station is facing.	Forward = 0,5 V Middle = 2,5 V Backwards = 4,5 V	*Sensor reversible operator's seat, description page 34* D8: Diagnostic menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 5, ECU790 input K1:37*
9	The Control unit general (ECU 790), sends a current signal to the solenoid valve, steering forward (Y636-1), or solenoid valve, steering backward (Y636-2).	-	*Directional valve reversible operator's seat, description page 33* D9: Diagnostic menu, see section *8 Control system*, group *8.4.1.2 View outputs, menu 1, ECU 790 output K2:38 (steering forward) and menu 2, ECU 790 output K2:41 (steering backward).*
10	Solenoid valve, steering forward (Y636-1), or solenoid valve, steering backward (Y636-2), pressurise the valve slide in directional control valve, reversible operator's position.	-	*Directional valve reversible operator's seat, description page 33*
11	Directional control valve, reversible operator's position, controls pressure to the steering cylinder.	-	*Directional valve reversible operator's seat, description page 33*

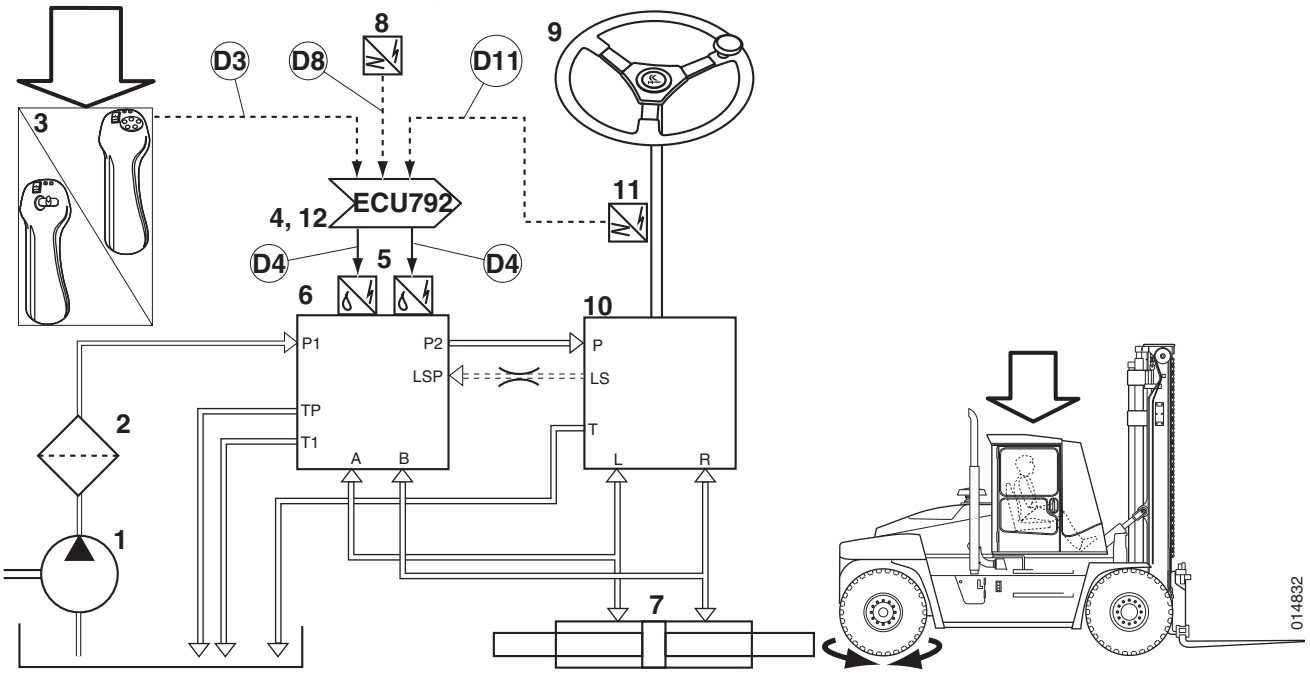
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Pos	Explanation	Signal description	Reference
12	Oil is pressed into one side of the steering cylinder, on the side needed to change direction. On the other side of the piston in the steering cylinder, oil has to be evacuated back to the steering cylinder.	-	*Steering cylinder, description page 25*
13	The steering valve ensures that returned oil from the steering cylinder is transported back to the hydraulic tank.	-	*Steering valve, description page 22*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

Lever steering/mini-wheel, function description

Condition	Reference value	Reference
Lever steering / Mini-wheel activated	Voltage signal from switch mini-wheel/joystick control.	*Mini-wheel, description page 4* *Feedback lever steering, description page 8*
Steering wheel stationary	No signal from sensor steering wheel movement.	*Sensor, steering wheel movement, description page 32*
Speed	Below 3 km/h (at engagement)	Section *2 Transmission*
Control switch	Not activated	Section *9 Frame, body, cab and accessories*, group *9.2.1 Control switch*



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Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic oil tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High pressure filter*
3	**Lever steering** The potentiometer in the switch joystick (R825) sends a voltage signal to Control unit steering (ECU 792).	Signal 1, U = 0.5 - 4.5 V	*Feedback lever steering, description page 8* D3: Diagnostic menu, see section *8 Control system*, group *8.4.2.1 View inputs, menu 4, ECU 792 input K1:31.*
	Mini-wheel *The 2-channel potentiometer in Switch mini-wheel (R825)* sends a voltage signal to Control unit steering (ECU 792) which calculates the turning speed of the mini wheel.	Signal 1, U = 0.5 - 4.5 V Signal 2, U = 0.5 - 4.5 V	*Mini-wheel, description page 4* D3: Diagnostic menu, see section *8 Control system*, group *8.4.2.1 View inputs, menu 4, ECU 792 input K1:35 and K1:36.*
4	Control unit steering (ECU 792) supplies voltage to solenoid valve, steering right (Y615-1), *or solenoid valve, steering left (Y615-2)*.	-	*Control valve mini-wheel/lever steering, description page 29* D4: Diagnostic menu, see section *8 Control system*, group *8.4.2.2 View outputs, menu 2, ECU 792 output K1:06 (steering right) and* menu 2, ECU 792 output K1:07 (steering left)
5	Solenoid valve steering right (Y615-1) *or Solenoid valve steering left (Y615-2)* pressurises steering spool in Control valve mini-wheel/lever steering. ⊕ On machines with reversible operator's seat, right is changed to left when the operator's position is turned to the back.	-	*Control valve mini-wheel/lever steering, description page 29*
6	The spool changes position and pressurises the steering cylinder.	-	*Control valve mini-wheel/lever steering, description page 29*
7	The steering cylinder turns the wheels.	-	*Steering cylinder, description page 25* *Link arm, description page 26* *Wheel spindle, general page 27*
8	When feedback lever steering is used, the wheel angle sensor (R807) sends a voltage signal, proportional to the wheel lock, to the Control unit steering (ECU 792).	U = 0.5 - 4.5 V	*Sensor, wheel angle, description page 28* D8: Diagnostic menu, see section *8 Control system*, group *8.4.2.1 View inputs, menu 4, ECU 792 input K1:32*
9	The steering wheel is turned and acts on the steering valve's input shaft.	-	Section *9 Frame, body, cab and accessories, group 9.1 Controls and instrumentation.*

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Pos	Explanation	Signal description	Reference
10	Steering with the wheel is given priority. Steering valve sends load signal to the Control valve mini-wheel/lever steering. Oil is supplied to the control valve in proportion to steering wheel angle.	-	*Steering valve, description page 22*
11	Sensor, steering wheel movement (B770), sends a voltage signal to control unit, steering (ECU 792).	U = 24 V	*Sensor, steering wheel movement, description page 32* D11: Diagnostic menu, see section *8 Control system*, group *8.4.2.1 View inputs, menu 1, ECU 792 input K1:03*
12	Control unit steering (ECU 792) aborts lever steering or mini-wheel.	-	-

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

5.2.1 Hydraulic oil pump, steering

Hydraulic oil pump, general

See section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

Pump 4 - mini-wheel/lever steering, description

For mini-wheel/lever steering, the steering pressure is generated by a separate pump that is intended solely for the steering system.

This pump 4 is physically mounted together with pump 3 as a double pump.

(Other pumps are not used for steering with option mini-wheel/lever steering, that is, pump 1 only works with the working hydraulics, see section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.)

Pump mini-wheel/lever steering, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.

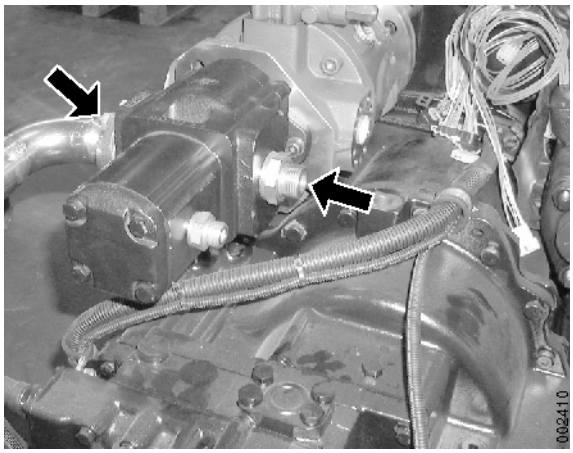
1 Machine in service position, please refer to section *B Safety*.

2 Clean the hydraulic oil pump and the area round it.

3 depressurise the hydraulic system, see section *B Safety*.

4 Place a receptacle under the hydraulic oil pump to collect spilled oil.

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5 Mark the hydraulic hoses and disconnect them from the pump.

6 Undo the vane pumps.

Remove the two screws securing the pump and pull it out.

7 Transfer the connection adapters to the new pump.

NOTE

Check that the O-rings are intact and fitted correctly.

8 Check the pump seals, replace if necessary.

9 Install the new pump and check that the splines engage on the shaft.

Install the pump fixing screws.

10 Connect the hydraulic hoses in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly

11 Close the drain valve on the accumulator charging valve.

12 Turn on the power supply and start the engine.

13 Check that the hose connections seal correctly.

NOTE

Pre-fill the pump with oil through the pressure connection before taking it into service.

If necessary, vent the pump by loosening the hoses on the delivery side.



14 Check the hydraulic oil level with all hydraulic cylinders fully retracted. Top up if needed.

NOTE

If the pump is replaced due to malfunction, change the oil and filter in the hydraulic system as well.

⚠ CAUTION

Overfilling of oil.

Leakage and environmental damage.

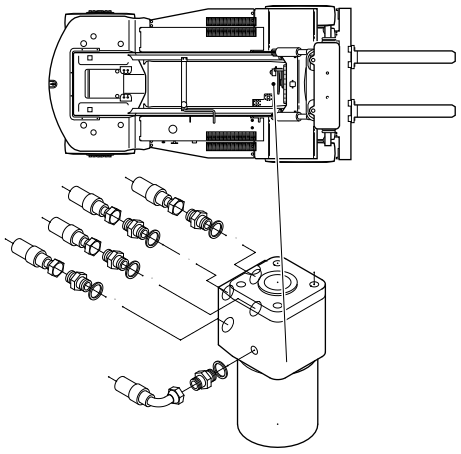
The hydraulic oil level is checked with all hydraulic cylinders fully retracted.

5.2.2 Main valve (priority valve for steering)

Main valve (priority valve for steering), description

See section *10 Common Hydraulics*, group *10.5.2 Main valve*.

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Steering valve and connections

5.2.3 Steering valve

Steering valve, description

The steering valve is of the 'closed centre', non-reaction type with a load signal connection to the valve block. The load signal gives load-dependent control of the oil pressure from the valve block to the steering valve.

Being of the closed centre type means that it closes to the oil flow between the pump and tank in neutral position. This is necessary to enable a signal pressure to be connected to the steering valve.

The steering valve consists of a gear pump and a distribution valve. When the steering wheel is turned, oil is fed from the valve block across the gear pump to the distribution valve, which makes sure that the oil flow is fed to the port that corresponds to the turn direction. The gear pump makes the oil flow fed to the cylinder proportional to the angle of the steering wheel.

The steering valve has double integrated shock and anti-cavitation valves.

The shock valves, which open at 200 bar, prevent high pressure increases (pressure peaks) resulting from jolts to the steering wheels on the ground, from reaching the steering valve. Negative pressures on the opposite side of the piston, which may lead to cavitation (spaces where steam can form), are prevented by the opening of the anti-cavitation valves (non-return valves).

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Steering valve, replacement

NOTE

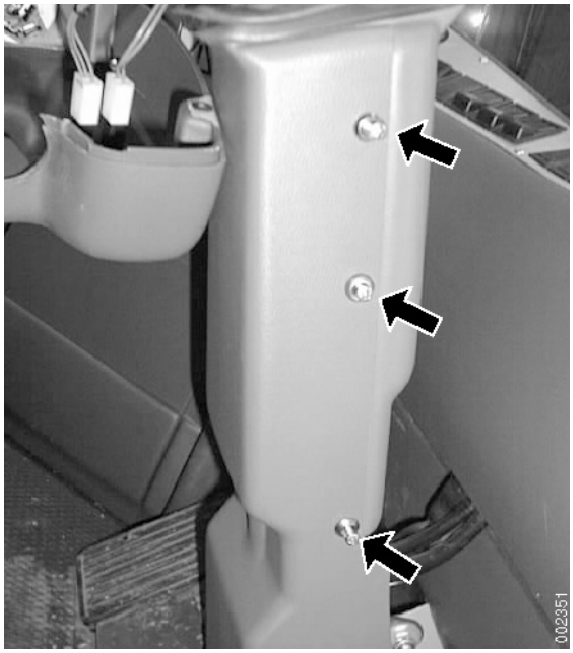
Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Depressurise the hydraulic system, see section *B Safety*.

3 Remove the six screws securing the lower plastic steering column cover.

Remove the plastic cover.





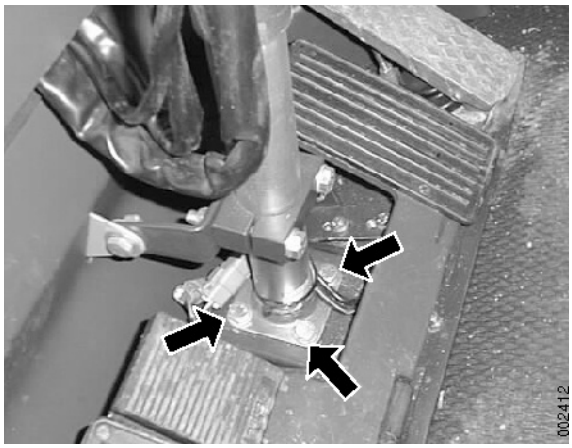
4 Mark up and detach the hydraulic hoses from the steering valve.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

5 Secure the steering valve.

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Attachment of steering valve.

6 Remove the four screws securing the steering valve to the cab floor.

7 Remove the steering valve by pulling it downward.

8 Transfer the connection adapters to the new steering valve.

9 Fit the new steering valve.

10 Connect the hydraulic hoses to the steering valve in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

11 Turn on the main electric power and start the engine. Run the engine at idling speed.

12 Test the steering a couple of times.

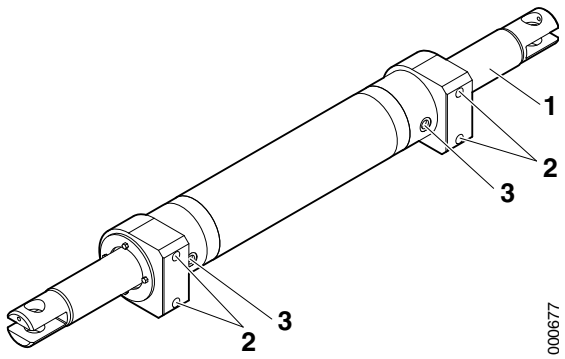
13 Check that the steering valve's connections are sealed tightly.

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5.2.4 Steering cylinder

Steering cylinder, description

The steering cylinder is a double-acting hydraulic cylinder with a piston rod running all the way through, acting on the wheels via link arms.



1. Piston rod
2. Attaching holes (bolts are tightened through the steering cradle)
3. Connection hole for oil

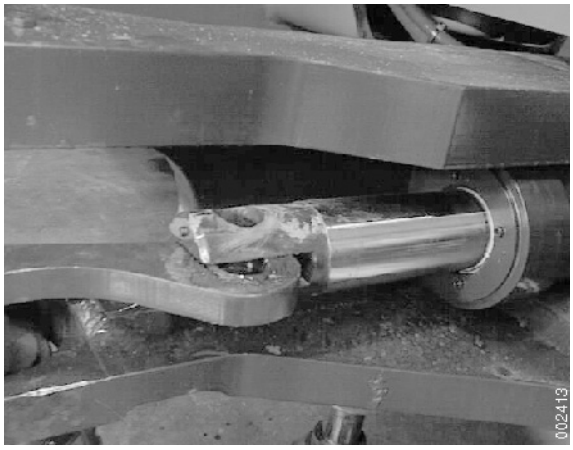
Steering cylinder, replacement

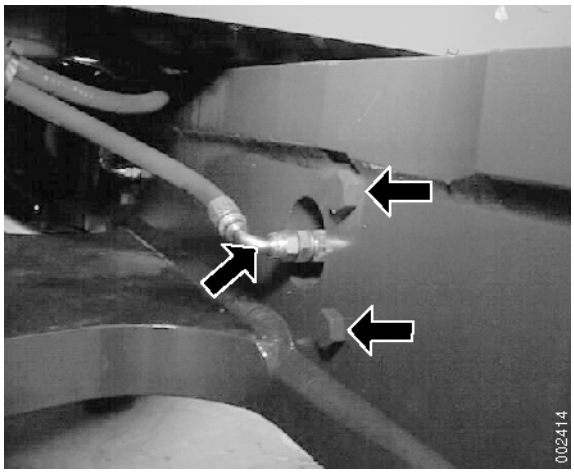
1 Machine in service position, see *B Safety*.

2 Depressurise the hydraulic system, see section *B Safety*.

3 Remove the wheels (steering).

4 Release the link arms from the steering cylinder as described under *Link arm, replacement page 26*.





5 Mark up and detach the hydraulic hoses from the steering cylinder.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

6 Remove the four screws securing the steering cylinder to the steering axle cradle.

7 Transfer the connection adapters to the new steering cylinder.

8 Fit the new steering cylinder. Tightening torque: **600 Nm (oil)**

9 Connect the hydraulic hoses to the steering cylinder in accordance with the marking.

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NOTE

Check that the O-rings are intact and are fitted correctly.

10 Fit the link arms to the steering cylinder.

11 Fit the wheels (steering).

12 Turn on the main electric power and start the engine. Run the engine at idling speed.

13 Test the steering a couple of times.

14 Check that the steering cylinder's connections are sealed tightly.

Hydraulic cylinders, repairing

See section *10 Common hydraulics*, group *10.7.1 Hydraulic cylinders*.

5.2.5 Steering axle cradle

Steering axle cradle, general

See section *6 Wheel suspension*, group *6.2.1 Steering axle cradle*.

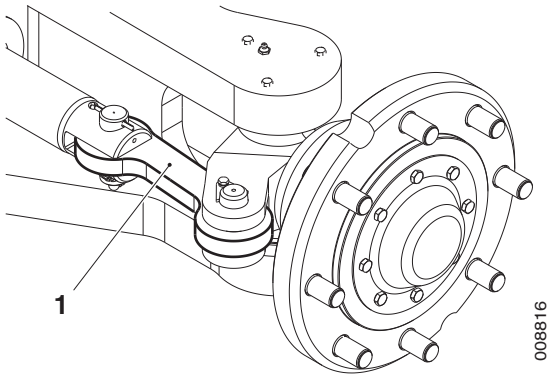
5.2.6 Link arm

Link arm, description

The link arm transfers the lateral movement of the steering cylinder to turning the wheel spindles.

The setting of the steering wheels cannot be adjusted. If the link arms are deformed so that the setting of the steering wheels is changed, they must be replaced.

The link arms must be turned to the right direction, otherwise they can be damaged by the rims with large wheel angles.



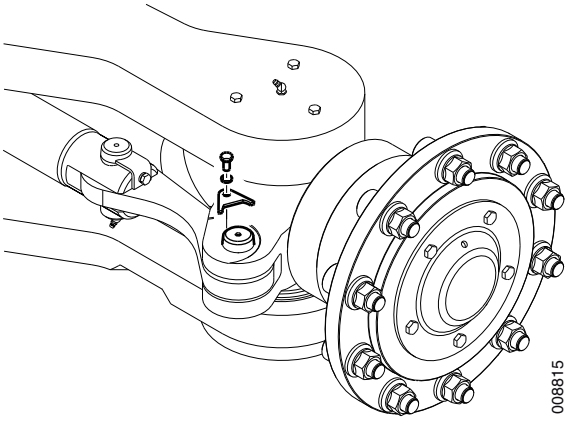
1. Link arm

Link arm, replacement

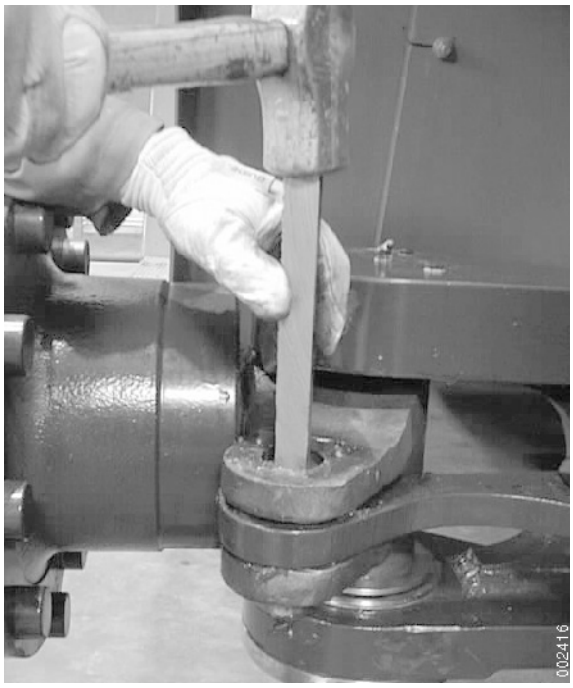
1 Machine in service position, see section *B Safety*.

2 Remove the wheels (steering).

3 Remove the screw and the securing plate holding the stub axle.



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4 Remove the stub axles.



5 Replace the link arm.

NOTE

Check that the bearings in the link arm are correctly aligned before the link arm is installed.

6 Fit in the reverse order.

5.2.7 Wheel spindle

Wheel spindle, general

See section *6 Wheel suspension*, group *6.2.2 Wheel spindle*.

Wheel spindle, replacement

See section *6 Wheel suspension*, group *6.2.2 Wheel spindle*.

5.2.8 Wheel hub

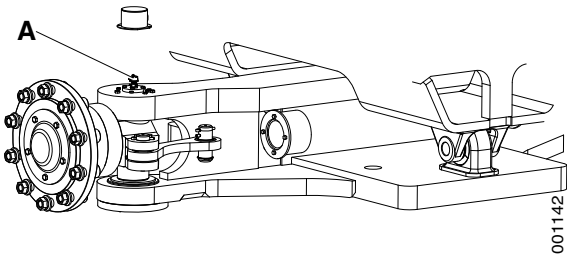
Wheel hub, general

See section *6 Wheel suspension*, group *6.2.3 Wheel hub*.

Wheel hub, replacement

See section *6 Wheel suspension*, group *6.2.3 Wheel hub*.

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A. Sensor wheel angle

5.2.9 Sensor, wheel angle

Sensor, wheel angle, description

Only for feedback lever steering.

This sensor measures the angle of the steering wheels to enable lever steering and, for example, to enable the wheels to return to the centre position (straight ahead) when the lever is in its neutral position.

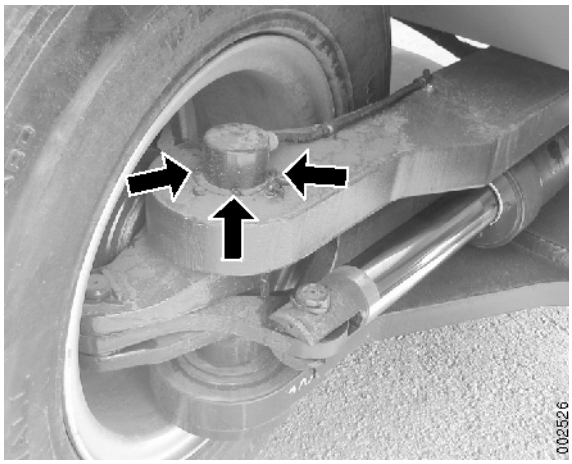
The sensor is located under a cover by the left king pin on the steering axle.

Sensor, wheel angle, replacement

1 Put the wheels at an angle.

2 Machine in service position, see section *B Safety*.

3 Remove the four screws securing the protective cover.





4 Undo the Allen screw and remove the nut securing the sensor.

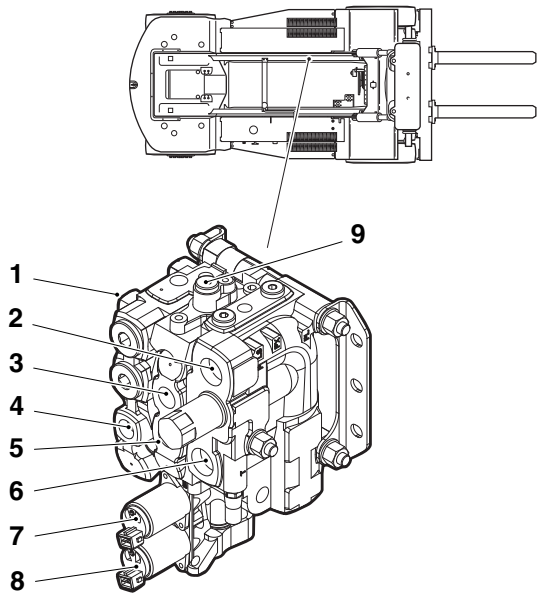
5 Using a soldering iron, detach the cables from the sensor.

6 Replace the sensor.

7 Fit in the reverse order.

8 Calibrate the new sensor.

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1. Pump connection to steering valve (P2)
2. Pressure supply (P)
3. Connection, steering cylinder (A)
4. Tank return (TP)
5. Connection, steering cylinder (B)
6. Tank return (T)
7. Servo valve left (Y615-2)
8. Servo valve right (Y615-1)
9. Load signal (LSP)

5.2.10 Control valve mini-wheel/lever steering

Control valve mini-wheel/lever steering, description

On machines with lever steering or mini-wheel, the steering cylinder's angle is controlled by Control valve lever steering or mini-wheel. The control valve is located internally on the left side of the chassis. The control valve is controlled by Control unit steering (ECU 792).

The control valve is an electro-hydraulically controlled, proportional and pressure-compensated directional valve. Electrically controlled pressure reducing valves convert electrical current to servo pressure. The servo pressure controls the spring-centred valve spools, which control pressure and flow for the function in question. The valve spools have flow limits so that several functions can be activated simultaneously.

Valve slide, steering

The valve slide controls the direction and steering angle by controlling the hydraulic pressure to the steering cylinder.

The valve slide is controlled by servo valve right and servo valve left.

Servo valve right

Servo valve right controls servo pressure to valve slide, steering, so that it controls oil pressure for steering right.

Servo valve right is controlled electrically with Solenoid valve steering right (Y615-1) which is activated by Control unit steering (ECU 792).

Servo valve left

Servo valve left controls servo pressure to valve slide, steering, so that it controls oil pressure for steering left.

Servo valve left is controlled electrically with Solenoid valve steering left (Y615-2) which is activated by Control unit steering (ECU 792).

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Control valve mini-wheel/lever steering, replacement

NOTE

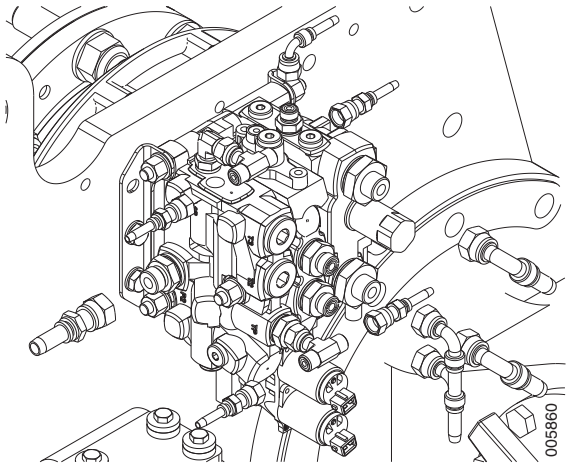
Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Depressurise the hydraulic system, see section *B Safety*.

3 Clean the control valve and its surrounding area.

4 Mark up and detach the hydraulic hoses from the control valve.



NOTE

Plug all connections immediately to protect the hydraulic system from impurities.

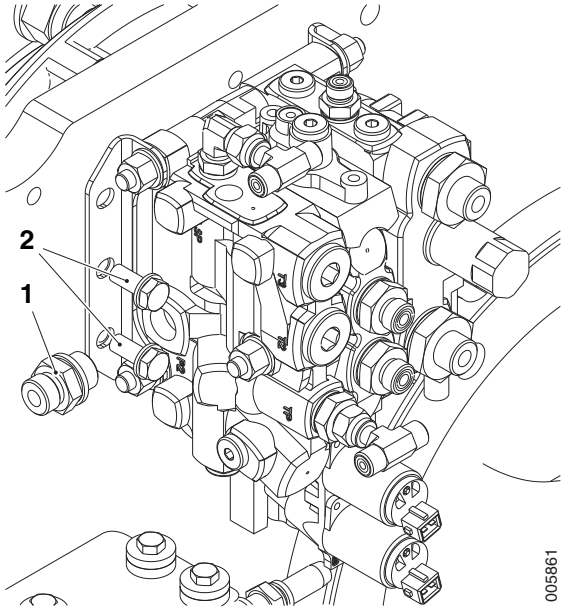
5 Mark up and detach the wiring from the control valve.

6 Remove the control valve.

Remove the connection adapter (position 1), then the attaching bolts and lift away the valve. Place the valve on a clean and protected surface.

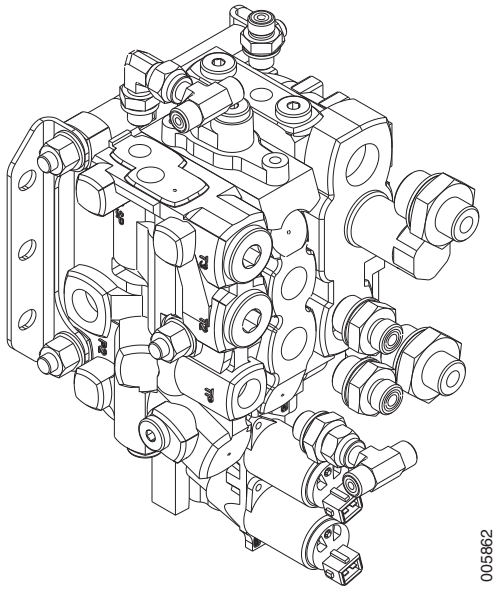
NOTE

The valve weighs approx. 30 kg.



1. Connection adapter
2. Attaching bolts

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7 Transfer the connection adapters to the new control valve.

NOTE

Check that the O-rings are intact and correctly fitted.

NOTE

Transfer one adapter at a time so that the marking is not mixed up.

8 Mark up the servo valves on the new control valve.

9 Fit the valve.

Lift the valve into place and fit the attaching bolts.

10 Connect the wiring to the control valve in accordance with the marking.

11 Connect the hydraulic hoses to the control valve in accordance with the marking.

NOTE

Check that the O-rings are intact and correctly fitted.

12 Turn on the main electric power and start the engine.

13 Check that the valve's hydraulic connections are sealed.

14 Remove the collection container, treat spills as environmentally hazardous waste.

15 Check that the steering is working.

16 Check the hydraulic oil level with all hydraulic cylinders fully retracted. Top up if needed.

⚠ CAUTION

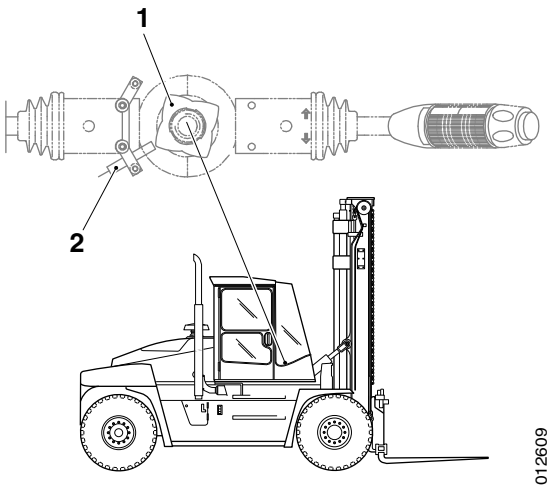
Overfilling of oil.

Leakage and environmental damage.

The hydraulic oil level is checked with all hydraulic cylinders fully retracted.

17 Calibrate the steering lever/mini-wheel, see section *8 Control system group 8.5.4.2 Calibrating Feedback lever steering*.

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1. Metal plate (with four teeth)
2. Sensor, steering wheel movement

5.2.11 Sensor, steering wheel movement

Sensor, steering wheel movement, description

Sensor steering wheel movement (B770) senses if the steering wheel is turned and sends a signal to Control unit steering (ECU 792). This is used to disengage lever steering or the mini-wheel. The sensor is located by the steering wheel shaft inside the panels.

The sensor is tripped by an activator on the steering wheel shaft with four lobes. The location of the sensor and lobes' spacing means that small steering wheel movements can be detected.

Sensor steering wheel movement, replacement

1 Machine in service position.

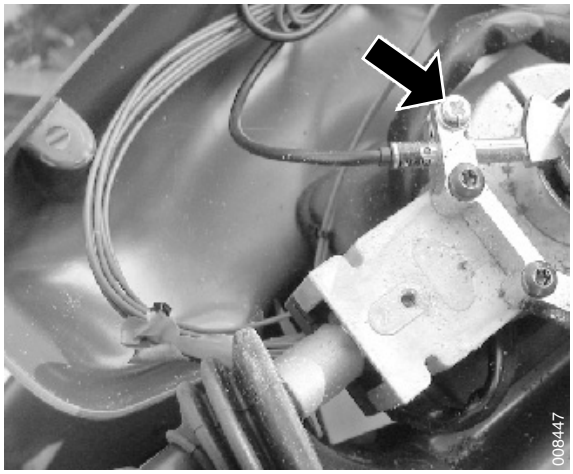
2 Remove the steering wheel and the steering panel covers, please refer to section *9 Frame, body, cab and accessories, Group 9.1.1 Multi-function lever, replacement.*

3 Undo the screw securing the sensor.

4 Unplug the connector from the sensor.

5 Replace the sensor.

6 Fit in the reverse order.



Attachment of steering wheel movement sensor.

NOTE

Do not tighten the screws which hold the sensor too hard. The sensor will then break.

NOTE

The distance between the sensor and metal plate must not be more than 1.5 mm.

5.2.12 Filter mini-wheel/lever steering

Filter mini-wheel/lever steering, description

There is a separate filter for mini-wheel/lever steering.

See section *10 Common hydraulics*, group *10.6.8 High-pressure filter*.

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5.2.13 Pressure reducing valve

Pressure reducing valve, description

See section *10 Common hydraulics*, group *10.5.2 Main valve*.

5.2.15 Directional valve reversible operator's seat

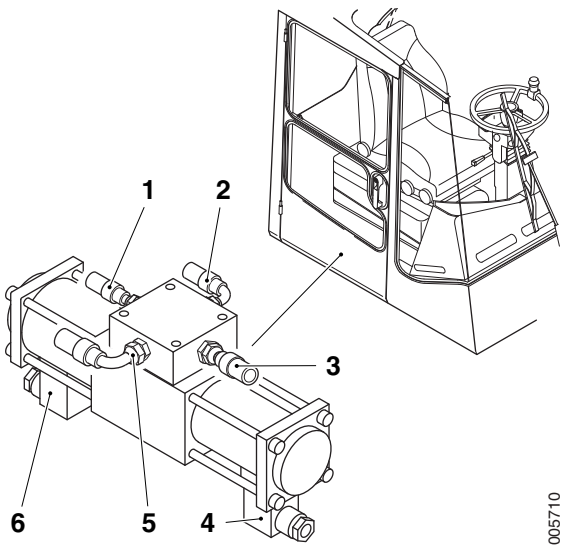
Directional valve reversible operator's seat, description

(+) Only with Spirit Delta.

Machines with a reversible operator's seat have an additional directional valve (reversing valve) between the steering valve and steering cylinder. The directional valve shifts the connection between the steering valve and the steering cylinder when the operator's seat is turned round for driving in reverse so that steering wheel and wheel movements correspond.

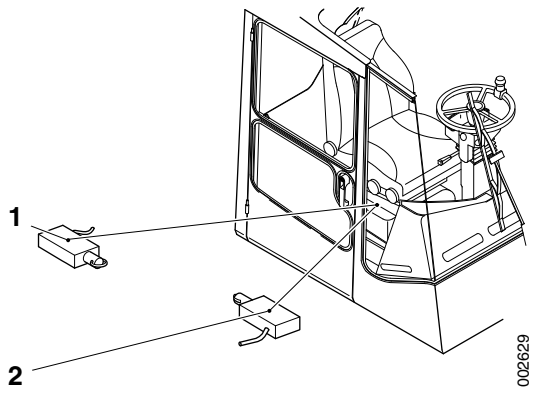
The directional valve is actuated by solenoid valve, steering forward (Y636-1) or solenoid valve, steering reverse (Y636-2).

See also section *9 Frame, body, cab and accessories*, group *9.3.10 Reversible operator's seat*.



1. Pressure to steering cylinder (A)
2. Pressure from steering valve (T)
3. Pressure to steering cylinder (B)
4. Solenoid valve, steering forward (Y636-1)
5. Pressure from steering valve (P)
6. Solenoid valve, steering reverse (Y636-2)

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1. Sensor, reversible operator's position, reverse (S720-2)
2. Sensor, reversible operator's position, forward (S720-1)

5.2.16 Sensor reversible operator’s seat

Sensor reversible operator's seat, description

Machines with a reversible operator's seat have two make-contacts that detect whether the operator's seat is facing forward or backward.

Sensor, reversible operator's seat, forward (S720-1) and Sensor, reversible operator's seat, reverse (S720-2) send a voltage signal to Directional valve, reversible operator's seat or Control Unit Steering (ECU 792).

See also section *9 Frame, body, cab and accessories*, group *9.3.10 Reversible operator's seat*.

5.2.17 Pipes and hoses

Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

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6.3.1 Tyres 18
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6 Suspension

Suspension, description

The machine’s suspension consists of its tyres (with associated rims and bolts), steering axle with hub, wheel spindles and the steering axle's suspension in the frame. The drive axle belongs to power transmission, see section *3 Driveline/axle,* group *3.3 Drive axle*.

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6.2 Suspension

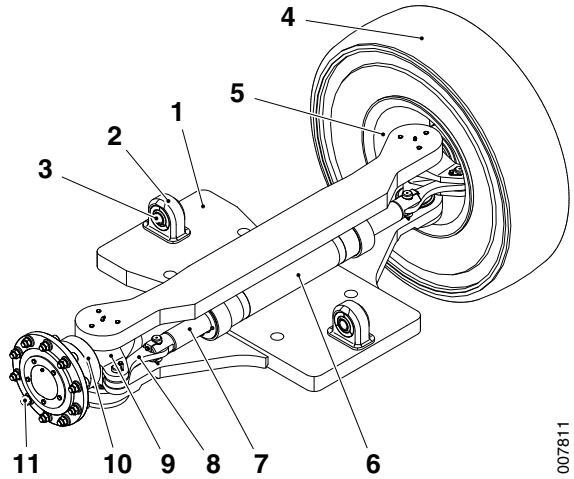
Suspension, description

The steering axle cradle is attached to the frame with two bushings, one at the leading edge and one at the trailing edge of the steering axle cradle. In the steering axle cradle there are two wheel spindles mounted on rotating king pins. The king pins turn to steer the machine. The wheel spindles have bearings for the wheel hubs, to which the wheels are attached.

Suspension, position of the components

Suspension refers to:

- Steering axle cradle
- Wheel spindle
- Wheel hub



1. Steering axle cradle
2. Fixing lug
3. Rubber damper
4. Tyre
5. Rim
6. Steering cylinder
7. Piston rod
8. Link arm
9. Wheel spindle
10. Hub
11. Bolts

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6.2.1 Steering axle cradle

Steering axle cradle, description

The steering axle is pendulum suspended with a double-acting steering cylinder. The construction comprises a minimum of moving parts to minimise service points and simplify maintenance.

The chassis suspension comprises maintenance free parts. The rear suspension is designed with a fixed bolted joint.

Steering axle cradle, replacement

⚠ DANGER

Steering axle and machine are very heavy.

Risk of crushing!

It is not permissible to go under a machine which has been lifted by a jack or similar. For machine weights, please refer to section *F Technical data*.



1 Machine in service position, see section *B Safety*.

2 Place supports under the counterweight under the machine.

3 Remove the steering wheels.

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4 Raise the steering axle cradle slightly.

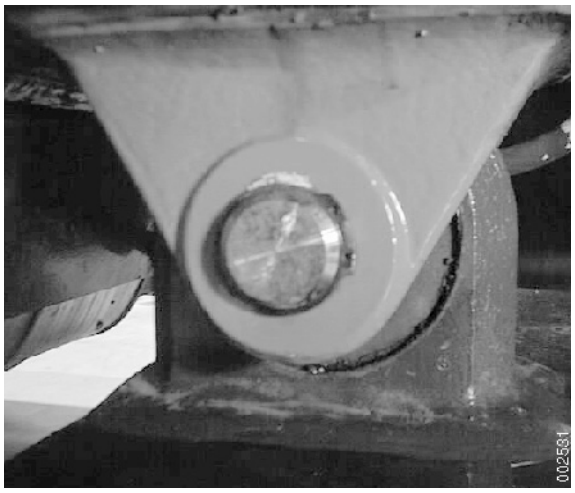
5 Release the cables from the steering angle sensor (only refers to machines with lever steering).

6 Place a receptacle under the hoses on the steering cylinder.

7 Mark up and detach the hydraulic hoses from the steering cylinder.

NOTE

Plug all connections immediately to protect the hydraulic system from impurities.



8 Remove the circlip from the stub axle in the front and rear attachment points.

9 Knock out the stub axle with a sledge hammer.

10 Move aside the steering axle cradle in a suitable way.

⚠ CAUTION

The steering axle may start to roll.

Crushing injury!

Make sure that the steering axle does not start uncontrolled movement.

11 Lift the new steering axle into place under the frame.

12 Install axle in the front and rear attachment points. Install circlips on the stub axles.

NOTE

Lubricate attachment point and axle with copper paste or equivalent to prevent corrosion.

13 Connect the hydraulic hoses to the steering cylinder in accordance with the marking.

NOTE

Check that the O-rings are intact and that they are fitted correctly.

14 Connect the cables to the steering angle sensor (only refers to machines with lever steering).

15 Remove the lifting equipment from the machine.

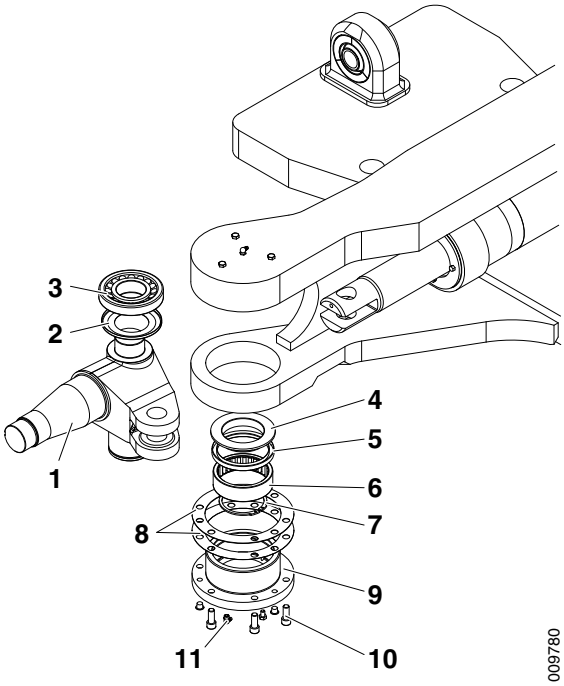
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6.2.2 Wheel spindle

Wheel spindle, description

The wheel spindle is the link between steering axle and wheel hubs which allows the wheels to be turned.

The wheel spindle is provided with a roller bearing (lower bearing) and a tapered roller bearing (upper bearing).



1. Wheel spindle
2. Seal ring
3. Tapered roller bearing (upper bearing)
4. Protection ring
5. Seal ring
6. Roller bearing (lower bearing)
7. Retaining ring
8. Shims
9. Bearing holder
10. Allen screw
11. Grease nipple

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Wheel spindle and wheel spindle bearings, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the wheel (steering).

DANGER

Tyres should be regarded as pressurized containers. They constitute fatal danger if handled incorrectly.

Parts can be thrown with explosive force and may cause severe injuries.

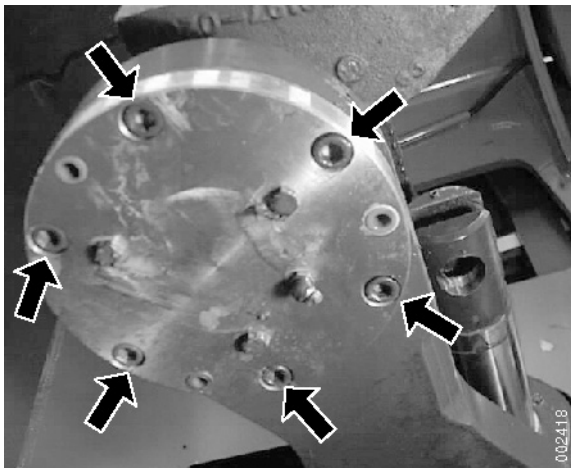
Never repair damaged tyres, rims or lock rings. Tyre repairs should only be performed by authorized personnel.

3 Clean the wheel spindle and its surrounding area.

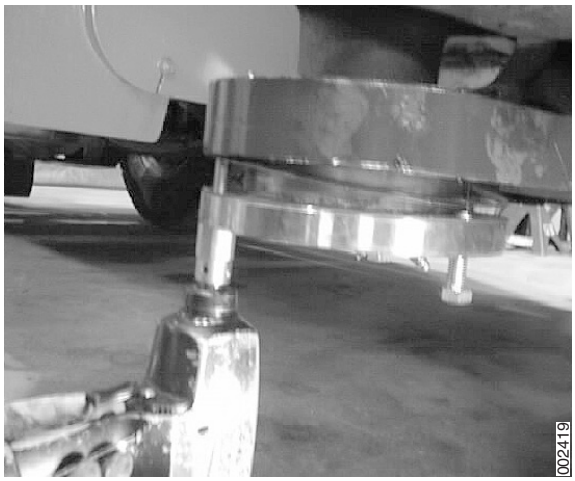
4 Detach the link arm from the wheel spindle, see section *5 Steering, group 5.2.6 Link arm*.

5 Remove the wheel hub and wheel bearing, see *Wheel hub and wheel bearings, replacement page 11*.

6 Remove the six Allen screws securing the bearing holder to the wheel spindle.



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7 Remove the bearing holder by screwing a bolt into the removal hole.

8 Release the bearing holder and shims from the wheel spindle.

9 Remove the wheel spindle.

10 Unscrew the three screws above the steering spindle´s upper bearing, on top of the steering cradle. Depress the upper bearing outer race by screwing three screws (lenght approximately 90 mm) into the holes.

11 Remove the inner race of the upper and lower bearing from the steering wheel spindle.

12 Pull the lower bearing outer race from the bearing holder.

13 Tap the outer race of the upper bearing into the steering wheel cradle from below, using a piece of tube.

14 Fit the three screws back into their holes.

15 Attach upper bearing´s inner race and seal ring, protection ring, seal ring, lower bearing inner race and retaining ring to the wheel spindle.

16 Fit the wheel spindle.

17 Tap the outer race of the lower bearing into the bearing holder.

18 Position the bearing holder and tighten it with shims, tighten the six screws to **70 Nm**.

19 Check that the wheel spindle rotates smothly with at maximum play of 0.25 mm. If not, adjust with shims.

20 Lubricate the bearings by means of the grease nipples.

21 Fit the wheel hub and wheel bearing, see *Wheel hub and wheel bearings, replacement page 11*.

22 Fit the link arm to the wheel spindle, see section *5 Steering, group 5.2.6 Link arm*.

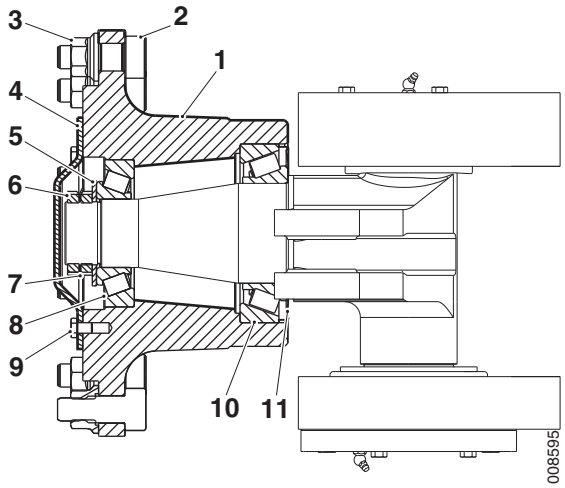
23 Mount the wheel.

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6.2.3 Wheel hub

Wheel hub, description

The wheel hub holds the wheel in place and enables the wheel to rotate. The hub is provided with two tapered roller bearings.



1. Hub
2. Wheel bolt
3. Wheel nut
4. Hub cap
5. Spacer
6. Nut
7. Washer
8. Bearing
9. Screw
10. Bearing
11. Dust shield

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Wheel hub and wheel bearings, replacement

1 Machine in service position, see section *B Safety*.

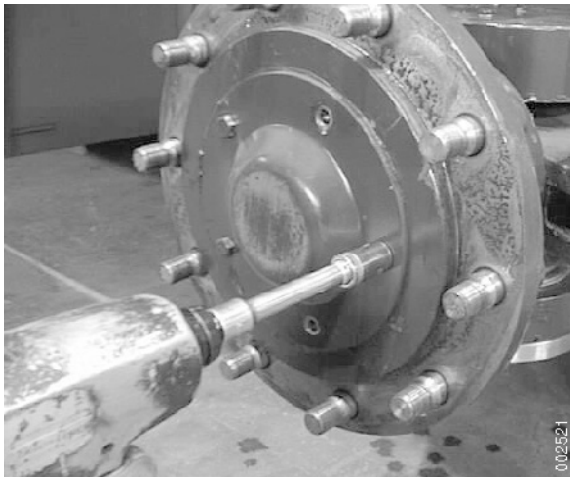
2 Remove the wheel (steering).

DANGER

Tyres should be regarded as pressurized containers. They constitute fatal danger if handled incorrectly.

Parts can be thrown with explosive force and may cause severe injuries.

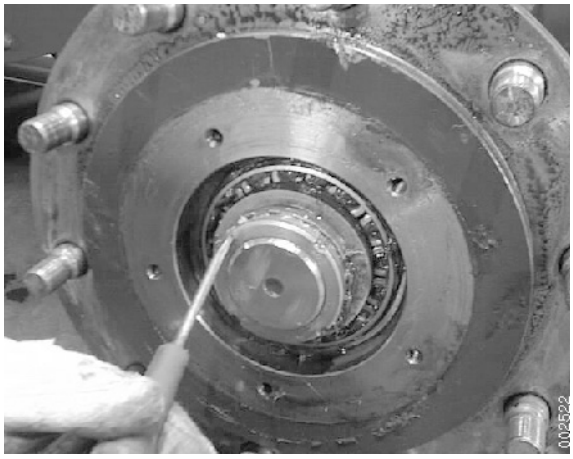
Never repair damaged tyres, rims or lock rings. Tyre repairs should only be performed by authorized personnel.



3 Clean the hub cover and its surrounding area.

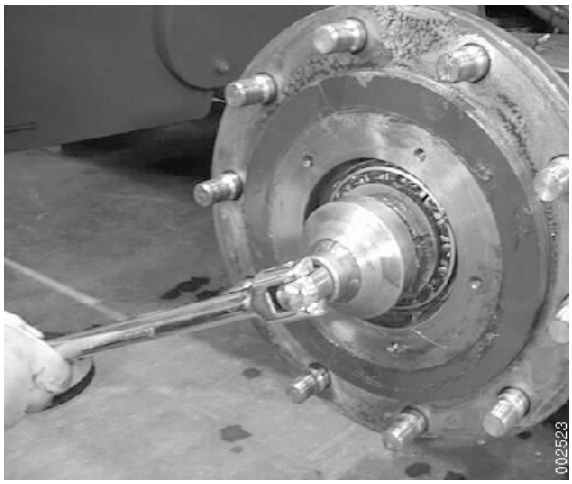
4 Remove the hub cover.

5 Remove excess grease with a rag. Treat as environmentally hazardous waste

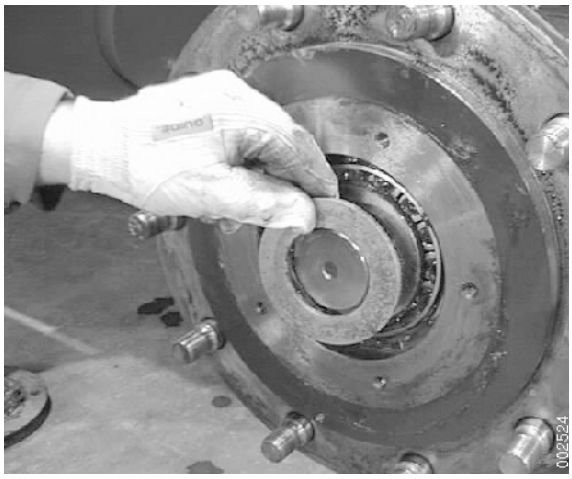


6 Open the lock washer with a screw driver.

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7 Remove the lock nut, lock washer and the bearing nut.



8 Remove the spacer washer from the bearing.



9 Remove the entire hub including the outer bearing.

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10 Remove the inner bearing inner race from the wheel spindle.

11 Remove the bearings' outer races from the hub.

Use a drift and press out the bearing races.

12 Remove the seal.

13 Clean the hub and smear the inside with universal grease “EP2”.

14 Fit new sealings and bearing races in the hub.

Use a drift and press in the bearing races. Never use directly on the bearings.

NOTE

Fit the outer bearings with the larger diameter outward.



15 Fit the inner bearing inner race and rollers on the wheel spindle. Pack in the bearing with universal grease “EP2”.

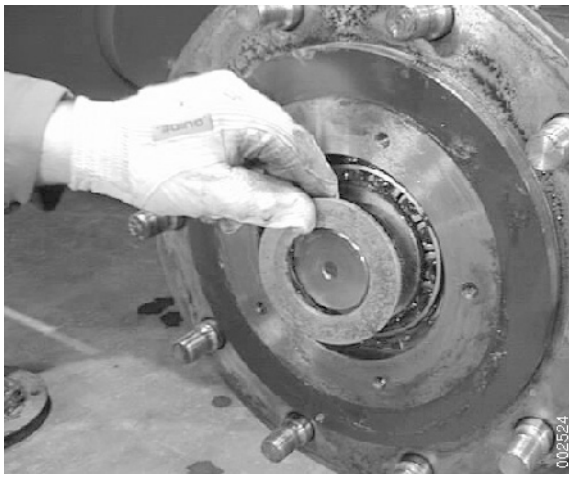


16 Fill the empty space in the hub with universal grease “EP2”.

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17 Fit the hub on the wheel spindle.



18 Fit the outer bearing and spacer washer and bearing nut.

Pack in the bearing with grease and fit the bearing.

Fit the washer and bearing nut with the smooth surface in towards the hub.



19 Torque the bearing nut as follows.

A. Grease the thread on the side of the nut turned to the bearing with oil (SAE 80W140).

B. Tighten the nut during rotation of the hub.

C. Rotate the hub at least 10 revolutions.

D. Retighten the nut during rotation of the hub.

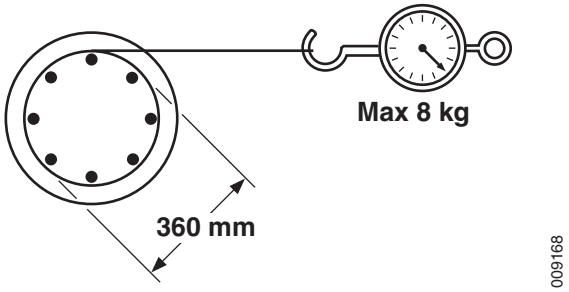
E. Repeat procedure B-D until the nut does not move when retightened.

F. Check friction torque as below:

The lower limit with no play will be reached when tightening the bearing nut until no play could be felt when trying to wobble the wheel.

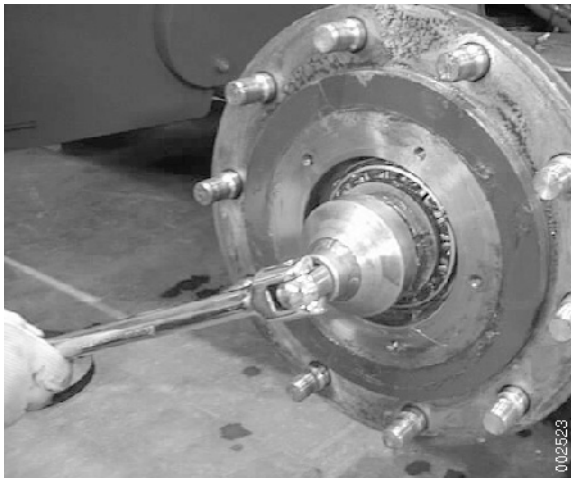
The upper limit could be checked with a spring balance which gives the maximum friction torque, the friction torque should be approximately **14.5 Nm.**

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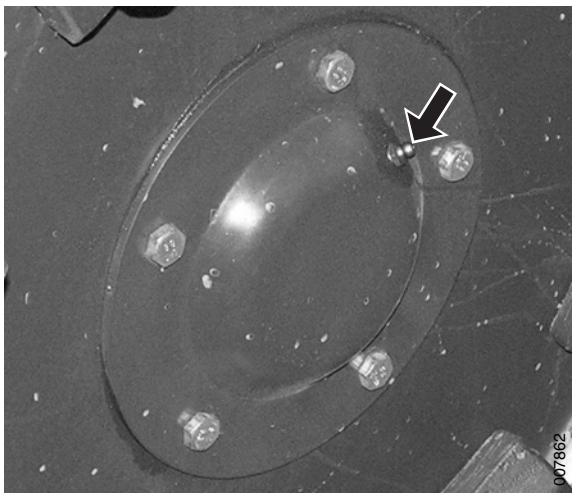


Wind a cord a few times around the wheelbolts before the wheel is mounted and pull with the spring balance. Read the scale when hub is rotated.

20 Grease the lock washer and fit it.



21 Fit the lock nut and tighten with a minimum torque of **250 Nm** or as hard as necessary to be able to turn the lock washer in the nearest groove. Lock the bearing nut and lock nut with the lock washer.



22 Fill the bearing casing with grease and fit it.

23 Grease the wheel bearing with grease through the grease nipple. Rotate now and then to distribute graese inside wheel hub, lift the seal ring's lip with a small screwdriver to enable air to escape. Grease until grease comes out by the seal.

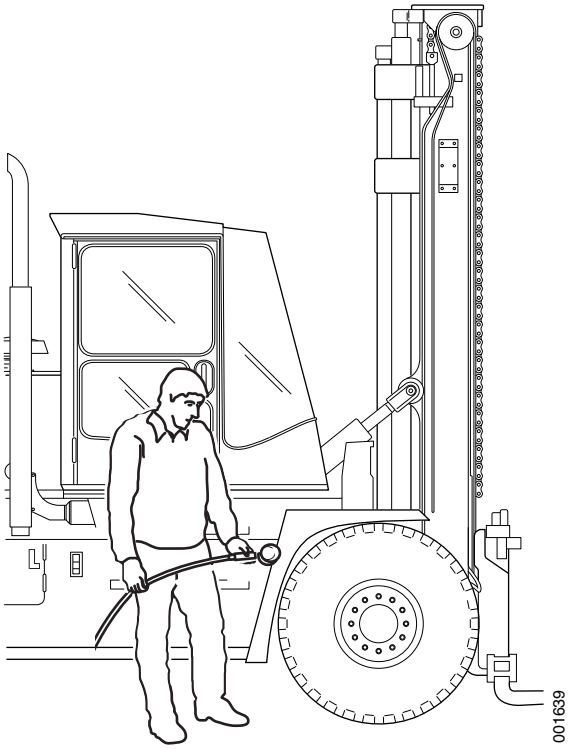
24 Fit the wheel.

25 Remove the support and lower the steering wheel.

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6.3 Tyres and rims

Tyres and rims, safety



DANGER

Always block the wheels on the side of the axle where no work is to be done before positioning the jack. Always secure the jack to prevent it from sliding out of position.

Fully deflate the tyre before removal. Otherwise parts from the wheel rim can loosen and shoot out when the pressure is changed. With double wheel fitting both tyres must be fully deflated!

The air should always be released through the valve. If this is not possible - drill holes in the tread to release the air. Damaged tyres may explode.

Never stand directly opposite the tyre when deflating or inflating. Parts from the wheel rim may release and shoot off when the pressure changes.

Never install damaged tyres or rims.

It's prohibited to repair rims with welding.

It's prohibited to operate the machine if one of the tyres is flat.

Wheels, tyres, and rims are dimensioned and selected for each machine type so that maximum wheel loads and speeds are not exceeded. For this reason, it is not permitted to change tyre dimension, tyre make, tyre type, rim type, or rim brand without approval from Cargotec.

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⚠ CAUTION

When removing wheels, the wheel nuts should be left in place after loosening. If the wheel nuts are removed immediately, the wheel may release from the hub.

When removing drive wheels, make sure that the wheels are fixed when the spacer rings are removed. If the wheels move, they may move the spacer rings and crushing damage may result.

When installing drive wheels, ensure that the clamps clamp straight on the spacer ring.

Wheel nuts should be check-tightened after 4–5 operating hours.

Always follow the tyre manufacturer's or other approved instructions when changing tyres.

Never use a steel hammer to install or remove rim components. Instead, use a lead, brass or plastic mallet.

Keep the tyre pressure at the prescribed level. Insufficient tyre pressure impairs stability and reduces the machine's capacity.

Remove penetrating objects such as crushed glass, pieces of wood, metal filings, etc.

Check if tyre wear is abnormal, this could indicate a mechanical fault. Rectify faults immediately and change damaged tyres.

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6.3.1 Tyres

Tyres, description

The tyres are the machine's contact with the ground, the tyres absorb rough surfaces and act as suspension.

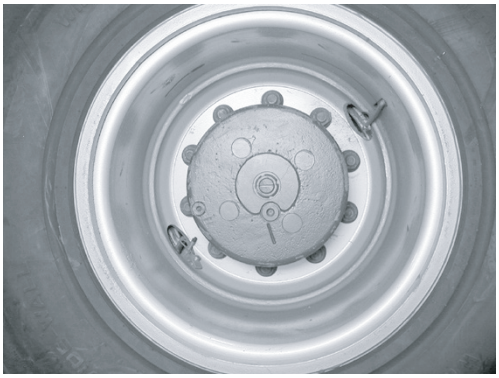
The drive axle is exposed to great stresses during operation, and the stresses increase if the drive wheels' rolling circumference differs. It is important that the tyres on the drive axle are of the same model, type and make, and have similar wear and the correct air pressure.

Spare and exchange tyres shall be of a make approved by Cargotec.



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Rear wheels



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Front wheels

Tyres, replacement

DANGER

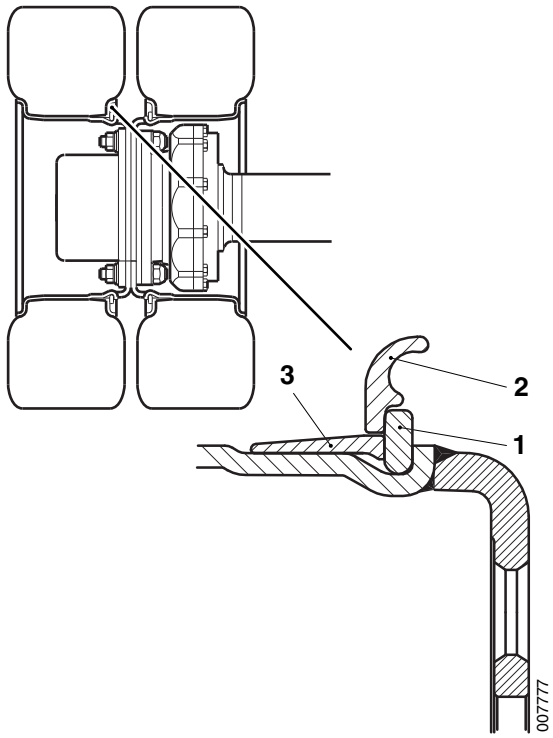
Changing tyres is complicated and dangerous work.

EXTREME DANGER!

Leave tyre work to authorised personnel/tyre company.

The rims must be checked when tyres are changed. See *Maintenance manual*.

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1. Lock ring
2. Side ring
3. Tapered ring

6.3.2 Rims

Rim, description

The rim is split to make it possible to fit a tyre. The rim consists of the following parts.

- Rim
- Lock ring
- Side ring
- Tapered ring

6.3.3 Nut, washer and clamp (wedge)

Nut, washer and clamp, description

The rim is secured to the wheel hub with nuts (washer integrated in the nut).

Clamps are not used here.

10 nuts are always used on this machine and these can be used as follows:

- Drive axle with hub reduction, nuts with integrated washers.
- Steering axle, nuts with integrated washers.
- Steering axle with nut caps (protection).

NOTE

Two different type of nuts when protection plate is mounted.

Bolt equipment, replacement

1 Machine in service position, see section *B Safety*.

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2 Lift the machine under the counter weight.

3 Remove the wheel.



4 Knock out the bolt with a sledge hammer.

5 Install the new bolt.

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7 Load handling

7.1 Controls and instruments

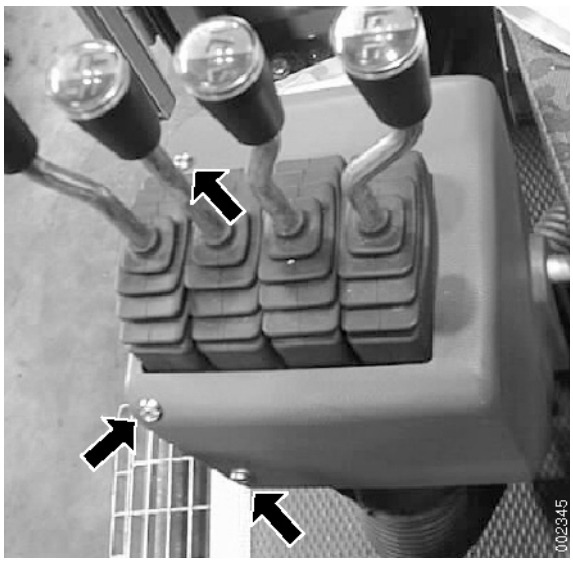
7.1.1 Control lever

Control lever, replacement

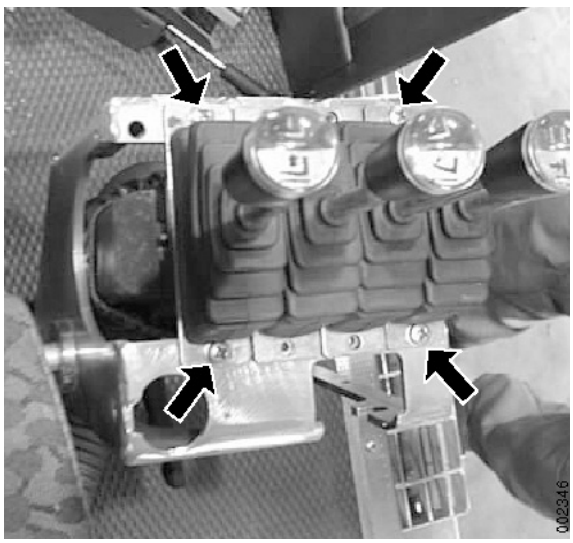
1 Machine in service position, see section *B Safety*.

2 Depressurize the hydraulic system, see section *B Safety*.

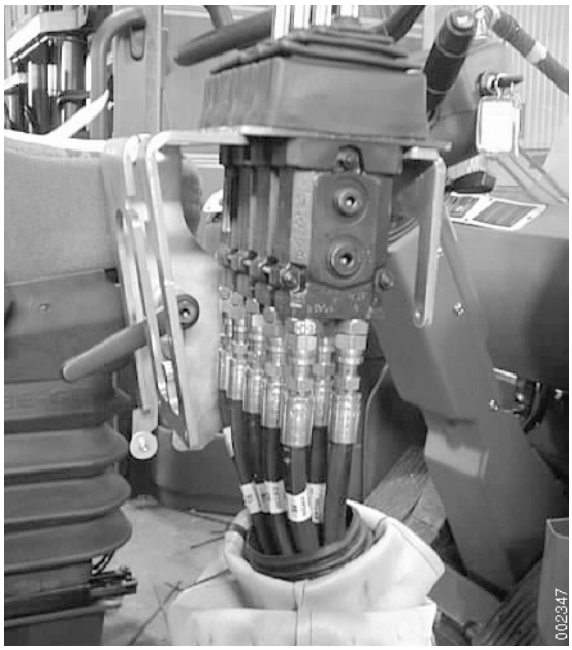
3 Remove the cover from the control levers (six screws).



4 Detach the control levers from the bracket (four screws).

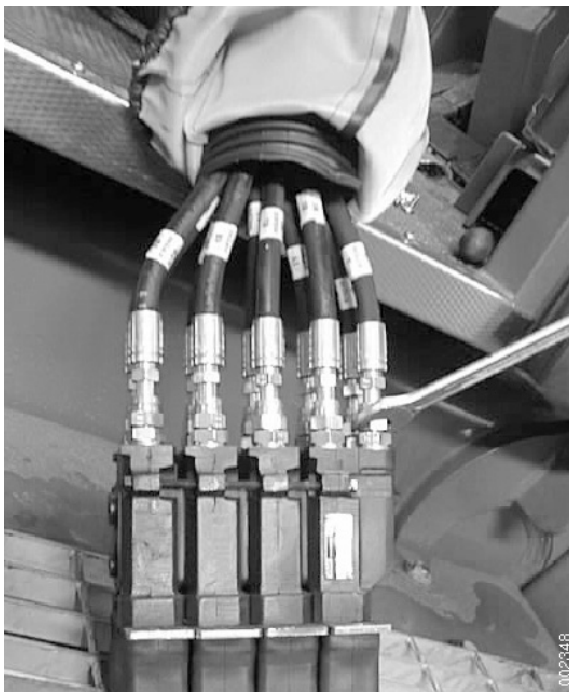


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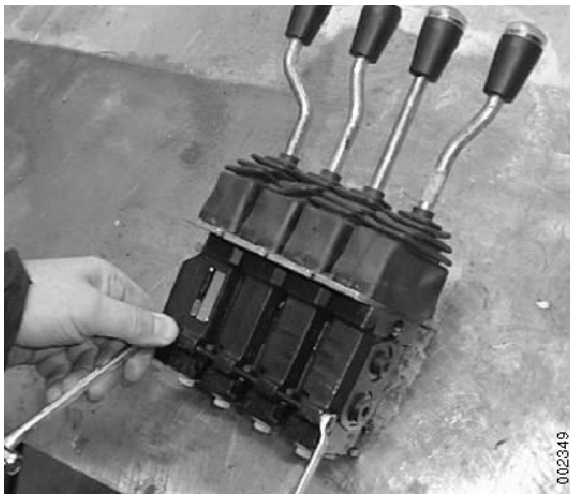
5 Cut the cable tie and fold down the gaiter to expose the control levers' connections.

6 Lift the control levers off the bracket.



7 Remove the hose connections.

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8 Unscrew the control levers.

9 Replace the control lever in question. Replace also the O-ring in case of leakage.

10 Check that there are no leaks when the levers are refitted.

11 Fit in the reverse order.

Electric hydraulic servo, description

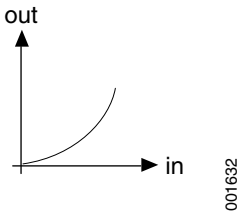
The electrical servo makes possible the use of small fingertip controlled linear levers, or a “joystick”, for the different functions of the working hydraulics.

The control levers contain potentiometers. The output signals from these are handled in ECU 796 and then used for control of electro-hydraulic proportional valves (see Workshop Manual, section *10 Common hydraulics*, group *10.5.5 Proportional valves*). These convert the output signals from ECU 796 to hydraulic servo pressure which then controls the control slides in the hydraulic system main valves.

During operation, the output signals are changed via two break points in proportion to the lever deflections, which gives direct control of the main valves. An IIR-type of filter and a ramp for lift/lower have been added to damp high frequency interference from the surroundings and to obtain smooth hydraulic movements but with maintained speed. The lower movement has a longer ramp time than lift.

There is an operating switch beside the electric servo levers/joystick. When pressed, it cuts off voltage supply to the PWM outputs in ECU796. Then, no hydraulic functions can move. Red light-emitting diode on the end of ECU796 flashes if emergency stop is pressed. Green light-emitting diode is activated with a fixed glow if the supply voltage is between 22 – 28V, flashes with high frequency if voltage is above 28V and with lower frequency if voltage is below 22V. Yellow light-emitting diode is activated with a fixed glow if communication on the CAN-bus is correct. The output signal is broken in two points for better fine feel. Break point 1 (BP1) is pre-set so that at 40% of the lever movement, the ECU gives 20% of max. output signal. Break point 2 (BP2) is set so that at 80% of the lever movement, the ECU gives 60% of max. output signal. Thus, at 100% lever movement, the ECU gives 100% output signal.

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The control of the main valve (diagram y-axis) is not proportional to the lever angle (diagram x-axis). This gives a better response with small lever angles.

The following signals are monitored:

- control levers or joystick
- proportional valves (impedance and current)

Function test

In general, test all hydraulic functions to make sure that they react and move in the correct direction. The speed of the movements may need to be adjusted individually for each machine, for example, side shift may be too fast at times, then max. current shall be set to a lower value for respective solenoid valve.

1. Dead zone. Check if the dead zone is sufficient by test-running the machine on a rough surface and note if any hydraulic function moves. If it does, increase the dead range, for example, 10 steps.
2. Lift/lower movement. Check smoothness of movement at idle and max. rpm.
3. Tilt in/out. Same as lift/lower.
4. Side shift. Same as lift/lower.
5. Positioning (spreading). Same as lift/lower.
6. Levelling. Same as lift/lower.

Trouble shooting

For error code tables, see section *D Error codes*.

A number of fault tracing examples are shown below.

Symptom. Lift/lower does not function!

- Error code 610. No or incorrect signal from lift/lower lever. If signal is outside calibrated values for more than 100 ms, the alarm is generated. Try re-calibrating the lever. If this doesn’t work, replace the lever.
- Error code 615 or 616. Short-circuit or open circuit in solenoid valve for lift/lower. Check if connector to valve block is pushed in enough. Alternatively, measure resistance in spool for solenoid valve. It should be approx. 20 Ohm, not below 15 Ohm.

Symptom. Tilt in/out does not function!

- Error code 611. See lift/lower above.
- Error code 617 or 618. See lift/lower above.

Symptom. Side shift does not function!

- Error code 612. See lift/lower above.
- Error code 619 or 620. See lift/lower above.

Symptom. Positioning (spread) does not function!

- Error code 613. See lift/lower above.
- Error code 621 or 622. See lift/lower above.

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Symptom. Levelling or 5th function does not function!

- Error code 614. See lift/lower above.
- Error code 623 or 624. See lift/lower above.

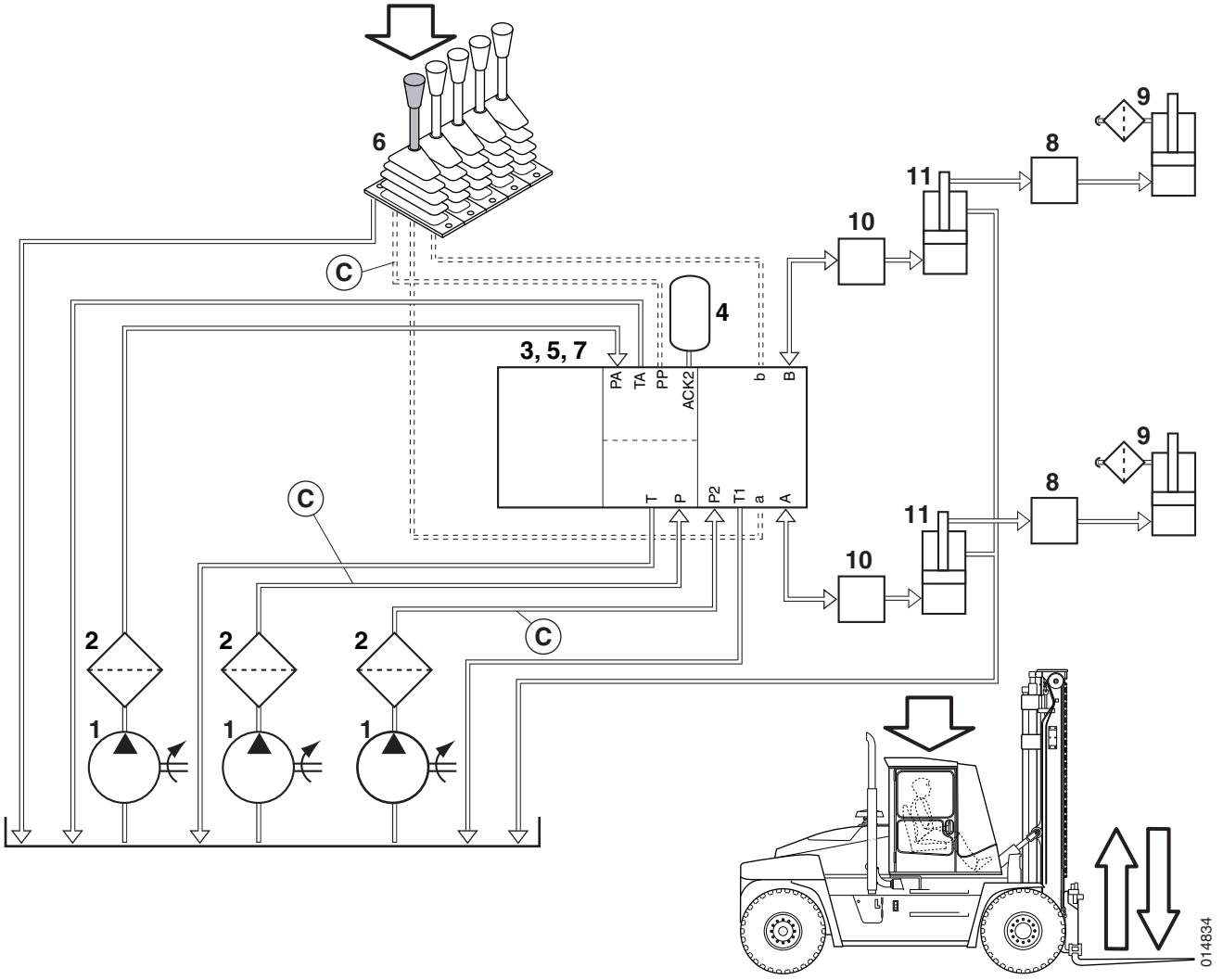
Symptom. No response in any hydraulic function.

- Error code 604. Voltage supply 24V to PWM outputs missing. Check if operating switch by the electric servo levers is pressed down. If electric servo still doesn't function, check fuse 58-4 no. 7 (10A) for DCE90-180. Otherwise, supply internally in ECU is defective and it must be replaced.
- Error code 603. Voltage supply 10V reference to electric servo levers missing. Measure 10V reference from ECU between terminals X46.7 (0V) and X46.6 (10V) for DCE90-180. If there's no 10V or voltage is below 9V or above 11V, then supply from ECU is defective and it must be replaced.
- Error code 601. Voltage supply to ECU 796 below 14V or above 33V or missing. Check fuse 58-4 no. 7 (5A) for DCE90-180.
- Error code 602, 605 or 606. Hardware error on ECU796. Try to restart the system with the ignition key. If this doesn't work, the ECU has to be replaced.

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7.2 Lifting/lowering

Lifting/lowering, function description (hydraulic servo)



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pumps oil from the hydraulic oil tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve in the valve block directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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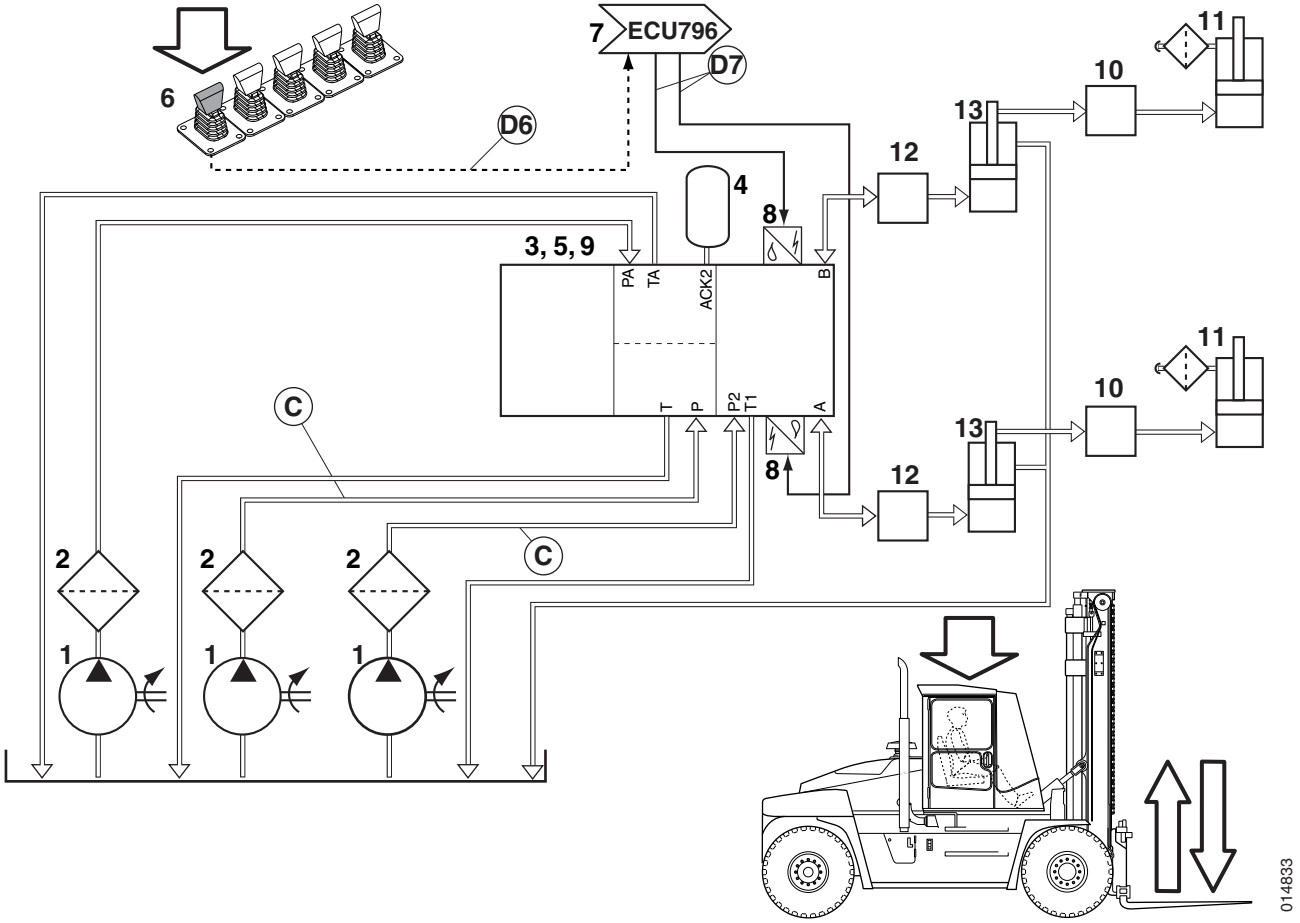
Pos	Explanation	Signal description	Reference
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*
6	Control lever, lift and lower, controls servo pressure in proportion to lever movement to control valve load handling.	-	
7	The servo pressure from control lever, lift and lower, acts on the lift slide in control valve, load handling, which changes position and pressurizes the lift cylinders.	-	*Main valve, description (hydraulic servo) page 12*
8 ⊕	**Lifting or lowering the fork carriage** (free lift) During lifting, the load control valve opens and directs pressure on to the lift cylinders. The free lift cylinders start to move at a lower pressure, since their area is 15-20% greater than in the lifting cylinders. *During lowering, the load control valve is closed and directs limited flow from the free lift cylinder.*	-	*Load control valve, description page 38*
9 ⊕	The free lift cylinder raises *or lowers* the fork carriage in relation to the inner mast.	-	*Lift cylinder, description page 13*
10	**Lift or lower mast** The load control valve opens and directs pressure on to the lift cylinders.	-	*Load control valve, description page 38*
11	The lift cylinders raises *or lowers* the inner mast in relation to the outer mast.	-	*Lift cylinder, description page 13* *Lift masts, description page 14*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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Lifting/lowering, function description (electrical servo)

Condition	Reference value	Reference
Control switch	Disengaged	Section *11 Common electrics*, group *11.5.1.4 Emergency stop voltage (15E)*



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pumps oil from the hydraulic oil tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve in the valve block directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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Pos	Explanation	Signal description	Reference
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*
6	The control lever, lifting and lowering (R8071), sends a voltage signal which is proportional to the lever movement to the Control Unit hydraulics (ECU 796).	U = 0-10 V DC	D6: Diagnostic menu, see section *8 Control system*, group *8.4.4.1 View inputs, menu 3, ECU 796 input K1:9*
7	The Control Unit Hydraulics (ECU 796), sends a current signal to the solenoid valve for mast lifting (Y6005) *or the solenoid valve for mast lowering (Y6004).*	-	*Main valve, description (electrical servo) page 12* D7: Diagnostic menu, see section *8 Control system*, group *8.4.4.2 View outputs, menu 1, ECU 796 output K2:3 (lower)*, output K2:4 (lift)
8	Solenoid valve, mast lifting (Y6005) *or the solenoid valve for mast lowering (Y6004)* allocates servo pressure in proportion to the control current in the lifting slide in control valve load handling.	-	*Main valve, description (electrical servo) page 12*
9	The control valve lifting slide changes position and pressurizes the lift cylinders.	-	*Main valve, description (electrical servo) page 12*
10 ⊕	**Lifting or lowering the fork carriage** (free lift) During lifting, the load control valve opens and directs pressure on to the lift cylinders. The free lift cylinders start to move at a lower pressure, since their area is 15-20% greater than in the lifting cylinders. *During lowering the load control valve is closed and directs limited flow from the free lift cylinder.*	-	*Load control valve, description page 38*
11 ⊕	The free lift cylinder raises *or lowers* the fork carriage in relation to the inner mast.	-	*Lift cylinder, description page 13*
12	**Lift or lower mast** The load control valve opens and directs pressure on to the lift cylinders.	-	*Load control valve, description page 38*
13	The lift cylinders raises *or lowers* the inner mast in relation to the outer mast.	-	*Lift cylinder, description page 13* *Lift masts, description page 14*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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7.2.1 Hydraulic oil pump

Hydraulic oil pump, description

Please refer to section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

7.2.2 Accumulator

Accumulator, description

See section *10 Common hydraulics*, group *10.3.2 Accumulator*.

7.2.3 Main valve

Main valve, description (hydraulic servo)

Lifting/lowering is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information on lifting/lowering, see *Lifting/lowering, function description (hydraulic servo) page 8*.

Lift slide

When the lift control lever is activated, pressure is applied to the lift spool, which controls the direction and flow of oil from the hydraulic oil pump to the lift cylinders. See *Lift cylinder, description page 13*.

Main valve, description (electrical servo)

Lifting/lowering is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information on lifting/lowering, see *Lifting/lowering, function description (electrical servo) page 10*.

Lift slide

The lift slide controls direction and flow of oil to the lift cylinder.

Servo valve, lift mast

The servo valve for lifting is controlled electrically by Solenoid valve lift (Y6005), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the lift spool. This pressure is proportional to the control current to the solenoid valve.

Servo valve, lower mast

The servo valve for lowering is controlled electrically by Solenoid valve lower (Y6004), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the lift spool. This pressure is proportional to the control current to the solenoid valve.

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7.2.4 Lift cylinder

Lift cylinder, description

The lifting cylinders lift and lower the inner mast, which runs inside the outer mast. The lower parts of the lifting cylinders are fixed to the outer mast, whereas their upper parts are fixed to the inner mast, one on the right and one on the left of the mast.

The lift cylinders are connected in parallel and fed from control valve load handling, see *Load control valve, description page 38*.

The cylinder head is threaded in the cylinder barrel (and can be removed using a hook wrench if needed). When the cylinder is reconditioned and the cylinder head is to be remounted, it is very important that the piston rod is unloaded exactly so that the threads aren't damaged.

There are double piston rod seals on the cylinders (applies to all cylinders for load handling). The bearing arrangement consists of guide bushings that hold the piston rod in the center of the cylinder.

For images of the lift cylinders, see *Lift masts, description page 14*.

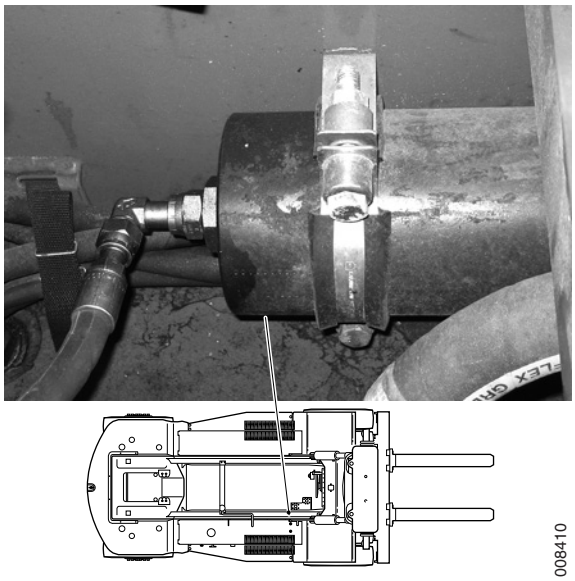
The lift cylinders for the mast duplex free-lift are provided with end-position damping. This function means that when the cylinders approach their bottom position, the oil flow out from the cylinders is restricted. The oil flow is forced through a gap between the piston end and the cylinder bottom. To ensure the cylinders' lift movement from the bottom position, a non-return valve directs oil past the restriction.

Hydraulic cylinders, repairing

See section *10 Common hydraulics,* group *10.7.1 Hydraulic cylinders*.

7.2.5 Accumulator damping

Accumulator damping, description



008410

Piston accumulator

This accumulator, which is only intended for the lift and lower function, is of the piston accumulator type (not to be confused with the diaphragm accumulator in group 10 Common Hydraulics). It is an option that significantly improves damping performance when lifting and lowering loads.

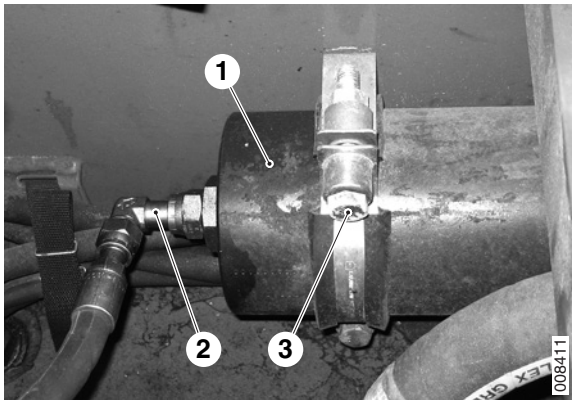
The piston accumulator is connected to the lift cylinders and provides a damping function in the cylinder, e.g. when driving on an uneven surface, which can create pressure spikes in the hydraulic system.

The function is ideal for handling rolls of paper, where the friction between the clamp and the roll of paper is at risk if accumulator damping is not used. Accumulator damping makes the grip on the roll of paper is more secure.

NOTE

Handling the accumulator requires special equipment and training.

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1. Piston accumulator
2. Nipple
3. Bolt and mounting clamp (2 pc.)

Accumulator damping, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

3 Mark up and detach the hydraulic hoses from the accumulator.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

4 Remove the accumulator attaching bolts.

5 Remove the accumulator.

6 Charge the new accumulator. As standard, it should be charged with 10 MPa preload pressure. This pressure can be lowered to achieve the desired functionality.

7 Transfer the connection adapters to the new accumulator.

8 Fit the new accumulator.

9 Connect the hydraulic hoses to the accumulator in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

10 Turn on the main electric power and start the engine. Run the engine at idling speed.

11 Test the lifting and lower a couple of times.

12 Check that the accumulator's connections are sealed tightly.

7.2.6 Mast

Lift masts, general

The lift masts that are available are: duplex standard, duplex freelift and triplex freelift. The duplex alternatives have an outer as well as an inner mast, while the triplex freelift also has a middle mast.

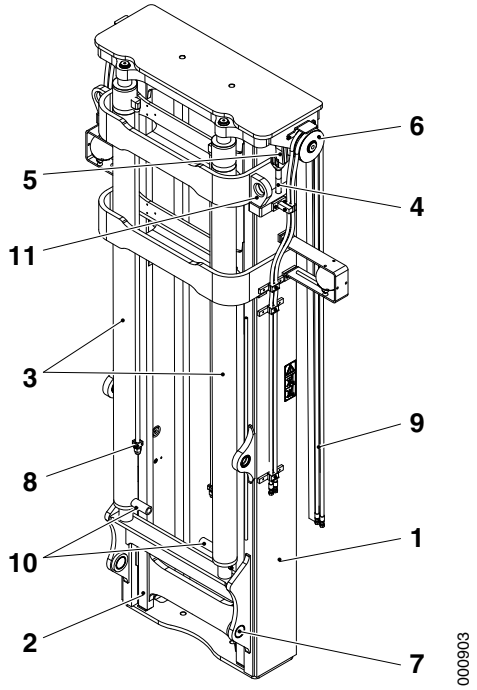
Lift masts, description

The mast lifts the load. The fork carriage runs on the mast, and holds the forks, attachment or coil ram in its turn.

The lower part of the mast is fixed to the frame by two shafts in the lugs on the front part of the frame. The mast is also fixed to the frame by two tilt cylinders.

The lift masts, both duplex as well as triplex, are based on a free-visibility concept. The number of welds has been reduced to a minimum for maximal strength, and stresses on the mast parts are low. All mast wheels are provided with high-quality bearings.

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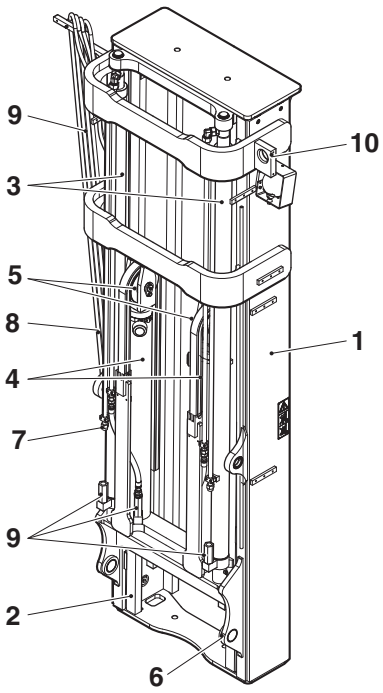
Duplex standard
1. Outer mast
2. Inner mast
3. Lift cylinders
4. Chain tensioner
5. Chain wheel
6. Hose wheel
7. Attachment to frame
8. Nipple
9. Hoses
10. Load control valves
11. Lifting eyes

Side (lateral) control of the inner mast (inner and middle mast on triplex) is achieved using sliding plastic blocks at the upper end of the outer mast and the lower end of the inner mast.

Duplex standard, description

Oil is forced into the lift cylinders. The lift cylinder piston rod is attached to the inner mast, which is lifted. The chain that is attached in the carriage (and in the outer mast) runs over chain wheels at the top of the inner mast. Thus, the carriage is also lifted at the same time as the inner mast.

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Duplex freelift
1. Outer mast
2. Inner mast
3. Lift cylinders
4. Freelift cylinders
5. Chain wheel
6. Attachment to frame
7. Nipple
8. Hoses
9. Load control valves
10. Lifting eyes

Duplex freelift, description

Oil is forced into the lift cylinders. The lift cylinders have a hollow piston rod that is connected to the freelift cylinders. Through area control (freelift cylinders require lower oil pressure than the lift cylinders to be lifted), the freelift cylinder piston rod is forced out before the lift cylinders. At the end of the piston rod on the freelift cylinders, is a wheel over which a chain runs. The chain is attached to the carriage and the inner mast, which means that the carriage is lifted at the same time as the freelift cylinders' piston rod is extended.

When the freelift cylinders have reached their end position, the pressure in the lift cylinders increases and their piston rod lifts the inner mast.

The lift cylinders for the duplex freelift mast have end position damping in the masts lower position, see *Lift cylinder, description page 13*.

Triplex freelift, description

Oil is forced into the lift cylinders. Through area control (freelift cylinders require lower oil pressure than the lift cylinders to be lifted), the freelift cylinder piston rod is forced out before the lift cylinders. At the end of the piston rod on the freelift cylinders is a wheel over which a chain runs. The chain is attached to the carriage and the inner mast, which means that the carriage is lifted at the same time as the freelift cylinders' piston rod is extended.

When the freelift cylinders have reached their end position, the pressure in the lift cylinders increases and their piston rod lifts the middle mast.

The chain attached to the inner mast and outer mast runs over a chain wheel at the top of the middle mast, which means that the inner mast is raised at the same time as the middle mast.

The lift cylinders for the triplex freelift mast have end position damping in the masts lower position, see *Lift cylinder, description page 13*.

Mast, removing

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Remove the fork carriage, please refer to *Fork carriage, removing page 35*.

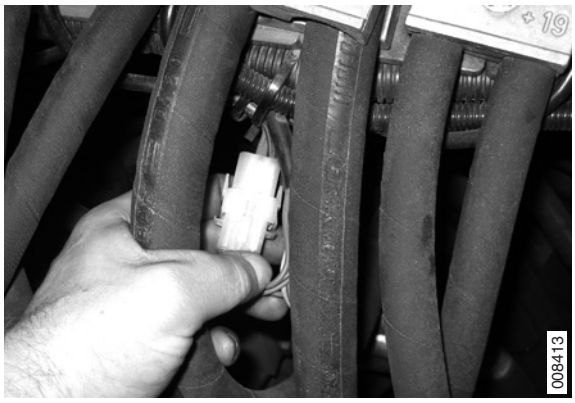
2 Machine in service position, see section *B Safety*

3 Depressurize the hydraulic system, see section *B Safety*.

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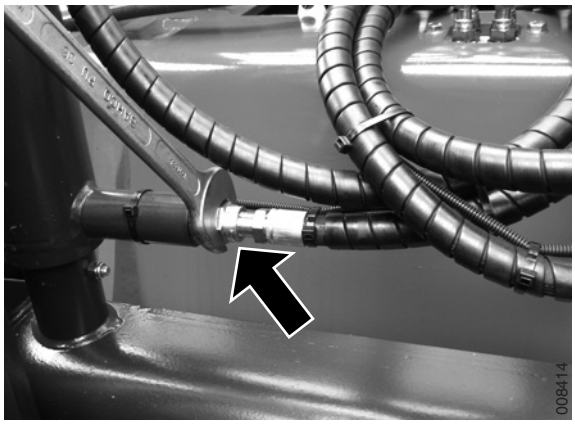


4 Connect lifting equipment to the lifting lugs on the mast in a secure manner.



5 Undo the mast lighting connector and release the mast lighting cable.

6 Mark up and undo other electrical connectors if there are any.

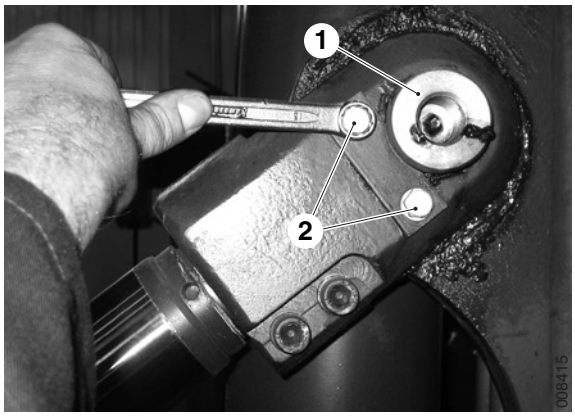


7 Put a collection vessel under the mast to collect any spilled oil.

8 Mark and undo the hydraulic connections for the lift cylinders.

NOTE

Plug all connections at once to protect the hydraulic system from contamination.



1. Cylinder shaft
2. Screw and washer

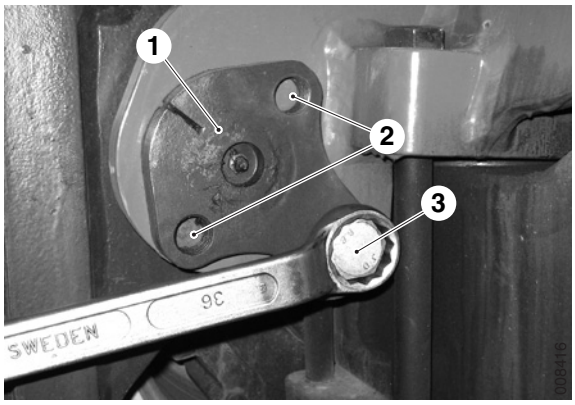
9 Secure the tilt cylinder to an overhead crane and release the tilt cylinder from the mast.

Remove the two screws and the lock plate for the shaft.

Remove the cylinder shaft. If necessary, use a slide hammer to drive the shaft out.

Repeat the procedure for the other cylinder.

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1. Shaft
2. Tapped holes (M24)
3. Screw

10 Undo the mast from the machine by undoing the screw and removing the shafts which fix the mast to the frame, use two screws (M24) in the tapped holes puller.

WARNING

The mast can swing out when it is released from the machine.

This can cause personal injury!



11 Lift the mast away and lay it on the ground.

12 Undo the lifting equipment (travelling crane).

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Mast, installing

NOTE

Read the safety instructions for oil before working, see section B Safety.

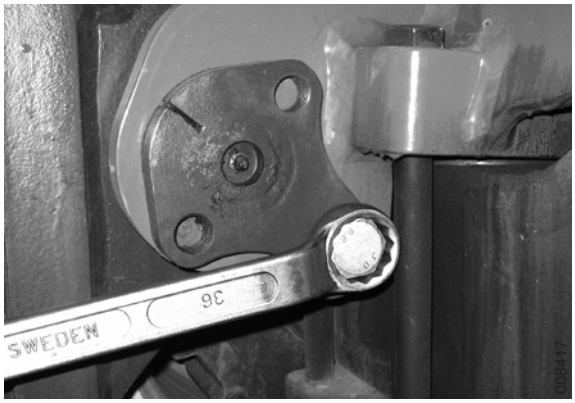
1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

3 Connect lifting equipment to the lifting lugs on the mast in a secure manner.

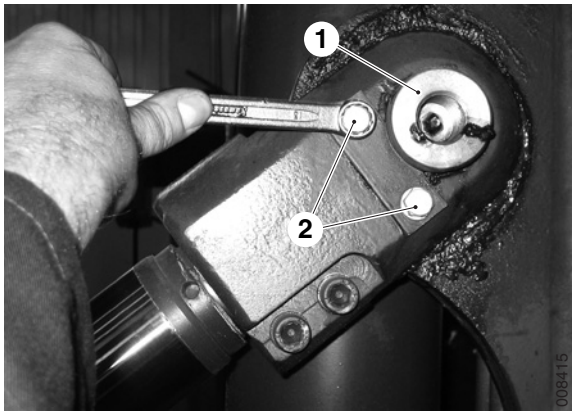
4 Lift the mast into place.





5 Install the shafts and fix them with screws.

6 Grease the mast anchorage.



1. Cylinder shaft
2. Screw and washer

7 Connect the tilt cylinders to the mast.

Install the cylinder shaft.

NOTE

Check that the bearing in the cylinder anchorage on the mast is correctly aligned before the shaft is installed.

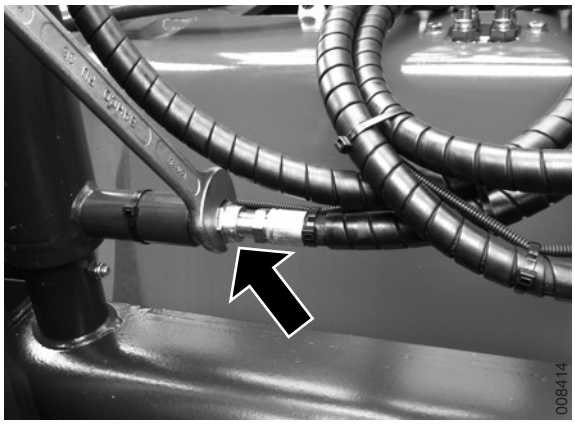
Rotate the shaft to find correct position for the lock plate.

Mount the lock plate and secure with the two screws.

Repeat the procedure for the other cylinder.

8 Grease the cylinder anchorages.

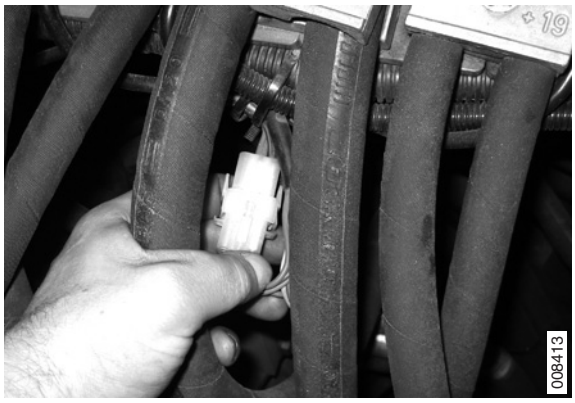
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9 Connect the hydraulic hoses to the lift cylinders in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.



10 Fix the mast lighting cable and join the mast lighting connector together.



11 Undo the lifting equipment (travelling crane).

12 Turn the main switch on and start the engine.

13 Check that the hydraulic connections seal correctly.

14 Extract air from lift cylinders, applies duplex freelift for DCE 90-140.

a) Lift the carriage about 0,5 m.

b) Connect a hose to the air vent valve. Put the other end on the hose in a vessel.

c) Open the valve and let the oil flow until the oil is free from air bubbles flows out from the hose.

⚠ WARNING

The trolley lowers.

Risk of crushing.

15 Check the mast functions. Adjust the tilt cylinders as necessary, please refer to *Tilt cylinder, adjustment page 62*.

16 Check the oil level in the hydraulic oil tank when all hydraulic pistons are fully retracted. Top up as necessary.

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Flanges on outer and inner mast beam

Flanges on outer and inner mast beam, description

The mast and mast components is constructed out of high tension materials and is tested under heavy operation and enviroments for a long and problem-free performance.

However problems due to neglected maintenance, heavy operation, malfunction of mast wheels or damages to mast / fork carriage may occur. For example flatting or pitting of the beam flanges, mostly on the inner mast but also on the outer mast.

Flanges on outer and inner mast beam, repair

If the surfaces have started breaking up in small flakes they can be prepared so that the mast can be used again.Method starts with grinding affected surface and continous with running in of surface.

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Remove the fork carriage from the mast, please refer to *Fork carriage, removing page 35*.

3 Remove the mast, please refer to *Mast, removing page 16*.

4 Divide the inner and and outer mast.

5 Remove mast wheels from inner mast.

6 Clean outer and inner mast.

7 Grind affected surfaces, with a belt grinder, to be smoth and bright. Start with grain 36-40 and finish with grain 60-80.

Grinding scratches shall run along beam direction

Check internal width between front and rear flange, if measure exceeds 187 mm for 185 mm beam or 247 mm for 245 mm beam, contact Cargotec.

8 Fit the mast wheels to the inner mast.

9 Apply a thin layer of grease to running surfaces on the outer mast and install inner mast to outer mast.

10 Apply a thin layer of grease to running surfaces on the inner mast and install mast to machine, please refer to *Mast, installing page 19*.

11 Install fork carriage into mast, please refer to *Fork carriage, installing page 36*.

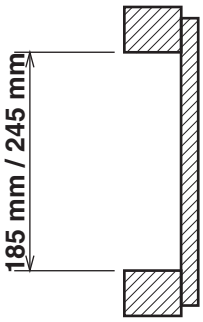
12 Lift and lower mast to check function as follows:

Take a load of 6 ton for 185 mm beam or 8 ton for 245 mm beam at stipulated CoG and run up and down 20 times.

Take a load of 10 ton for 185 mm beam or 12 ton for 245 mm beam at stipulated CoG and run up and down 20 times.

Take max load at stipulated CoG and run up and down 20 times.

13 Check if running surfaces looks normal, if not, contact Cargotec.



Beam size of 185 or 245 mm depending on type of mast.

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7.2.7 Mast wheels

Mast wheels, description

The mast wheels consist of a rim with one spherical roller bearing.

Adjustment of play for inner mast

1 Removing the fork carriage, please refer to *Fork carriage, removing page 35*.

2 It is possible to divide the mast when installed on the machine or remove the mast, please refer to *Mast, removing page 16* and divide the mast on the ground.

3 Dividing the inner and outer mast.

Applies to Duplex standard

a) Undo cables, chains and hoses necessary for dividing the mast, loosen the circlip attaching the lift cylinders to the inner mast.

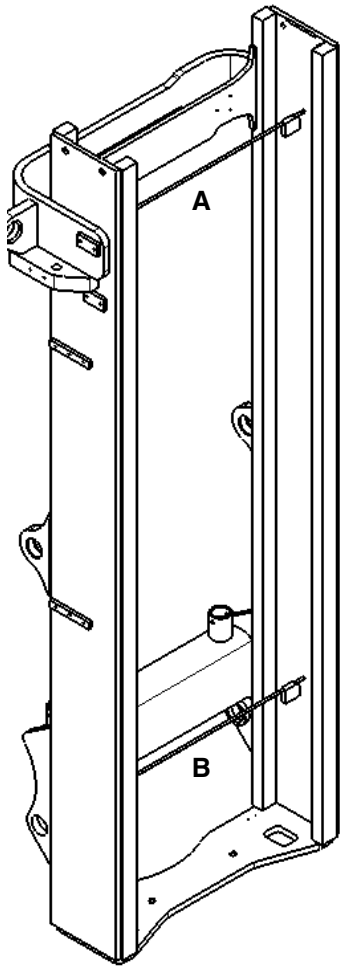
b) Connect lifting equipment to the inner mast, lift the inner mast away from the outer mast.

c) Place the inner mast on the ground in a secure manner.



Circlip attaching the lift cylinders

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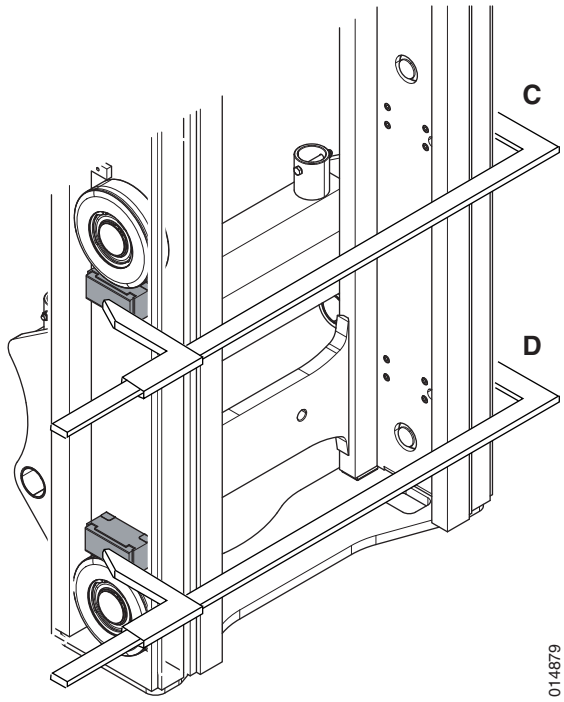


Measure internal width of outer mast (A and B)

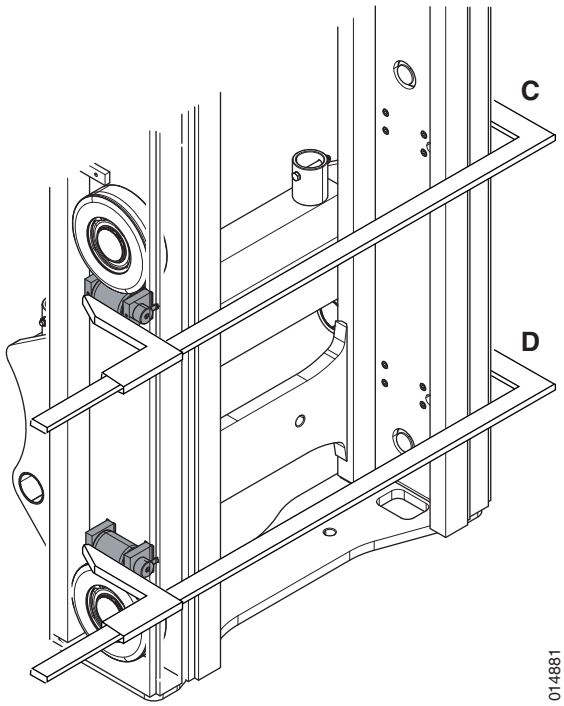
4 Check the mast wheels and replace as necessary.

5 Use a Vernier calliper to measure the internal width of the outer mast.

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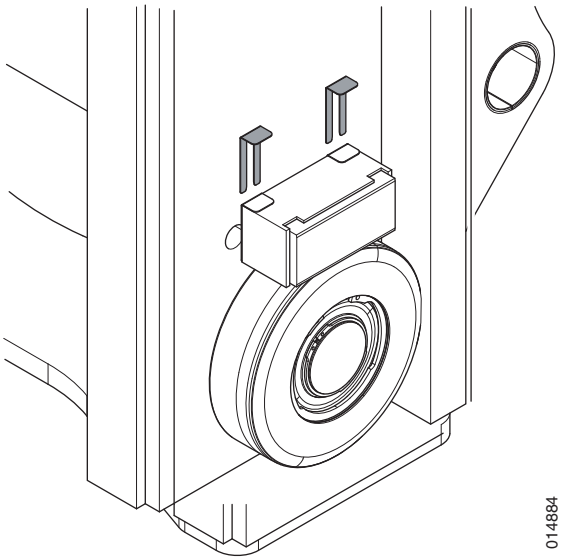
Mast with slide plates



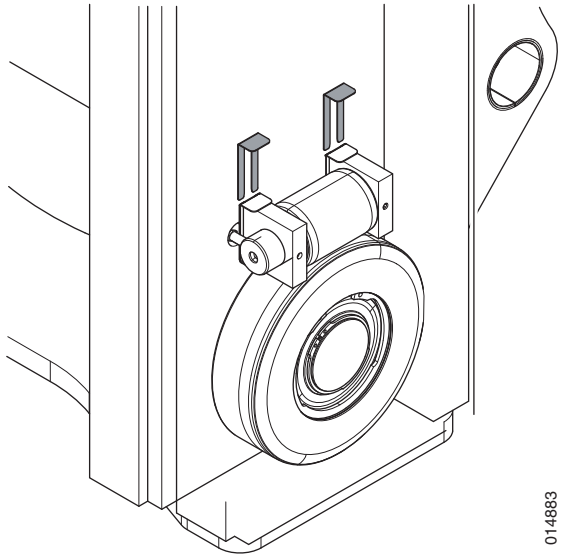
Mast with support rollers ⊕

6 Use a Vernier calliper to measure the external width of the slide plates (C and D).

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Mast with slide plates



Mast with support rollers ⊕

7 Adjust the play.

a) If A and B is equal:

Adjust D to be equal to or max 0,5 mm less than B.

Adjust C to be equal to or max 0,5 mm less than D.

b) If A is larger than B:

Adjust D to be equal to or max 0,5 mm less than B.

Adjust C to be equal to or max 0,5 mm less than D.

c) If A is less than B:

Adjust D to be equal to or max 0,5 mm less than B.

Adjust C to be equal to or max 0,5 mm less than A.

8 Apply a thin layer of sliding grease to internal sliding surfaces of outer mast.

9 Lift the inner mast and slide the inner and outer mast together.

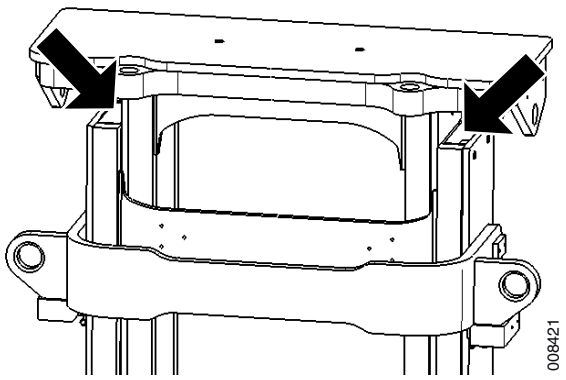
Adjustment of play between upper support, in outer mast, and inner mast

1 Apply a thin layer of sliding grease to external sliding surfaces of inner mast.

2 Lower inner mast to bottom position.

3 Raise inner mast about 200 mm.

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4 Adjust upper support to touch outside of inner mast or give a play of max 0,5 mm.

   Use appropriate number of shims in rear and front end to give alignment along the whole width of wear pad.

5 Lift inner mast to top position and check that wear pads not touch to hard along beam.

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Adjustment of play between fork carriage and inner mast

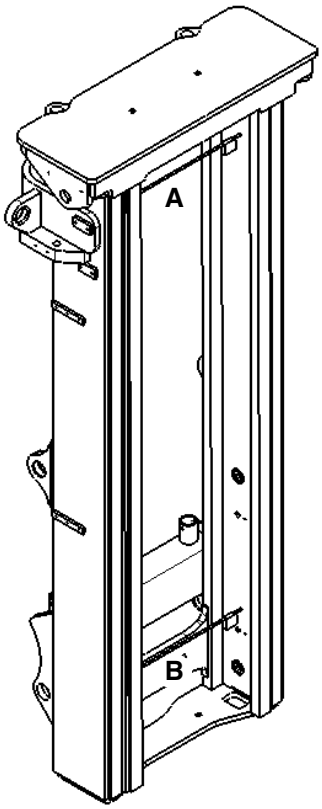
1 Removing the fork carriage, please refer to *Fork carriage, removing page 35*.

NOTE

Smaller adjutment of play between fork carriage and inner mast is possible to perform without removing the fork carriage.

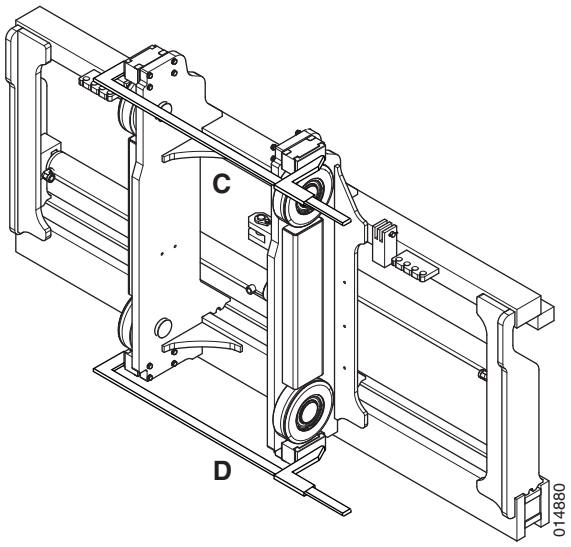
2 Check the mast wheels in the fork carriage and replace as necessary.

3 Use a Vernier calliper to measure the internal width of the inner mast.

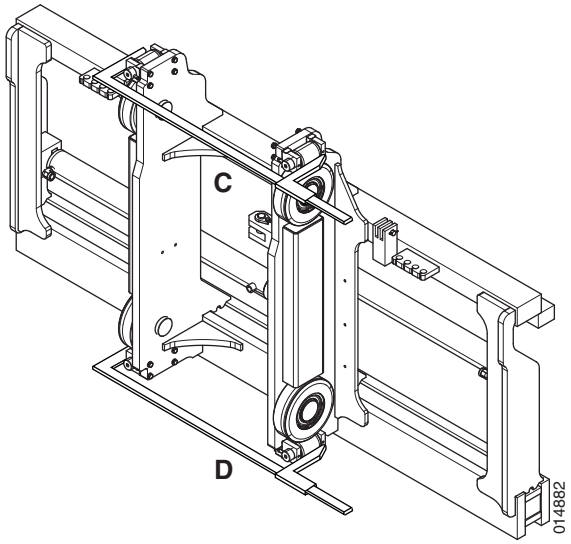


Measure internal width of inner mast (A and B)

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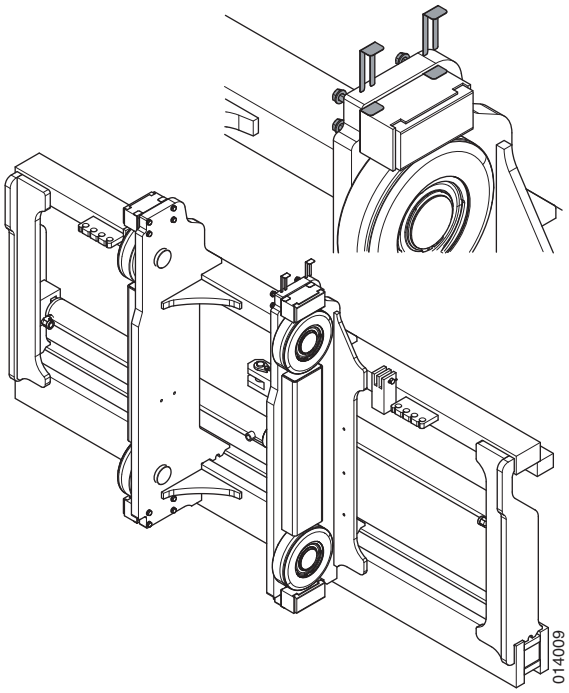
Mast with slide plates



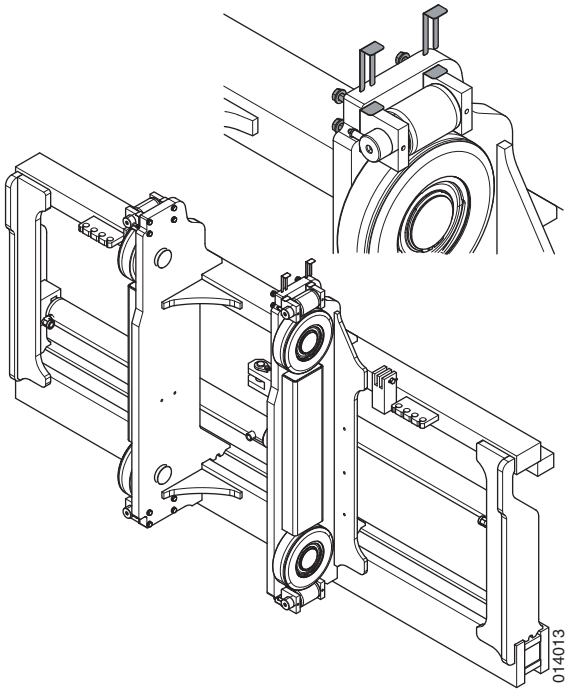
Mast with support rollers ⊕

4 Use a Vernier calliper to measure the external width of the slide plates/support rollers of the fork carriage.

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Mast with slide plates



Mast with support rollers ⊞

5 Adjust the play by loosen the screw (position 1) and adding or removing shim plates (position 2).

   a) If A and B is equal:

      Adjust C and D to be equal to or max 0,5 mm more than A.

   b) If A is larger than B:

      Adjust C to be equal to or max 0,5 mm more than A.

      Adjust D to be equal to or max 0,5 mm more than B.

   c) If A is less than B:

      Adjust C to be equal to or max 0,5 mm more than A.

      Adjust D to be equal to or max 0,5 mm less than B.

6 Apply a thin layer of sliding grease to internal sliding surfaces of inner mast.

7 Install the fork carriage, see *Fork carriage, installing page 36*.

8 Lift the fork carriage to top position and check wear pads not touch to hard along beam.

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7.2.8 Chains

Chains, description

The chains are of the Fleyer chains type.

Chains, replacement

⚠ WARNING

The lifting chain is heavy.

Risk of crushing. The chain is difficult to handle.

Handle with caution and be very careful when the chain is removed from the sprocket. Serious personal injury and damage to the vehicle can result from carelessness.

1 Machine in service position, see section *B Safety*

2 Lower the load unit to the lowest position.

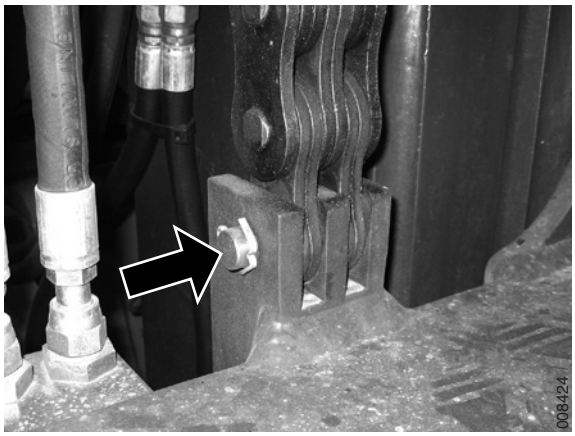
3 Release the lifting chain from the load unit.

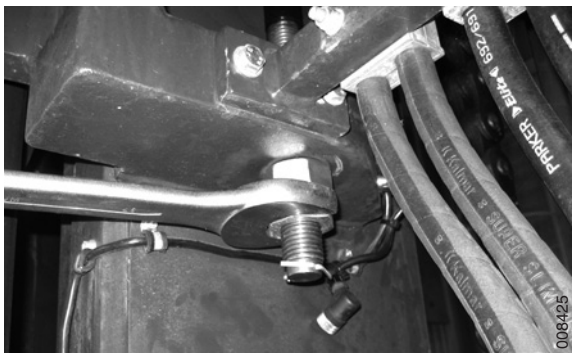
Remove the pin and shaft from each side of the load unit.

4 Connect lifting equipment to the chain in a secure manner.

Undo the chain anchorage from the chain tensioner and lay the chain down.

5 Fit a new chain.





6 Tension the chains with the chain tensioners. Check that the chains are tensioned equally.

7 Measure the ground clearance of the fork carriage. The distance must be equal on the right and left sides, with a tolerance of ±5 mm. Adjust further with the chain tensioner if necessary.

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7.2.9 Chain wheels and hose wheels

Chain wheels and hose wheels, description

The chain wheels and hose wheels are provided with two roller bearings.

Chain wheels, replacement

1 Machine in service position, see section *B Safety*.

2 Raise the mast.

3 Put a support under the fork carriage and lower the mast again. Chains and hoses are now slackened.

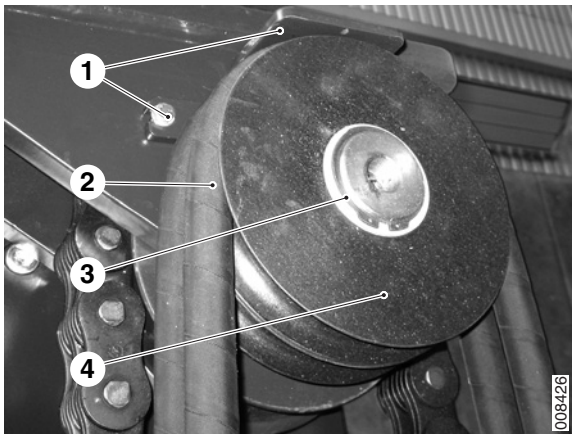
4 Connect lifting equipment to the chain in a secure manner.

Undo the chain anchorage from the chain tensioner and lay the chain down.

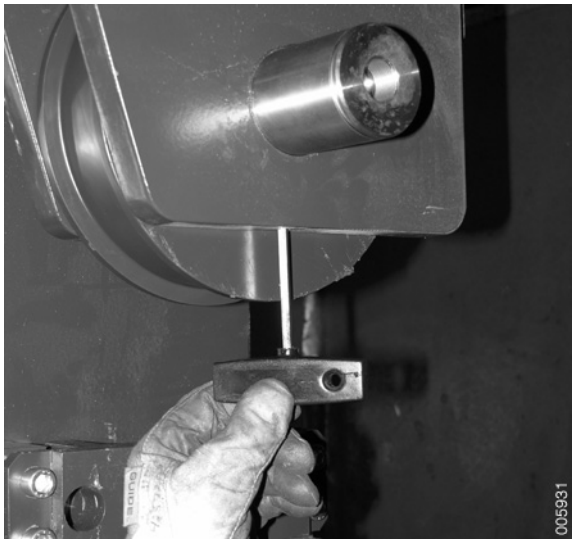
5 Remove the hose guide that prevents the hoses from becoming derailed.

6 Lift the hose off the hose wheel.

7 Undo the circlip and remove the hose wheel.



1. Hose guide and attaching bolt
2. Hoses
3. Circlip ring
4. Hose wheel.



8 Undo the set screw that locks the shaft.

9 Pull the shaft out and remove the sprocket.

NOTE

The sprocket will fall down when the shaft is loosened!

10 Install a new sprocket and re-install the shaft.

NOTE

Lubricate the shaft with sliding grease.

11 Lock the shaft with the set screw.

12 Install the hose wheel.

13 Install the circlip.

14 Grease the sprocket.

15 Put the hoses back and install the hose guide.

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Chain wheels for freelift, replacement

1 Machine in service position, see section *B Safety*.

2 Raise the mast.

3 Put a support under the fork carriage and lower the mast again. Chains and hoses are now slackened.

4 Connect lifting equipment to the chain in a secure manner.

Undo the chain anchorage from the chain tensioner and lay the chain down.

5 Undo the set screw that locks the shaft.

6 Pull the shaft out and remove the sprocket.

NOTE

The sprocket will fall down when the shaft is loosened!

7 Install a new sprocket and re-install the shaft.

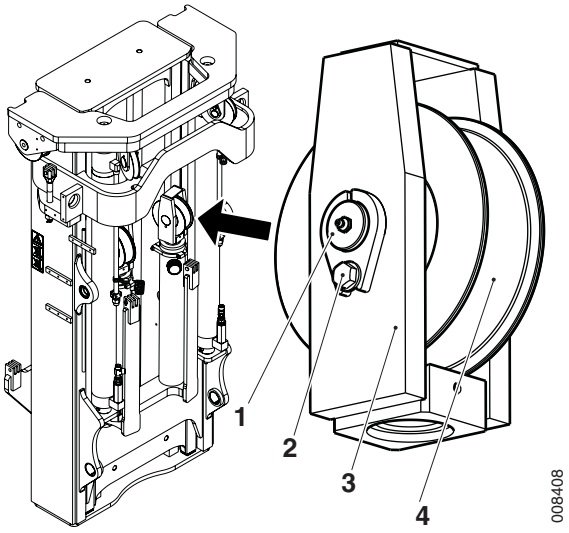
NOTE

Lubricate the shaft with sliding grease.

8 Lock the shaft with the set screw.

9 Grease the sprocket.

10 Re-install the chain.



1. Shaft
2. Set screw
3. Bracket
4. Chain wheel

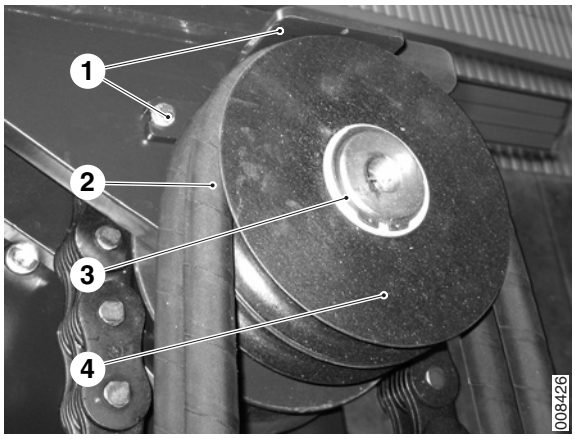
Hose wheels, replacement

1 Machine in service position, see section *B Safety*.

2 Raise the mast.

3 Put a support under the fork carriage and lower the mast again. Chains and hoses are now slackened.

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1. Hose guide and attaching bolt
2. Hoses
3. Circlip ring
4. Hose wheel.

4 Remove the hose guide that prevents the hoses from becoming derailed.

5 Lift the hose off the hose wheel.

6 Undo the circlip and remove the hose wheel.

NOTE

Lubricate the shaft with sliding grease.

7 Install a new hose wheel.

8 Install a circlip.

9 Put the hoses back and install the hose guide.

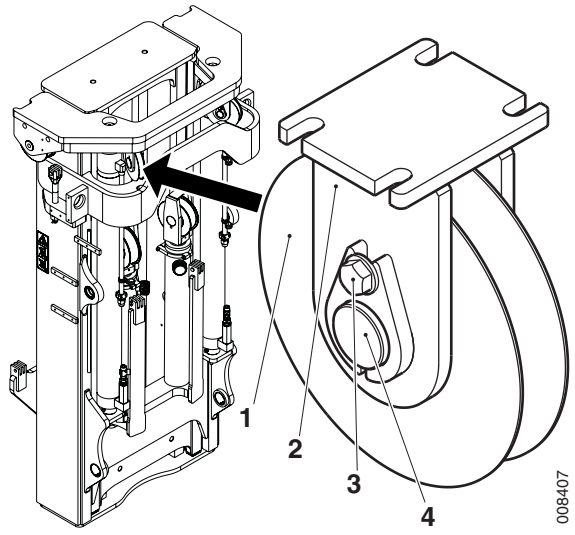
Hose wheels for Triplex freelift, replacement

1 Machine in service position, see section *B Safety*.

2 Raise the mast.

3 Put a support under the fork carriage and lower the mast again. Chains and hoses are now slackened.

4 Undo the screw, pull out the shaft and remove the hose wheel.



1. Hose wheel
2. Bracket
3. Screw
4. Shaft

NOTE

Lubricate the shaft with sliding grease.

5 Install a new hose wheel.

6 Re-install the shaft and lock it with the screw.

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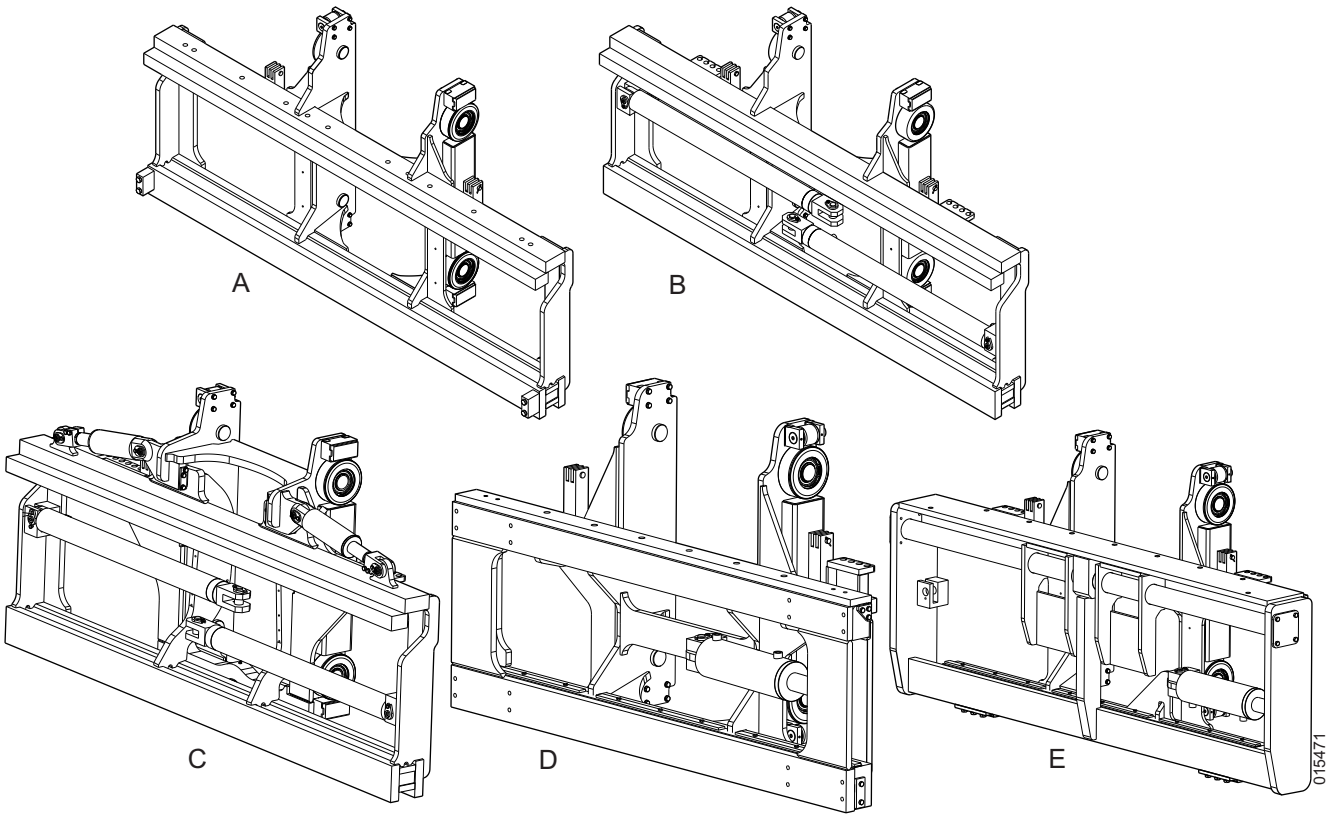
7.2.10 Fork carriage

Fork carriage, description

A number of different fork carriages are available. The most common version is with hydraulic side shift and fork spreading.

All fork carriage types work on the different masts, see *Lift masts, description page 14*.

The spreading-side shift carriage and center levelling carriage have the same forks, while the carriage for manually adjusted forks and side shift carriage have forks with different mountings, see *Lift forks, description page 70*.



A. Carriage for manually adjusted forks

B. Spreading-side shift carriage

C. Center levelling carriage

D. Side shift carriage

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Fork carriage, removing

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Start the machine and set the mast vertical. Lower the mast.

NOTE

The fork carriage must be placed on a flat surface and secured. It could otherwise tip over when the machine is reversed away.

2 Machine in service position, see section *B Safety*

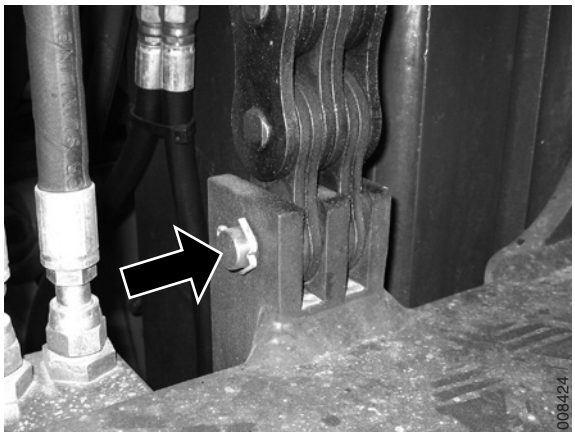
3 Depressurize the hydraulic system, see section *B Safety*.

4 Mark and undo the hose connections to the fork carriage.



NOTE

Plug all connections at once to protect the hydraulic system from contamination.

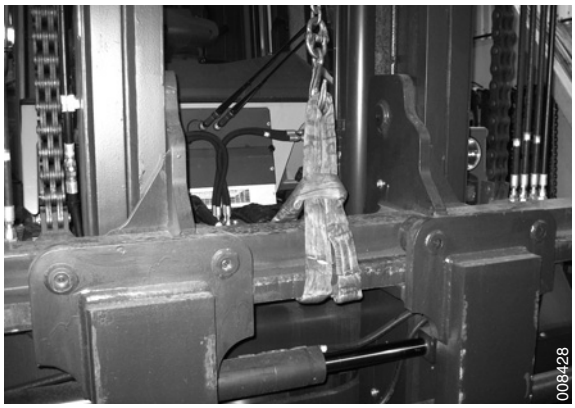


5 Loosen the lifting chains in the vehicle.



6 Hang weights on the chain to prevent them from running away over the sprocket when the mast is raised.

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7 Start the machine and raise the mast, so that the fork carriage comes loose. Reverse away from the mast, or move the fork carriage.

Fork carriage, installing

NOTE

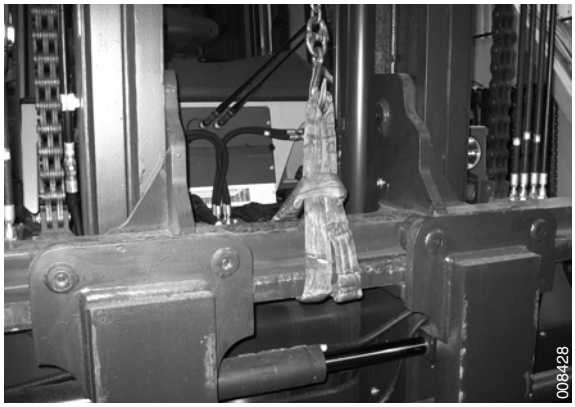
Read the safety instructions for oil before working, see section B Safety.

1 Start the machine and set the mast vertical.



2 Hang weights on the chain to prevent them from running away over the sprocket when the mast is raised.

3 Raise the mast so high that there is room for the fork carriage.



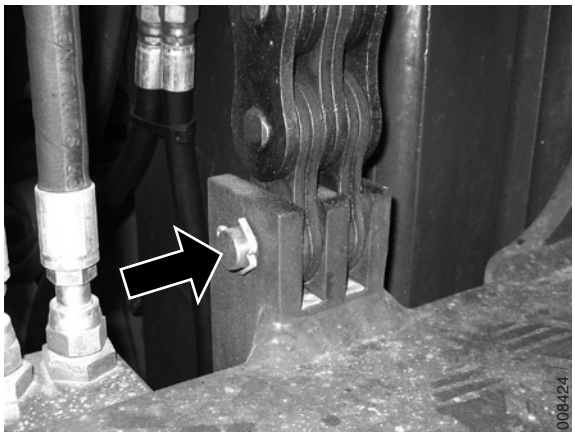
4 Fix the fork carriage on a traversing crane and drive the machine towards the fork carriage, or put the fork carriage in place against the mast.

5 Lower the mast.

6 Machine in service position, see section *B Safety*

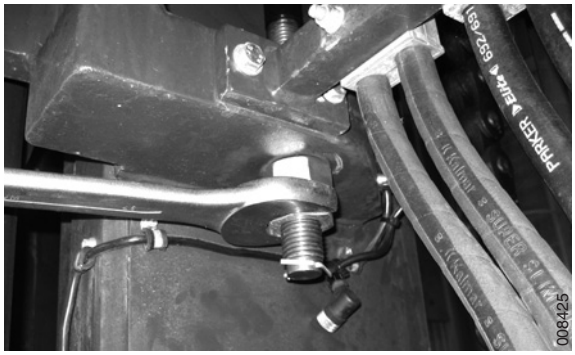
7 Depressurize the hydraulic system, see section *B Safety*.

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8 Fix the chains in the fork carriage.

Install the shaft and lock it with a split pin.



9 Tension the chains with the chain tensioners. Check that the chains are tensioned equally.

10 Measure the ground clearance of the fork carriage. The distance must be equal on the right and left sides, with a tolerance of ±5 mm. Adjust further with the chain tensioner if necessary.



11 Connect the hydraulic hoses to the fork carriage in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

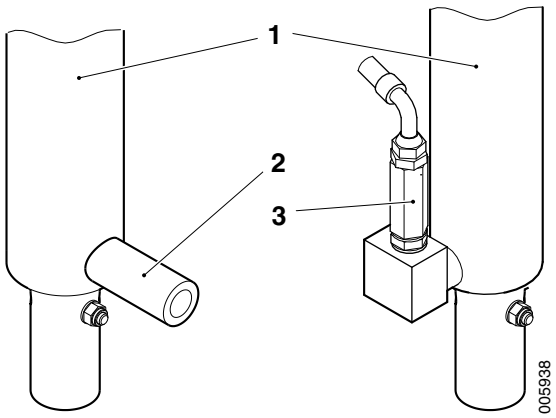
12 Undo the lifting equipment (travelling crane).

13 Turn the main switch on and start the engine.

14 Activate the mast functions. Check that the hydraulic connections seal correctly.

15 Check the oil level in the hydraulic oil tank when all hydraulic pistons are fully retracted. Top up as necessary.

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1. Lift cylinder
2. Load control valve Duplex standard
3. Load control valve Duplex freelift, Triplex freelift

7.2.11 Load control valve

Load control valve, description

The load control valves are located inside the bottom connection for lifting cylinders for duplex standard mast and at the bottom for lift and free-lift cylinders for duplex and triplex freelift masts.

The valve contains a spring-loaded guide piston and a moveable throttle plate that work together to give a constant through-flow, regardless of size of the load. The maximum lowering speed is constant and independent of the weight of the load.

For lifting, the throttle plate and the guide piston are in the through-flow position, allowing the unobstructed passage of the oil. For lowering, the throttle plate assumes a throttle position. The internal pressure drop in the valve and the pre-load force of the guide piston's spring counteract each other, balancing the position of the guide piston, with a corresponding size of restriction gap. Big load - small gap, small load - big gap.

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Load control valve, replacement

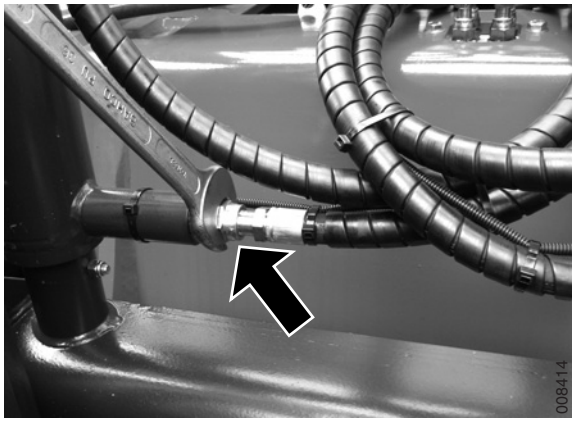
NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

3 Detach the hydraulic hose from the load control valve.



NOTE

Plug the connection immediately to protect the hydraulic system from impurities.

4 Remove the connection adapter.



5 Undo the old load control valve with a flat blade screwdriver and remove it.

6 Fit the new load control valve, (torque a 1” valve to **20 Nm).**

7 Fit the connection adapter.

8 Connect the hydraulic hose to the adapter.

NOTE

Check that the O-rings are intact and fitted correctly.

9 Turn on the main electric power and start the engine. Run the engine at idling speed.

10 Test the lifting and lower a couple of times checking max. lowering speed with max load.

11 Check that the connections are sealed tightly.

7.2.12 Pipes and hoses

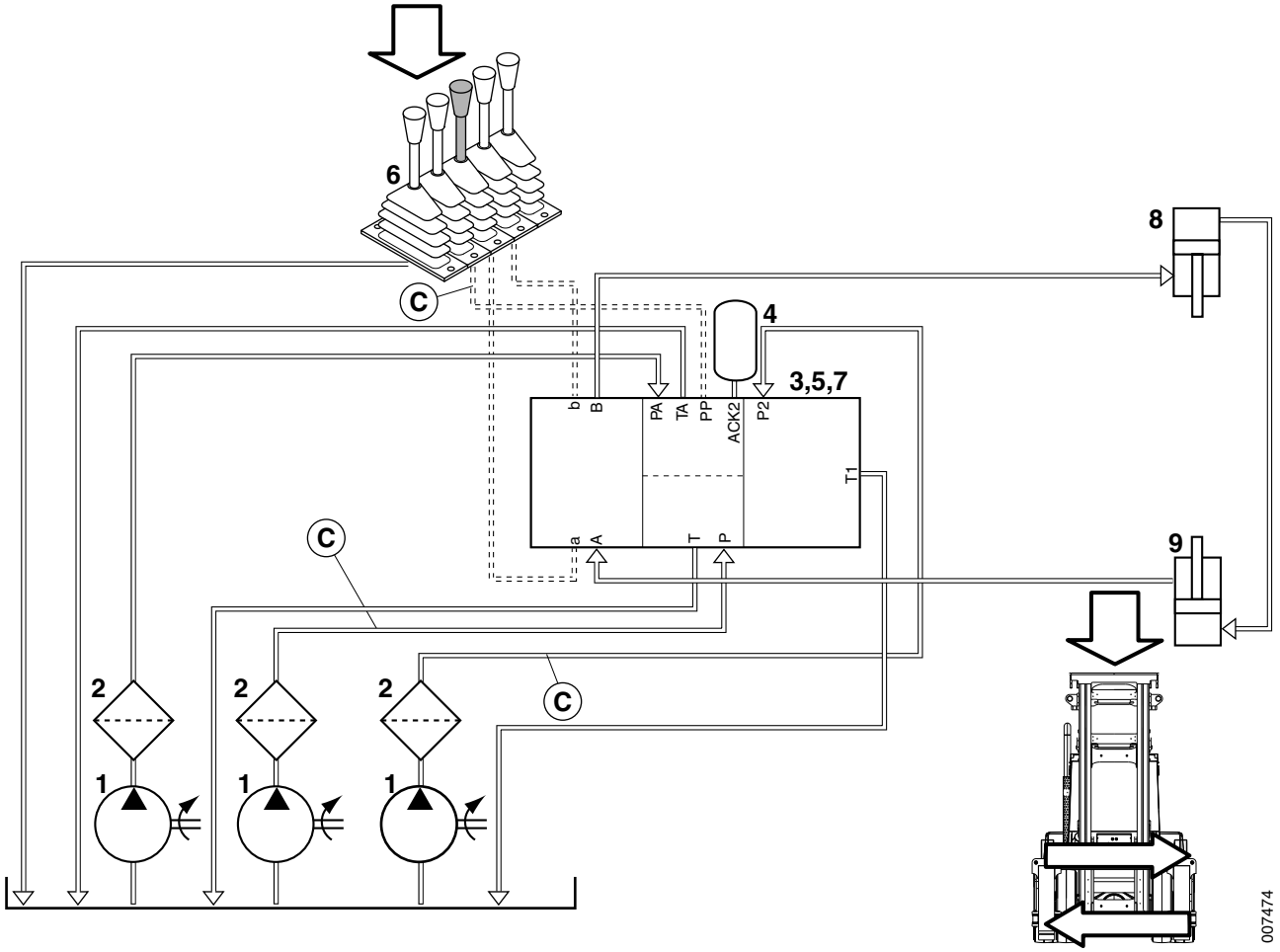
Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

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7.4 Side shift

Side shift, function description (hydraulic servo)



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pump oil from the hydraulic oil tank.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*

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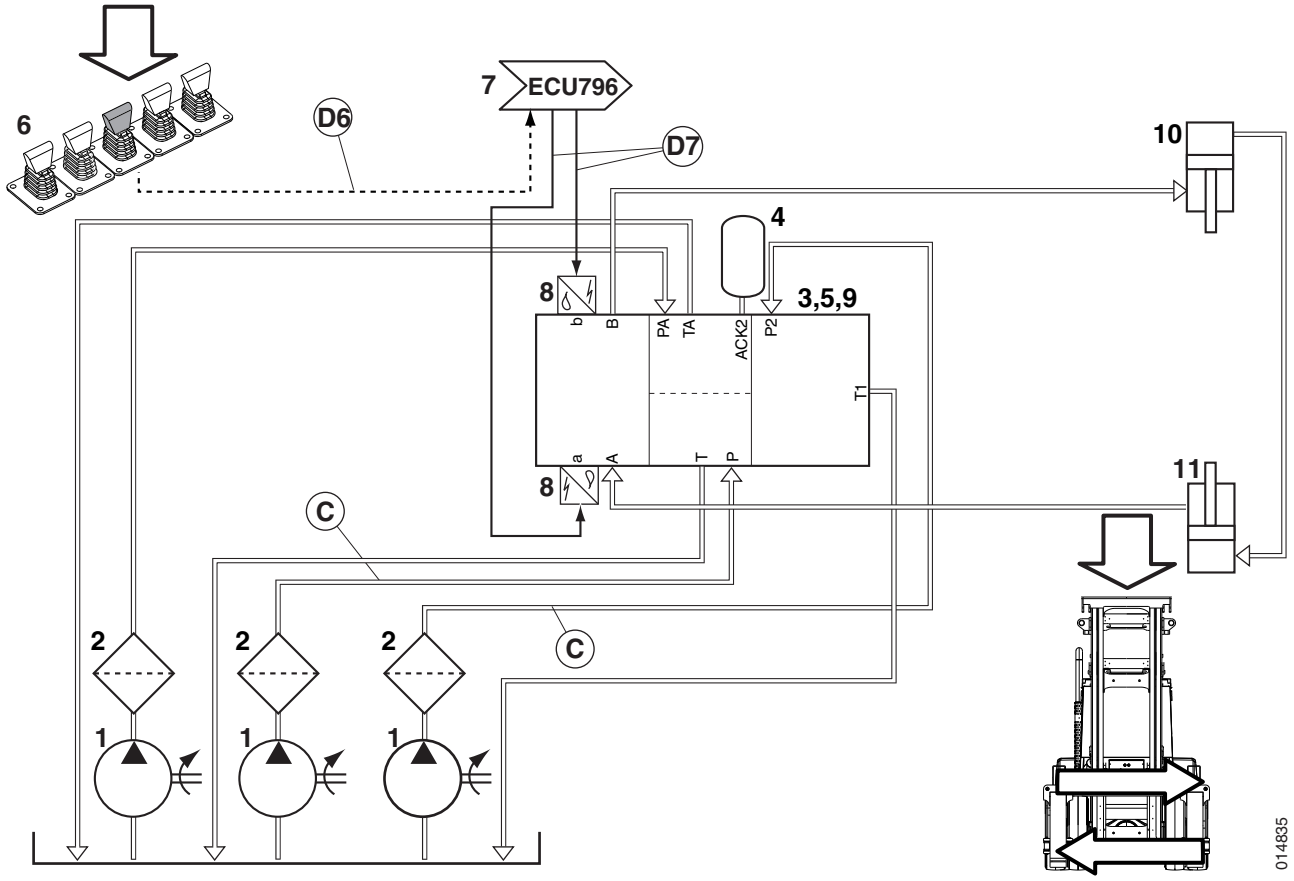
Pos	Explanation	Signal description	Reference
6	Control lever, side shift, controls servo pressure in proportion to lever movement to control valve load handling.	-	
7	The servo pressure from control lever, side shift, acts on the side shift slide in control valve, load handling, which changes position and pressurizes the side shift cylinders.	-	*Main valve, description (hydraulic servo) page 12*
8	The oil pressurizes the shaft side of one of the side shift cylinders. Oil is pressed out on the piston side.	-	*Main valve, description (hydraulic servo) page 12*
9	Oil is directed into the piston side of the other side shift cylinder. This presses out oil on its shaft side and the forks are moved sideways in parallel. Oil from the side shift cylinder is directed back into the tank.	-	-

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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Side shift, function description (electrical servo)

Condition	Reference value	Reference
Control switch	Disengaged	Section *11 Common electrics*, group *11.5.1.4 Emergency stop voltage (15E)*



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pump oil from the hydraulic oil tank.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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Pos	Explanation	Signal description	Reference
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*
6	The control lever, side shift, (R8073) sends a voltage signal to Control unit hydraulics (ECU 796).	U = 0-10 V DC	D6: Diagnostic menu, see section *8 Control system*, group *8.4.4.1 View inputs, menu 3, ECU 796 input K1:11*
7	The Control Unit Hydraulics (ECU 796), sends a current signal to the solenoid valve for left-hand side shift (Y6020) *or the solenoid valve for right -hand side shift (Y6021)*.	-	*Main valve, description (electrical servo) page 12* D7: Diagnostic menu, see section *8 Control system*, group *8.4.4.2 View outputs, menu 1, ECU 796 input K2:7 (left)*, input K2:8 (right)
8	Solenoid valve side shift left (Y6020) *or Solenoid valve side shift right (Y6021)* controls servo pressure to the side shift slide in control valve load handling.	-	*Main valve, description (electrical servo) page 12*
9	The control valve's side shift slide changes position and pressurizes the side shift cylinders.	-	*Main valve, description (electrical servo) page 12*
10	The oil pressurizes the shaft side of one of the side shift cylinders. Oil is pressed out on the piston side.	-	*Side shift cylinder, description page 44*
11	Oil is directed into the piston side of the other side shift cylinder. This presses out oil on its shaft side and the forks are moved sideways in parallel. Oil from the side shift cylinder is directed back into the tank.	-	*Side shift cylinder, description page 44*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

7.4.1 Hydraulic oil pump

Hydraulic oil pump, general

Please refer to section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

7.4.2 Accumulator

Accumulator, description

See section *10 Common hydraulics*, group *10.3.2 Accumulator*.

7.4.3 Main valve

Main valve, description (hydraulic servo)

Side shift is controlled by a separate section of the load handling control valve.

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For general information on the control valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information on side shift, see *Side shift, function description (hydraulic servo) page 40*.

Side shift slide

When the side shift control lever is activated, pressure is applied to the side shift spool, which controls the direction and flow of oil from the hydraulic oil pumps to the spreading cylinders. See *Side shift cylinder, description page 44*.

Main valve, description (electrical servo)

Side shift is controlled by a separate section of the load handling control valve.

For general information on the control valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information on side shift, see *Side shift, function description (electrical servo) page 42*.

Side shift slide

The side shift spool controls the direction and flow of oil to the side shift cylinders.

Servo valve side shift left

On machines with electric servo, the servo valve for side shift left is controlled electrically by Solenoid valve side shift left (Y6020), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the side shift spool. This pressure is proportional to the control current to the solenoid valve.

Servo valve side shift right

On machines with electric servo, the servo valve for side shift right is controlled electrically by Solenoid valve side shift right (Y6021), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the side shift spool. This pressure is proportional to the control current to the solenoid valve.

7.4.4 Side shift cylinder

Side shift cylinder, description

The side shift cylinder (same cylinders used for spreading function, if available) is provided with a pivot bearing at the cylinder end. The piston rod mounting is threaded to the piston rod.

The cylinder head is threaded in the cylinder barrel (and can be removed using a hook wrench if needed).

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Side shift cylinder, replacement

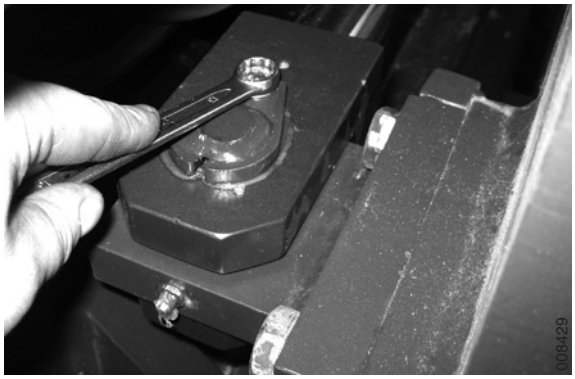
NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Secure the side shift cylinder to the fork carriage with a strap.





3 Remove the shaft connecting the side shift cylinder to the fork. Remove the screw and knock out the shaft.

4 Contract the side shift cylinder with the machine running.

5 Machine in service position, see section *B Safety*.

6 Depressurize the hydraulic system, see section *B Safety*.

7 Place a receptacle under the hydraulic hoses attached to the side shift cylinder.

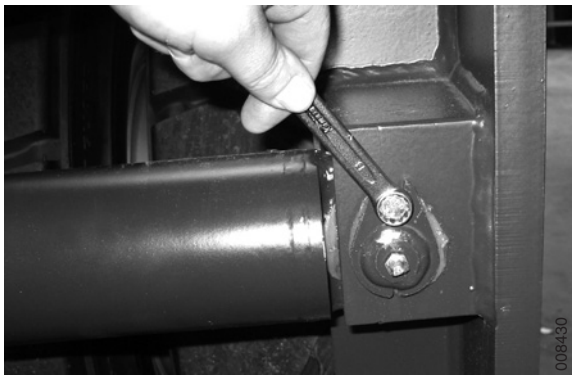


8 Mark up and detach the hydraulic hoses from the side shift cylinder.

NOTE

Plug the connection immediately to protect the hydraulic system from impurities.

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9 Remove the shaft connecting the side shift cylinder to the carriage. Remove the screw and pull out the shaft.

10 Transfer the connection adapters to the new side shift cylinder.

11 Fit the new side shift cylinder.

12 Fit the shafts and screws that connects the side shift cylinder to the fork carriage and forks.

13 Connect the hydraulic hoses to the side shift cylinder in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

14 Turn on the main electric power and start the engine. Run the engine at idling speed.

15 Test the side shift and spreading a couple of times.

16 Check that the connections are sealed tightly.

7.4.5 Side shift frame

Side shift frame, description

The side shift frame is the moveable part of the side shift carriage. The side shift cylinder is attached to the frame as well as the carriage, and thus provides the side shift movement.

See the image under *Fork carriage, description page 34* (option D).

7.4.6 Fork carriage

Fork carriage, description

See *Fork carriage, description page 34*.

7.4.7 Pipes and hoses

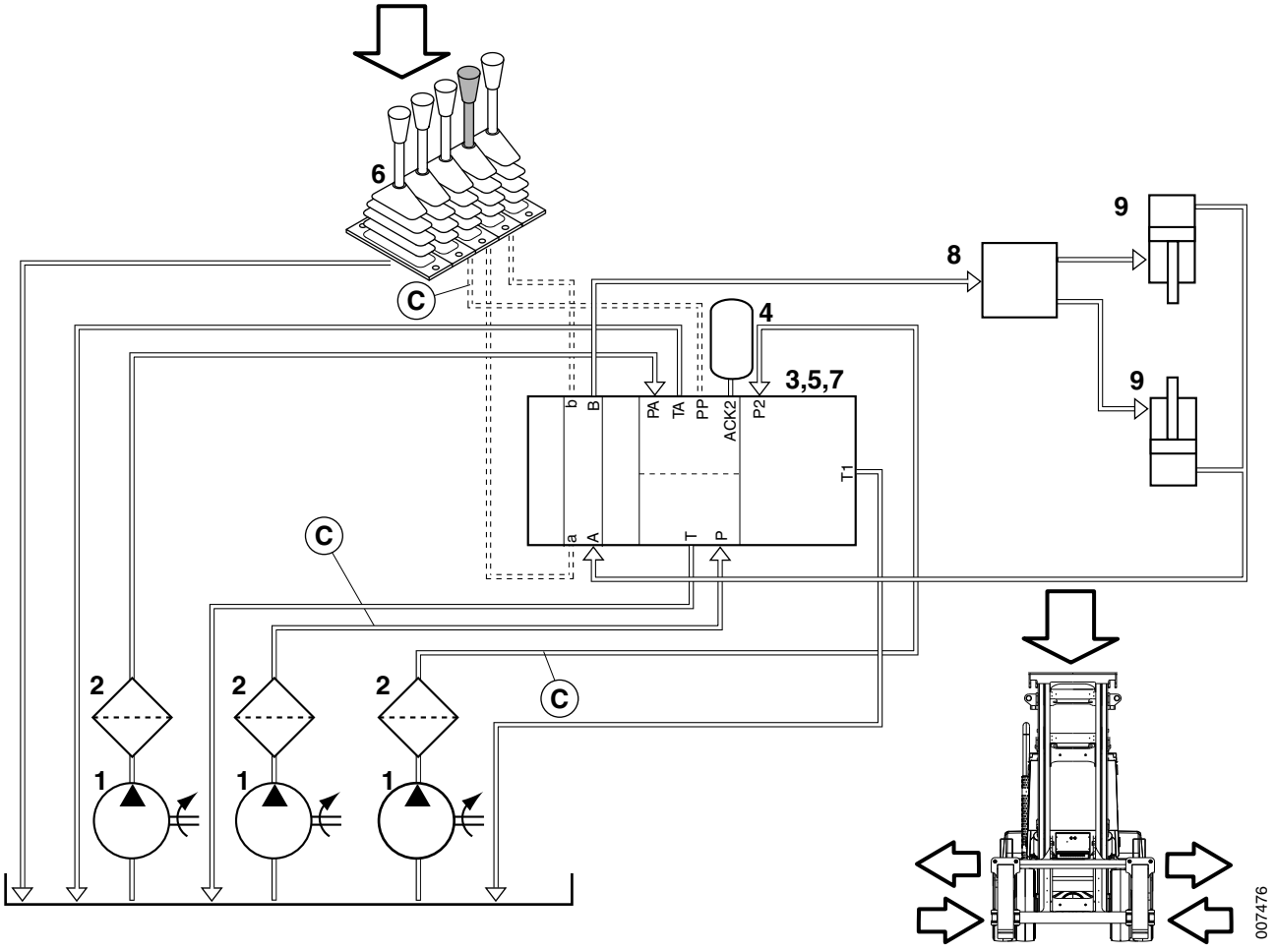
Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

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7.5 Spreading

Spreading, function description (hydraulic servo)



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pump oil from the hydraulic oil tank.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.3.5 Accumulator charging valve, description*
4	The accumulator stores pressure.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*

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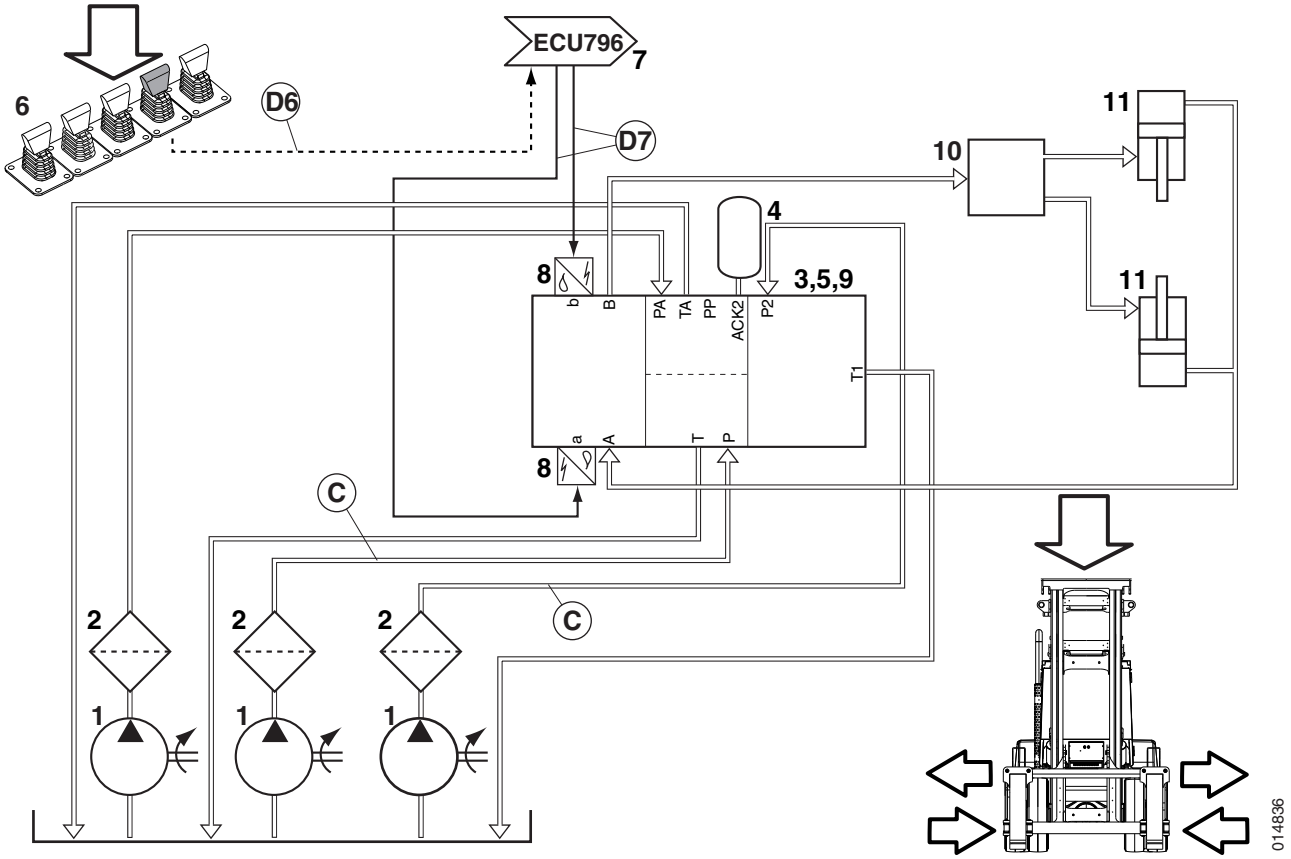
Pos	Explanation	Signal description	Reference
6	Control lever, spreading, controls servo pressure in proportion to lever movement to control valve load handling.	-	
7	The servo pressure from control lever, spreading, acts on the spreading slide in control valve, load handling, which changes position and pressurizes the spreading cylinders.	-	*Main valve, description (hydraulic servo) page 12*
8	**Spread inwards** The flow distributor checks that the oil volume supplied to the piston sides of each cylinder is equal. **Spread outwards** The flow distributor checks that the oil volume that comes from the piston sides of each cylinder is equal.	-	Section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*
9	The spread cylinders move the forks sideways.	-	*Spreading cylinder, description page 53*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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Spreading, function description (electrical servo)

Condition	Reference value	Reference
Control switch	Disengaged	Section *11 Common electrics*, group *11.5.1.4 Emergency stop voltage (15E)*



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pump oil from the hydraulic oil tank.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.3.5 Accumulator charging valve, description*
4	The accumulator stores pressure.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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Pos	Explanation	Signal description	Reference
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*
6	The control lever, spreading (R8074) sends a voltage signal to the Control Unit Hydraulics (ECU 796).	U = 0-10 V DC	D6: Diagnostic menu, see section *8 Control system*, group *8.4.4.1 View inputs, menu 3, ECU 796 input K1:12*
7	The Control Unit Hydraulics (ECU 796), sends a current signal to the solenoid valve for inwards spread (Y6019) *or the solenoid valve for outwards spread (Y6018)*.	-	*Main valve, description (electrical servo) page 51* D7: Diagnostic menu, see section *8 Control system*, group *8.4.4.2 View outputs, menu 2, ECU 796 input K2:12 (in)*, input K2:11 (out)
8	The solenoid valve for inwards spread (Y6019) *or the solenoid valve for outwards spread (Y6018)* controls servo pressure to the spread slide in control valve load handling.	-	*Main valve, description (electrical servo) page 51*
9	The control valve's spread slide changes position and pressurizes the spread cylinders.	-	*Spreading cylinder, description page 53*
10	**Spread inwards** The flow distributor checks that the oil volume supplied to the piston sides of each cylinder is equal. **Spread outwards** The flow distributor checks that the oil volume that comes from the piston sides of each cylinder is equal.	-	*Flow divider, description page 52*
11	The spread cylinders move the forks sideways.	-	*Spreading cylinder, description page 53*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

7.5.1 Hydraulic oil pump

Hydraulic oil pump, description

Please refer to section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

7.5.2 Accumulator

Accumulator, description

See section *10 Common hydraulics*, group *10.3.2 Accumulator*.

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7.5.3 Main valve

Main valve, description

See section *10 Common hydraulics*, group *10.5.2 Main valve*.

Main valve, description (hydraulic servo)

Spreading is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information on spreading, see *Spreading, function description (hydraulic servo) page 47*.

Spreading slide

When the spreading control lever is activated, pressure is applied to the spreading spool, which controls the direction and flow of oil from the hydraulic oil pumps to the side shift cylinders. See *Spreading cylinder, description page 53*.

Main valve, description (electrical servo)

Spreading is controlled by a separate section of the main control valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information on spreading, see *Spreading, function description (electrical servo) page 49*.

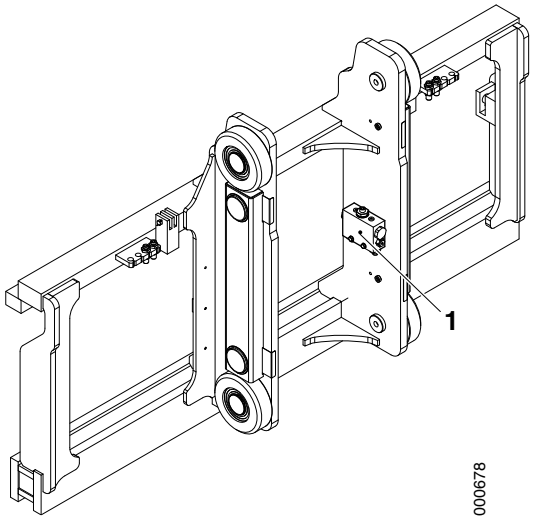
Servo valve spreading out

The servo valve for spreading out is controlled electrically by Solenoid valve spreading out (Y6018), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the spreading spool. This pressure is proportional to the control current to the solenoid valve.

Servo valve spreading in

The servo valve for spreading in is controlled electrically by Solenoid valve spreading in (Y6019), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the spreading spool. This pressure is proportional to the control current to the solenoid valve.

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1. Flow divider

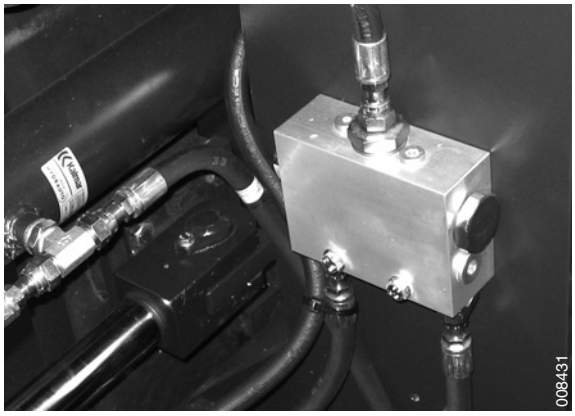
7.5.4 Flow divider

Flow divider, description

The flow divider is a pressure-compensated valve that synchronizes the forks' movements during fork spreading. The valve divides the flow from the main valve in two equal parts, regardless of the load on the two connected cylinders.

The difference between pressures P1 and P2 behind the respective control slide balances the slides producing the correct sizes of control gap. When the flow goes the other way, the valve combines the flows by each connected cylinder contributing equal flow to the common return.

Flow divider, replacement



NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Depressurize the hydraulic system, see section *B Safety*.

3 Place a container under the flow divider to collect oil waste.

4 Mark up and detach the hydraulic hoses from the flow divider.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

5 Remove the two bolts that secure the flow divider to the carriage.

6 Remove the flow divider.

7 Transfer the connection adapters to the new flow divider.

8 Fit the new flow divider.

9 Connect the hydraulic hoses to the flow divider in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

10 Turn on the main electric power and start the engine. Run the engine at idling speed.

11 Test the spreading a couple of times.

12 Check that the flow divider's connections are sealed tightly.

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7.5.5 Spreading cylinder

Spreading cylinder, description

See *Side shift cylinder, description page 44*.

7.5.6 Fork carriage

Fork carriage, description

See *Fork carriage, description page 34*.

7.5.7 Pipes and hoses

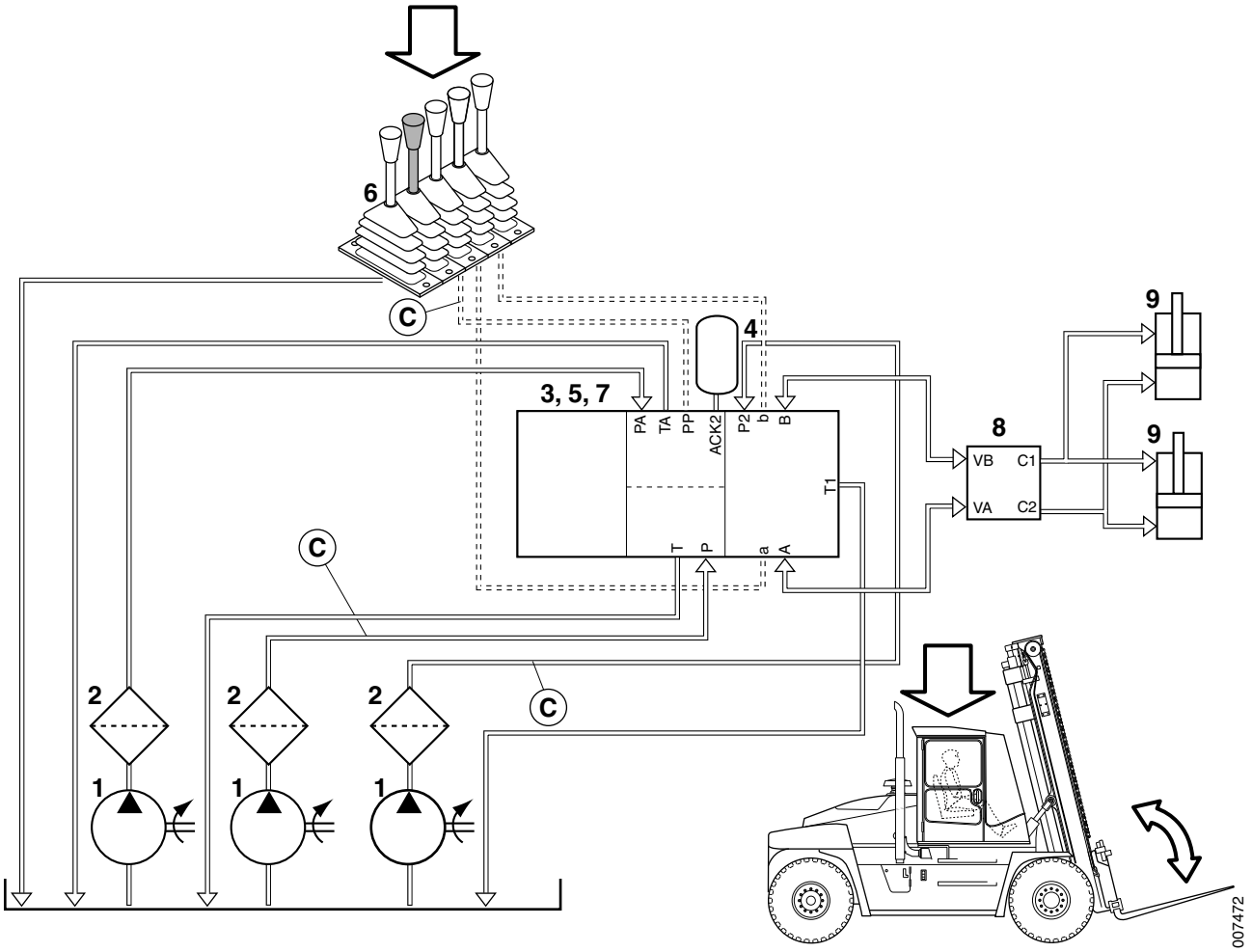
Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

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7.7 Tilt

Tilt, function description (hydraulic servo)



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pumps oil from the hydraulic oil tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve in the valve block directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*

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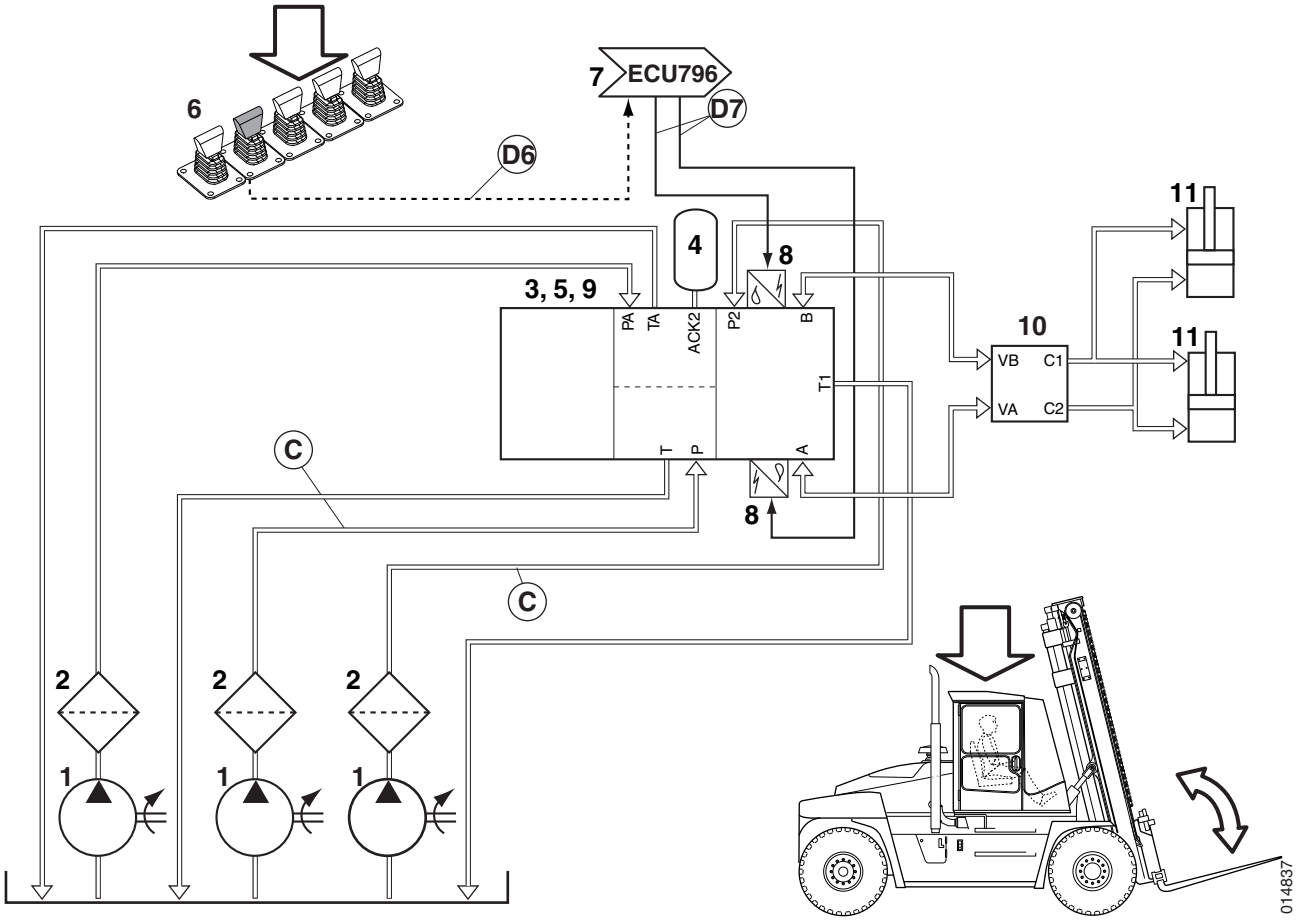
Pos	Explanation	Signal description	Reference
6	Control lever, tilt, controls servo pressure in proportion to lever movement to control valve load handling.	-	
7	The servo pressure from control lever, tilt, acts on the tilt slide in control valve, load handling, which changes position and pressurizes the tilt cylinders.	-	*Main valve, description (hydraulic servo) page 12*
8	**Tilt in** The oil is pressed in via the load holding valve to the tilt cylinders' shaft side. Oil is evacuated from the piston sides of the cylinders via the load holding valve and the control valve, back to the tank. **Tilt out** The oil is pressed in via the load holding valve to the tilt cylinders' piston side. From the shaft sides of the cylinders, the oil is evacuated to the load holding valve. This provides back pressure in the return line. This way unwanted tilt out is avoided which would otherwise occur with the combination of heavy load and high lifting height. Oil is moved from the load holding valve via the control valve to the tank	-	*Load control valve, description page 38*
9	The tilt cylinders angle the mast in relation to the frame.	-	*Tilt cylinder, description page 60* *Lift masts, description page 14*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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Tilt, function description (electrical servo)

Condition	Reference value	Reference
Control switch	Disengaged	Section *11 Common electrics*, group *11.5.1.4 Emergency stop voltage (15E)*



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pumps oil from the hydraulic oil tank.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve in the valve block directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mudguard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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Pos	Explanation	Signal description	Reference
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*
6	The control lever tilt (R8072) sends a voltage signal which is proportional to the lever movement to the Control Unit Hydraulics (ECU 796).	U = 0-10 V DC	D6: Diagnostic menu, see section *8 Control system*, group *8.4.4.1 View inputs, menu 3, ECU 796 input K1:10*
7	The Control Unit Hydraulics (ECU 796), sends a current signal to the solenoid valve for tilt out (Y6010) *or the solenoid valve for tilt in (Y6011).*	-	*Main valve, description (electrical servo) page 12* D7: Diagnostic menu, see section *8 Control system*, group *8.4.4.2 View outputs, menu 1, ECU 796 input K2:5 (tilt out)*, input K2:6 (tilt in)
8	Solenoid valve for tilt out (Y6010) *or the solenoid valve for tilt in (Y6011)* allocates servo pressure in proportion to the control current to the tilt slide in control valve load handling.	-	*Main valve, description (electrical servo) page 12*
9	The control valve tilt slide changes position and pressurizes the tilt cylinders.	-	*Main valve, description (electrical servo) page 12*
10	**Tilt in** The oil is pressed in via the load holding valve to the tilt cylinders' shaft side. Oil is evacuated from the piston sides of the cylinders via the load holding valve and the control valve, back to the tank. **Tilt out** The oil is pressed in via the load holding valve to the tilt cylinders' piston side. From the shaft sides of the cylinders, the oil is evacuated to the load retention valve. This provides back pressure in the return line. This way unwanted tilt out is avoided which would otherwise occur with the combination of heavy load and high lifting height. Oil is moved from the load holding valve via the control valve to the tank.	-	*Load control valve, replacement page 39*
11	The tilt cylinders angle the mast in relation to the frame.	-	*Tilt cylinder, description page 60* *Lift masts, description page 14*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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7.7.1 Hydraulic oil pump

Hydraulic oil pump, description

Please refer to section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

7.7.2 Accumulator

Accumulator, description

See section *10 Common hydraulics*, group *10.3.2 Accumulator*.

7.7.3 Main valve

Main valve, description (hydraulic servo)

Tilting is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information about tilting, see *Tilt, function description (hydraulic servo) page 54*.

Tilt slide

When the tilt control lever is activated, pressure is fed to the tilt spool, which controls the direction and flow of oil from the hydraulic oil pumps to the tilt cylinders.

Main valve, description (electrical servo)



Tilt is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information about tilting, see *Tilt, function description (electrical servo) page 56*.

Tilt slide

When the servo valves are activated, pressure is fed to the tilt spool, which controls the direction and flow of oil from the hydraulic oil pumps to the tilt cylinders.

Servo valve tilt out

On machines with electric servo, the servo valve for tilt out is controlled electrically by Solenoid valve tilt out (Y6010), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the tilt spool. This pressure is proportional to the control current to the solenoid valve.

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Servo valve tilt in

On machines with electric servo, the servo valve for tilt in is controlled electrically by Solenoid valve tilt in (Y6011), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the tilt spool. This pressure is proportional to the control current to the solenoid valve.

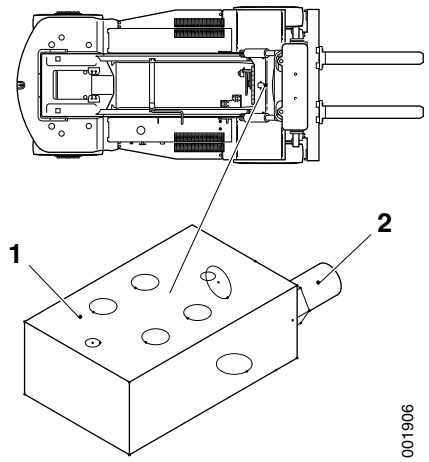
7.7.4 Load holding valve (over-centre valve)

Load holding valve, description

The load holding valve is integrated in the distribution block on the front plate of the chassis.

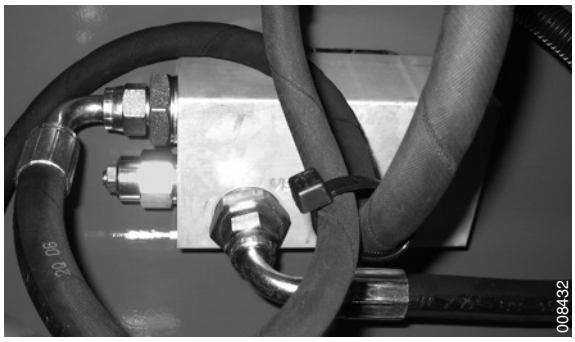
The valve's task is to produce a back-pressure in the return line from the tilt cylinders. In this way, undesired forward tilt is avoided, which would otherwise result for the combination of a heavy load and high lifting height. Tilting becomes smoother as a result of the load holding valve.

In this case, the load holding valve is set to 160 bar. A load that gives a pressure of 100 bar requires 20 bar in the pilot line, which is connected to the other end of cylinder, for the load holding valve to release oil at a pilot ratio of 1:3. This is somewhat simplified since the 20 bar in the cylinder's other end also gives a pressure increase in the end that is connected to the load holding valve.



1. Distribution block
2. Load holding valve

Load holding valve, replacement



NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

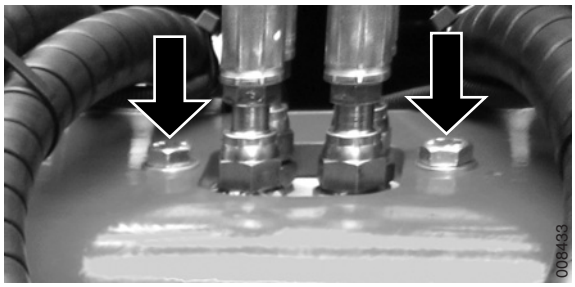
2 Depressurize the hydraulic system, see section *B Safety*.

3 Mark up and detach the hydraulic hoses from the load holding valve.

NOTE

Plug the connections immediately to protect the hydraulic system from impurities.

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4 Remove the two bolts that secure the load holding valve to the chassis.

5 Remove the load holding valve.

6 Fit the new load holding valve.

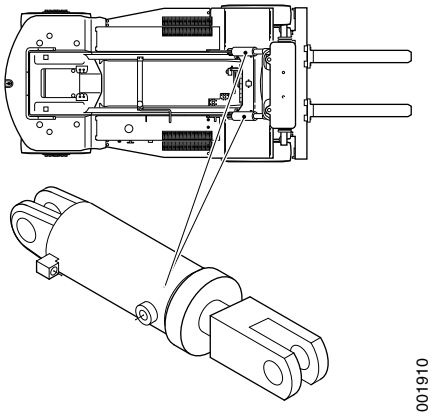
7 Turn on the main electric power and start the engine. Run the engine at idling speed.

8 Test the tilt a couple of times.

9 Check that the load holding valve's connection are sealed tightly.

7.7.5 Tilt cylinder

Tilt cylinder, description



The tilt cylinder is provided with double attaching eyes at the cylinder end. The piston rod mounting is threaded to the piston rod and is locked with screws and lock plates.

The tilt cylinder is attached to the outer mast and to the front plate of the frame.

The cylinder head is threaded in the cylinder barrel (and can be removed using a hook wrench if needed).

Tilt cylinder, replacement



NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Tilt the mast forward.

2 Machine in service position, see section *B Safety*.

3 Depressurize the hydraulic system, see section *B Safety*.

4 Connect lifting equipment to the lifting lugs on the mast in a secure manner.

5 Secure the tilt cylinder to an overhead crane.

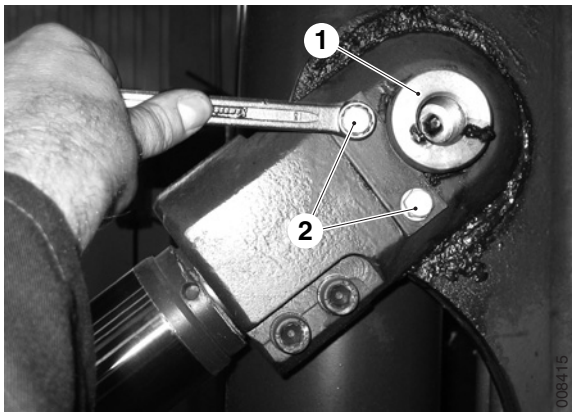
6 Place a container under the hose connections on the tilt cylinder to collect oil waste.

7 Mark and undo the hydraulic connections to the tilt cylinder.

NOTE

Plug all connections at once to protect the hydraulic system from contamination.

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1. Cylinder shaft
2. Screw and washer

8 Release the tilt cylinder from the mast and frame.

Remove the screws that holds the lock plate for the cylinder shafts.

9 Remove the cylinder shafts. If necessary, use a slide hammer to drive the shafts out.

10 Remove the tilt cylinder.

11 Transfer the connection adapters to the new tilt cylinder.

12 Connect the new tilt cylinder.

Install the cylinder shafts

NOTE

Check that the bearings in the cylinder anchorages are correctly aligned before the cylinder shafts are installed.

Rotate the shaft to find correct position for the lock plate.

Mount the lock plate and secure with the two screws.

Repeat the procedure for the other cylinder.

13 Grease the cylinder anchorages.

14 Connect the hydraulic hoses to the tilt cylinder in accordance with the marking.

NOTE

Check that the O-rings are intact and fitted correctly.

15 Undo the lifting equipment (travelling crane).

16 Turn on the main electric power and start the engine. Run the engine at idling speed.

17 Test the tilt a couple of times.

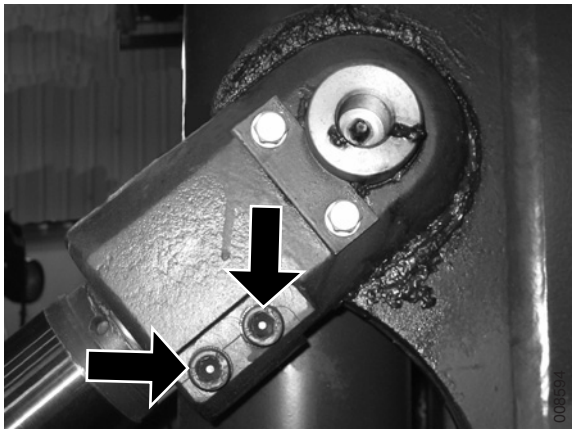
18 Check that the tilt cylinders' connections are sealed tightly.

19 Check the tilt function. Adjust the new tilt cylinder as necessary, please refer to *Tilt cylinder, adjustment page 62*

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Tilt cylinder, adjustment

During tilting in or out, the mast should stop solidly and not be twisted. If the mast is twisted, the tilt cylinders must be adjusted to make their stroke equal.



1 Tilt the mast so that the cylinders are half extended.
2 Machine in service position, see section *B Safety*.
3 Undo the screws.
4 Turn the piston rod with a hook spanner.
5 Check that the cylinder strokes are equal in length.
6 Check the tilt function. Repeat the adjustment until the tilt function operates correctly.
7 Install the screws.

Hydraulic cylinders, repairing

See section *10 Common hydraulics*, group *10.7.1 Hydraulic cylinders*.

7.7.6 Mast

Lift masts, description

See *Lift masts, description page 14*.

7.7.7 Pipes and hoses

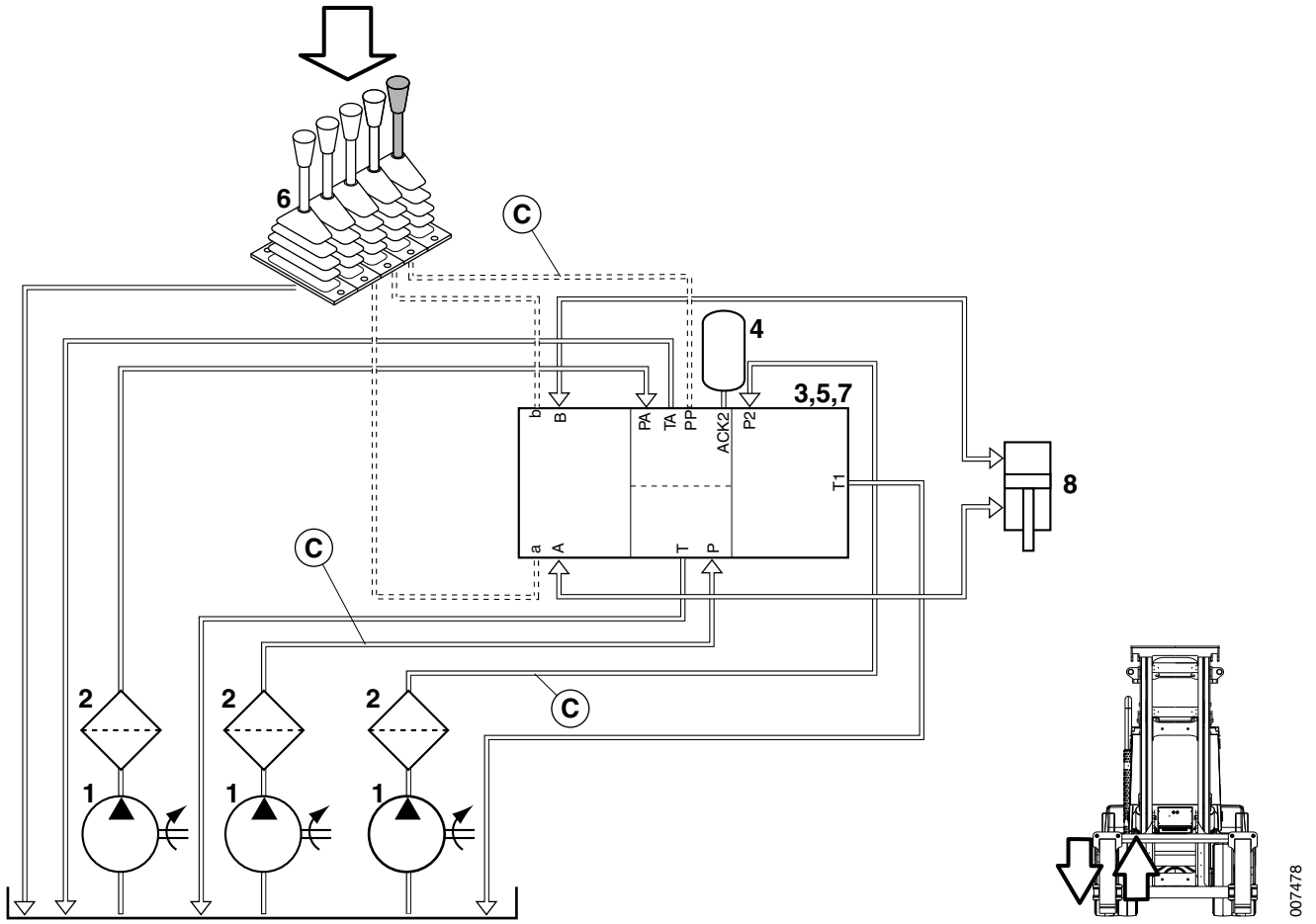
Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

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7.8 Levelling

Levelling, function description (hydraulic servo)



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pump oil from the hydraulic oil tank.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*

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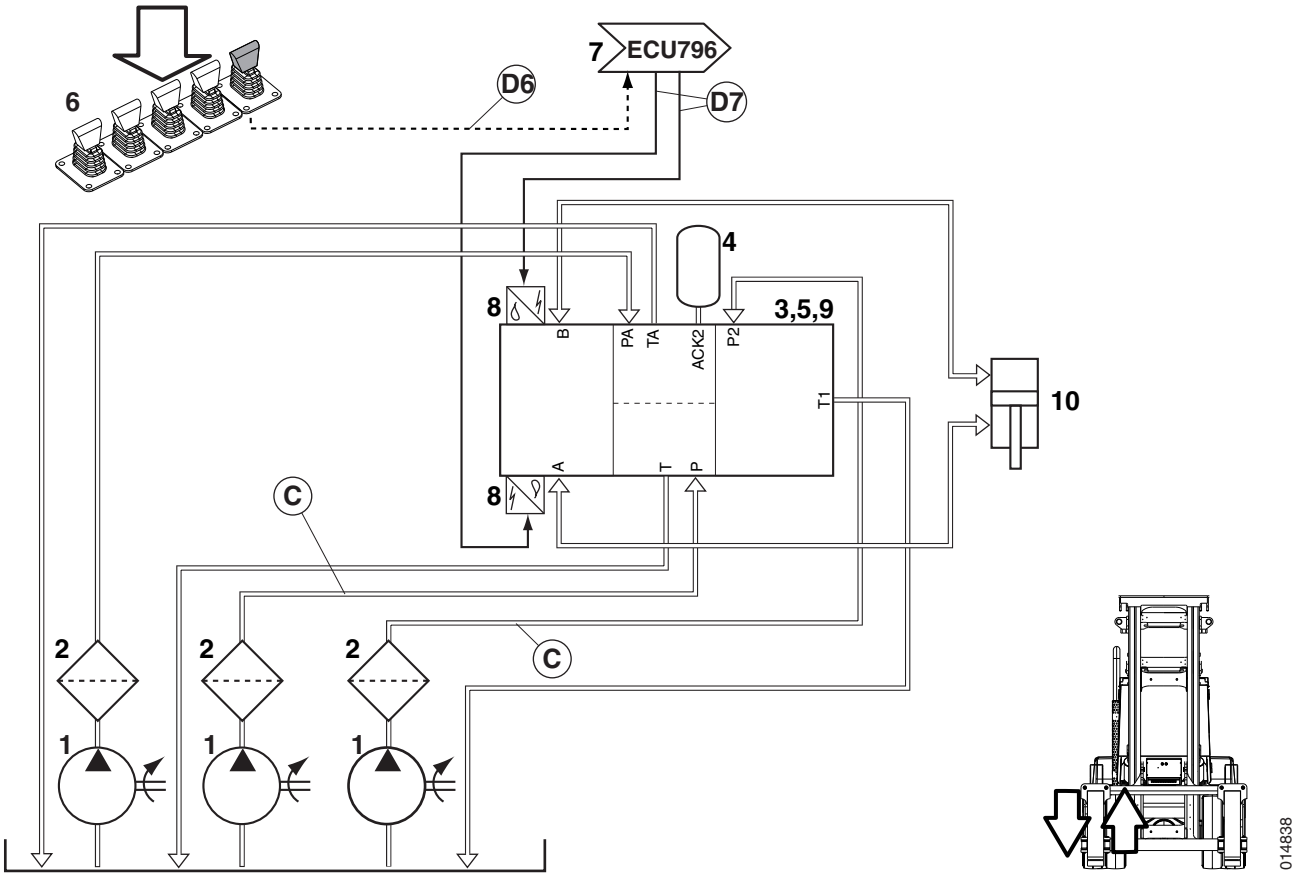
Pos	Explanation	Signal description	Reference
6	Control lever, levelling, controls servo pressure in proportion to lever movement to control valve load handling.	-	
7	The servo pressure from control lever, levelling, acts on the levelling slide in control valve, load handling, which changes position and pressurizes the levelling cylinder.	-	*Main valve, description (hydraulic servo) page 67*
8	**Levelling fork upwards** Oil is directed to the piston side of the levelling cylinder and evacuated from its shaft side via the control valve, back to the tank. **Levelling fork downwards** Oil is directed to the shaft side of the levelling cylinder and evacuated from its piston side via the control valve, back to the tank.	-	*Levelling cylinder, description page 68*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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Levelling, function description (electrical servo)

Condition	Reference value	Reference
Control switch	Disengaged	Section *11 Common electrics*, group *11.5.1.4 Emergency stop voltage (15E)*



Pos	Explanation	Signal description	Reference
1	The hydraulic oil pumps pump oil from the hydraulic oil tank.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.4.1 Gear pump with fixed displacement*
2	High-pressure filter cleans the oil.	-	Section *10 Common hydraulics,* group *10.6.8 High-pressure filter/Return filter*
3	The accumulator charging valve directs oil to charging of the accumulator.	-	Section *10 Common hydraulics,* group *10.5.2 Control valve*
4	The accumulator stores pressure.	See pressure plate on left-hand front mud-guard.	Section *10 Common hydraulics,* group *10.3.2 Accumulator*

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Pos	Explanation	Signal description	Reference
5	A reduction valve in the valve block reduces the pressure from hydraulic oil pump 3 to servo pressure.	P = 3.5 MPa	Section *10 Common hydraulics,* group *10.5.2 Control valve*
6	Control lever levelling (R8075) sends voltage signal to Control unit hydraulics (ECU 796).	U = 0-10 V DC	D6: Diagnostic menu, see section *8 Control system*, group *8.4.4.1 View inputs, menu 3, ECU 796 input K1:13*
7	The Control Unit Hydraulics (ECU 796), sends a current signal to the solenoid valve for downwards levelling (Y6022) *or the solenoid valve for upwards levelling (Y6023)*.	-	*Main valve, description (electrical servo) page 67* D7: Diagnostic menu, see section *8 Control system*, group *8.4.4.2 View outputs, menu 2, ECU 796 input K2:13 (down)*, input K2:14 (up)
8	The solenoid valve for downwards levelling (Y6022) *or the solenoid valve for upwards levelling (Y6023)* controls servo pressure to the levelling slide in control valve load handling.	-	*Main valve, description (electrical servo) page 67*
9	The control valve's levelling slide changes position and pressurizes the levelling cylinders.	-	*Main valve, description (electrical servo) page 67*
10	**Levelling fork upwards** Oil is directed to the piston side of the levelling cylinder and evacuated from its shaft side via the control valve, back to the tank. **Levelling fork downwards** Oil is directed to the shaft side of the levelling cylinder and evacuated from its piston side via the control valve, back to the tank.	-	*Levelling cylinder, description page 68*

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

7.8.1 Hydraulic oil pump

Hydraulic oil pump, description

Please refer to section *10 Common hydraulics*, group *10.4.1 Gear pump with fixed displacement*.

7.8.2 Accumulator

Accumulator, description

See section *10 Common hydraulics*, group *10.3.2 Accumulator*.

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7.8.3 Main valve

Main valve, description (hydraulic servo)

Levelling is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information about levelling, see *Levelling, function description (hydraulic servo) page 63*.

Levelling slide

When the levelling control lever is activated, pressure is fed to the levelling spool, which controls the direction and flow of oil from the hydraulic oil pumps to the fork levelling cylinder.

Main valve, description (electrical servo)

Levelling is controlled by a separate section of the main valve.

For general information on the main valve, refer to section *10 Common hydraulics*, group *10.5.2 Main valve*.

For more information about levelling, see *Levelling, function description (electrical servo) page 65*.

Levelling slide

When the servo valves are activated, pressure is fed to the tilt spool, which controls the direction and flow of oil from the hydraulic oil pumps to the fork levelling cylinder.

Servo valve levelling down

On machines with electric servo, the servo valve for tilt out is controlled electrically by Solenoid valve fork levelling down (Y6022), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the tilt spool. This pressure is proportional to the control current to the solenoid valve.

Servo valve levelling up

On machines with electric servo, the servo valve for tilt in is controlled electrically by Solenoid fork levelling up (Y6023), which is activated by Control unit hydraulics (ECU 796). The servo valve actuates the servo pressure to the tilt spool. This pressure is proportional to the control current to the solenoid valve.

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7.8.4 Levelling cylinder

Levelling cylinder, description

The levelling cylinder is provided with double attaching eyes at the cylinder end. The piston rod mounting is threaded to the piston rod and is locked with lock bolts and lock plate.

If the machine has levelling forks, the levelling cylinder is attached to the fork and the fork levelling guide in the carriage.

If the machine has a center levelling carriage, the two levelling cylinder are attached to the inner and outer carriage on either side.

The cylinder head is threaded in the cylinder barrel (and can be removed using a hook wrench if needed).

Levelling cylinder, replacement



NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Remove the screw that is holding the rod end of cylinder in the fork carriage.

3 Contract the cylinder with the machine running so that rod goes into the cylinder.

4 Machine in service position, see section *B Safety*.

5 Depressurize the hydraulic system, see section *B Safety*.

6 Mark and undo the hydraulic connections to the levelling cylinder.

NOTE

Plug all connections at once to protect the hydraulic system from contamination.

7 Remove the split pin and the shaft that is holding the cylinder in the fork.

8 Remove the levelling cylinder.

9 Transfer the connection adapters to the new levelling cylinder.

10 Connect the new levelling cylinder.

Install the cylinder shaft and split pin holding the cylinder to the fork.

Install the screw holding the cylinder to the fork carriage.

11 Connect the hydraulic hoses to the levelling cylinder in accordance with the marking.

NOTE

Check that the O-rings are intact and are fitted correctly.

12 Turn on the main electric power and start the engine. Run the engine at idling speed.

13 Test the levelling a couple of times.

14 Check that the levelling cylinders' connections are sealed tightly.

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Hydraulic cylinders, repairing

See section *10 Common hydraulics*, group *10.7.1 Hydraulic cylinders*.

7.8.5 Fork carriage

Fork carriage, description

See *Fork carriage, description page 34*.

7.8.6 Levelling fork

Levelling fork, description

The levelling fork can be manoeuvred up and down through the action of the levelling cylinder. The fork runs through a sleeve for up and down movements. See *Lift forks, description page 70*.

7.8.7 Pipes and hoses

Pipes and hoses, description

See section *10 Common hydraulics*, group *10.5.1 Pipes and hoses*.

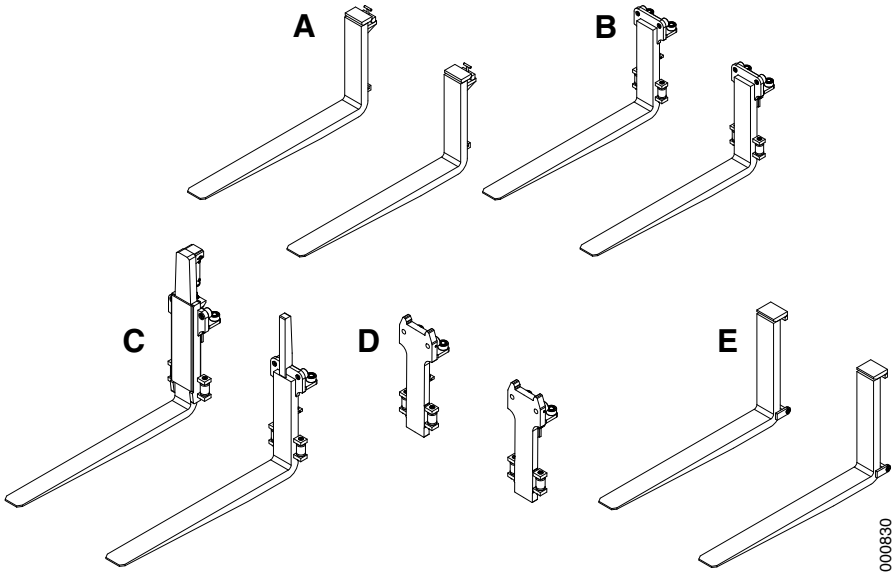
https://truckmanualshub.com/

7.9 Load carrier

7.9.1 Lift forks

Lift forks, description

The forks are fully forged of high-strength steel. The standard mounting, with manually adjusted forks, is with hooks on the fork carriage. The hydraulically maneuverable forks are mounted on bearing-equipped rollers, four rollers at the top and two support rollers at the bottom on each fork.



A. Manually adjustable forks

B. Spreading-side shift forks

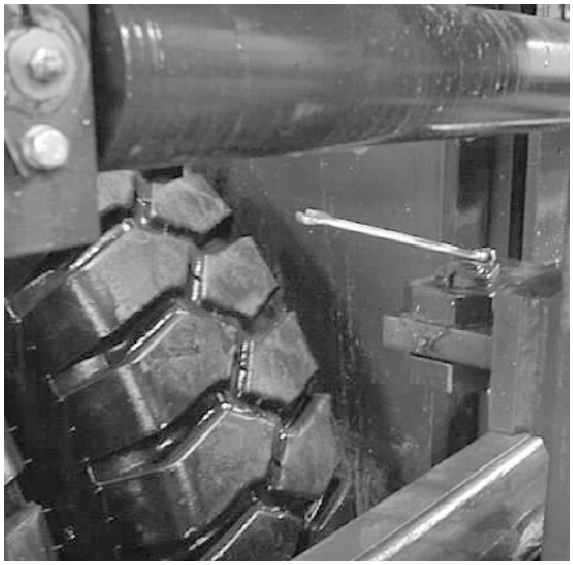
C. levelling fork as well as fork with timber support.

D. Fork carrier

E. Fork for fork carrier

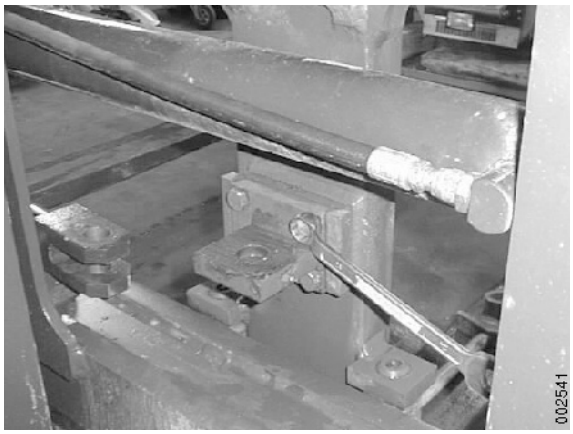
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Lift forks, replacement



1 Machine in service position, see section B Safety.

2 Remove the shaft connecting the spreading cylinder to the fork. Remove the screw and knock out the shaft.



3 Remove the four screws that secure the bracket for the spreading cylinder.

4 Place a hand truck under the fork for support.



5 Pull out the fork to the side along the carriage.

Secure the lift fork in a suitable way so that it does not tip.

6 Replace the fork.

7 Fit in the reverse order.

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7.10 Other functions

7.10.1 Electric scales

Scales, description

Machine can be installed with two different scale functions:

1. Electric-hydraulic scales that do not display anything to the driver, but can be used by other functions in the machine. A pressure sensor in the lift cylinder measures the pressure and so estimates the weight of the load.
2. Electric scales, which use a load cell sensor in the two chain tensioners and measures weight with higher precision and in the main display screen showing the weight in 0,1 ton resolution, giving a more direct interface with the driver.

With the electric scales there are two load cells in the chain tightener with built-in amplifier that gives the weight of the load. The accuracy depends on mast movement before measuring. The scales and load sensors are very sensitive and are affected by several factors such as friction in the mast and fork carriage, oil temperature and bearings. The mast should be in a vertical position and the fork carriage centred. Under these conditions the load sensors in the chain tightener function optimally. The fork carriage should be raised and then lowered to about 1 metre above the ground before calibration and weighing. If the system is calibrated after gentle lowering, and weighing is performed in the same way, then an accuracy of about ±1% of the maximum load capacity is achieved. The weight is presented continuously on the display, in tonnes to one decimal place (e.g. 5.2 tonnes).

Scales, calibration

The scales on a machine equipped with complete scales are always adjusted and calibrated from the factory. For correct use of the scales they must be calibrated regularly against a known test weight.

NOTE

The mast should be in a vertical position and the fork carriage should be centred for weighing, calibration and taring.

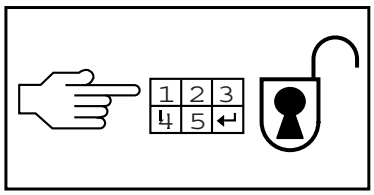
1 Operate the trolley up and down a few times to remove any mechanical tension.

2 Operate the machine for a few minutes before zero adjustment and weight calibration take place.

3 To select the function to calibrate, first navigate to the service menu. Then press Enter.



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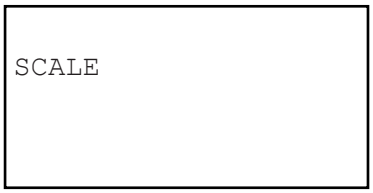
4 Enter the code for calibration.

The code is obtained from Cargotec Support.

NOTE

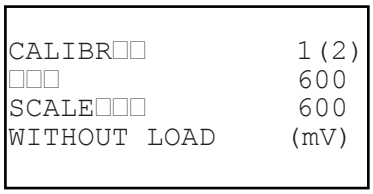
The code determines which service menu shall be activated (Diagnostics, Initiation or Calibration).

5 Select SCALE by scrolling with the arrow keys (1 and 2) and confirm with Enter.



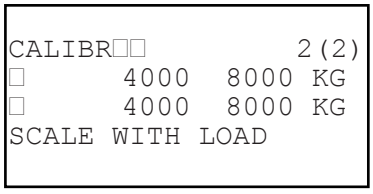
000803

6 Unload, operate the trolley up and lower it slowly to about 1 metre above the ground. Reset to zero by pressing in the menu 1 (2).



000804

7 Load with a known weight (preferably a frequently used loading weight or close to the machine's maximum load), adjust with and to the correct weight and lower the trolley slightly. Confirm the weight by pressing in the menu 2 (2). For the weight to be adjustable there must be a value in setup for maximum lift capacity.



000805

Function test

If scale is calibrated load using an arbitrary weight (another weight than that used when calibrating) and read the display. Does this correspond to the weight?

Trouble shooting

Error/malfunction symptoms:

- If error code 304 is generated all the time, then check the output voltage from the load cells. The summed voltage souldn't be below 0.2V.

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7.10.2 Pre-selected lift height

Pre-selected lift height, description

When the lifting height is selected the driver activates the lift and lower function to move the forks (or attachment) to the selected height. When the forks approach the selected lifting height the lift or lower speed is reduced. Note that the lever must be activated by the driver during the whole movement. The system ensures that the forks stop at the correct lifting height. (Pre-selection can also be switched on or off by pressing the switch by the lifting lever). The current position, ON or OFF is indicated in the display. End position damping at lowest and highest lifting height provides gentle stops.

Function test

Operate the forks / bale clamp to about 100 mm (4”) and read the lifting height into “Lifting height 1” by holding 4 and 5 in for 1 second. Continue this procedure with “lifting height 2 - 15” with increased mast height. “Lifting height 15” should be close to the machine’s highest lifting height.

Lower to the lowest height. Select an arbitrary height. The display shows “ON”. Pull the lift lever and check that the forks / bale clamp stop gently at the selected lifting height. The display shows “OFF”. Do the same test with a load.

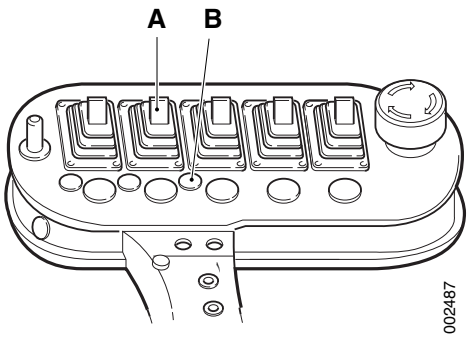
Do the same test when the selected lifting height is below the current lifting height, i.e. the load is lowered to the selected height. Do this test with and without load as well.

Trouble shooting

All alarms are saved and can be read out according to “Last alarms”. This may be of great value when troubleshooting a machine that, according to the operator/test, has had problems, but that aren’t triggered when troubleshooting.

For error code tables, see section *D Error codes*.

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A. Lever for tilt
B. Switch for vertical alignment

7.10.3 Vertical alignment

Vertical alignment, description

The vertical alignment function constantly attempts to hold the load vertical. The system is load compensating and also takes into consideration the downward pitch of the machine when a load is picked up or deposited. Load compensation takes place after lift and lower is concluded. Instead of the driver needing to seek vertical orientation manually, it takes place automatically via pressing the switch by the tilt lever.

Vertical alignment is switched off by pressing the switch or activating the tilt lever.

Kalmar's vertical alignment function uses a tilt angle sensor located between the mast and frame, and a pressure sensor in the lifting cylinder, which also serves as a scale to weigh the load. If electronic scales are installed, they are used.

With load and without load, deviation of the tilt angle is only +/- 1 degree with the load in lowest position. For example, with 6000 mm lift height, the tilt angle deviation is +/- 2 degrees with and without load in the attachment.

An orange lamp located on the stand or steering wheel panel indicates the status of the vertical alignment.

Lamp extinguished	Vertical alignment shut off
Flashing lamp	The vertical alignment adjusts the mast to the vertical position.
Lamp lit	The load is aligned vertically.

Function test

Check that the vertical position is achieved with different loads. The stand should move slowly, with gentle starting and stopping.

Trouble shooting

All alarms are saved and can be read out according to "Last alarms". This may be of great value when troubleshooting a machine that, according to the operator/test, has had problems, but that aren't triggered when troubleshooting.

For error code tables, see section *D Error codes*.

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7.10.4 Optimum lift

Optimum lift, description

Optimum lift optimises lift speed in relation to engine speed, load and lifting lever deflection when the machine is operated under a fixed set speed limit. This results in a higher lift speed, lower sound level, lower fuel consumption and reduced exhaust emissions during load handling.

The function intelligently controls a variable pump in relation to engine speed, current load and the lifting lever's position when lifting. The pump is load sensing, which only allows the oil quantity (flow) and the pressure required in each step to be added to the flow and pressure that the fixed pump supplies. The variable pump operates in parallel with the fixed pump. This means that the lift speed can be increased significantly (up to 60%).

Optimum lift is activated when engine speed exceeds a lower adjustable limit (e.g. 1000 rpm), the machine's speed is below 8 km/h and the position of the lifting lever fulfils set limit values.

Depending on the value from the load sensor, control unit (ECU 790) reduces the pump's displacement linearly in order to prevent the engine being overloaded. The engine speed is limited to an upper adjustable limit in order to use the engine's torque more efficiently.

7.10.5 Side lift attachment

Side lift attachment, description

Component supplier documentation

The workshop manual only describes components and job descriptions related to installation in the machine. Please refer to the component supplier documentation for descriptions and instructions of the side lift attachments components and systems.

References to component supplier documentation are only provided in exceptional cases. If information about a component is not found, the component supplier documentation should be used.

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8 Control system

Control system, general

Many of the machines functions are controlled electrically. The signals that control the machine are monitored to warn the operator or limit the machine's functions in certain dangerous situations or in case of machine malfunctions.

The control system is divided into the following functions:

- Monitoring functions
- Error codes
- Diagnostics
- Setup
- Software

Monitoring functions describe the machine’s monitoring functions that warn the operator or limit the machine’s functions in case of eventual dangerous situations.

Error codes notify operators and mechanics when malfunctions have been detected.

Diagnostics is tool for performing service and troubleshooting with menus in the machine’s display.

Setup is the tool for setting and adapting the machine’s functions.

The software creates the functions in the control system.

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8.2 Monitoring

8.2.3 Speed limitation

Speed limitation, description

Speed limitation prevents the machine's road speed from exceeding the set speed by limiting the engine speed.

Machine speed is limited when:

- constant speed limitation is set.
- conditional speed limitation is activated and there is 0 V on the digital input in ECU790 K1:16 to conditional speed limitation.

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8.3 Error codes

Error codes, description

When a malfunction occurs in the machine error messages (error codes) are generated by the control unit in question that is sending the error code via the CAN-bus to Control unit display (EDU795) that shows the error codes on the display and stores the error codes.

Explanation of error codes is available in section *D Error codes*.

Error code indication

An error code is indicated by a lit indicator for active error codes (position 2). Error codes are classified into three levels based on severity.

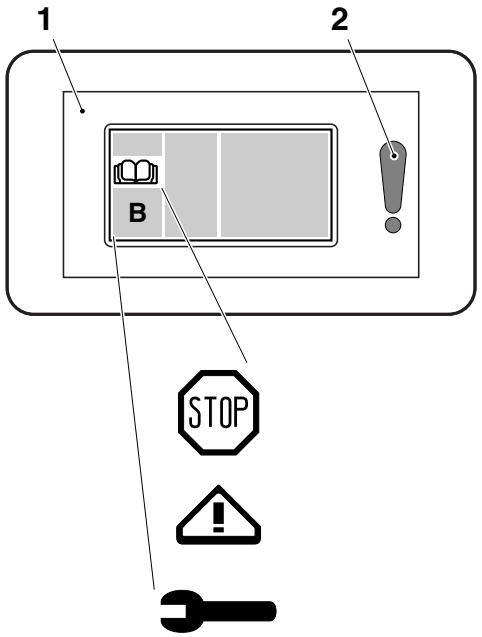
The error code levels are indicated as follows:

- STOP is indicated with a STOP sign on the display, together with continuous red light from the indicator control system (position 2).

  Error code with level Stop is shown automatically on the display.
- Warning is indicated by a warning triangle in the display together with a steady red glow from the indicator for the control system (position 2).

  Error code with level Warning is shown automatically on display.
- Information is indicated by a spanner in the display together with a constant red light from the indicator for the control system (position 2).

  Error code with level Information is shown automatically in the display.



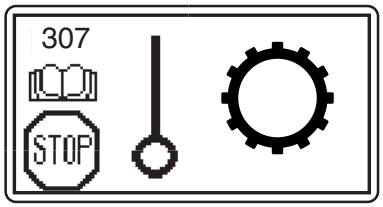
009450

B. Error code level symbol
1. Display control system, KCS
2. Indicator control system, KCS

Error code display

Error code information is shown with display figures and symbols that indicate what error has occurred.

The error codes and images can be temporarily removed using the Reset (R) function key, at which time they disappear from the display. If the error code is active, it reappears in the display within 1-3 minutes.



004257

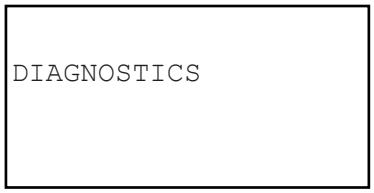
Example figure, automatic display figure

NOTE

If error code disappears automatically, it may be due to the following:

– *the fault that generated the error code is no longer active, e.g. the sensor has a loose connection and causes poor connection.*

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8.4 Diagnostics

Diagnostics, general

The machine can be delivered in different electrical versions and using the schematics, display and a diagnostic display, all ECU 790, ECU 792, ECU 793 and ECU 796 inputs and outputs can be diagnosed.

The machine has integrated functions for troubleshooting (diagnostics). The diagnostics comprises several menus presented in the display. The menus are grouped according to control unit for faster access. The following pages describe the menu images' contents and what functions can be checked.

The diagnostics is divided into the following groups:

- Control unit, ECU 790, *ECU 790, diagnostic description page 9*.
- Control unit, ECU 792, *ECU 792, diagnostic description page 15*.
- Control unit, ECU 793, *ECU 793, diagnostic description page 18*.
- Control unit, ECU 796, *ECU 796, diagnostic description page 18*.
- Error codes history, *Last alarms, description page 25*.

In this section the different diagnosis menus included in the control system, KCS, are explained.

The values stated in the following menus are relevant examples (standard values) of what can be in these positions. The actual value can deviate from these examples.

Diagnostics, description

The diagnostics varies between the different control units as to what type of diagnostics can be carried out, but the following alternatives are possible:

- View inputs – means that the inputs can be checked (digital and analogue).
- View outputs – means that the outputs can be checked (digital and analogue).
- Control outputs – means that the outputs can be checked and controlled (digital and analogue).

NOTE

The application program closes due to safety reasons when controlling outputs. Control O/P is only possible with service code.

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Diagnostics, example

If there is a problem with the lifting function then this can be resolved using the wiring diagram and/or PIN-out (connections), to see which input and output on the control unit (ECU) the function is using. See section *E Schematics*, group *11 Common electrical* and section *11 Common electrical*, group *11.5.3 Control units*.

The input value from a lever is shown in the diagnostic menus (e.g. mV). The ECU dedicated output current to the valve can be viewed and a check if the ECU software want to control the valve. It can be quickly ascertained whether the problem is on the in or output side and if the control unit is working properly without connecting to other instruments.

This way the diagnosis can quickly be made for all functions in the control system.

With appropriate authority the outputs can also be controlled using a service code. When this is carried out the application program is closed (not possible to run as normal) as long as the “Control Output” menu is selected and the red indicators (position 2) are flashing. The deactivation of the application programme enables “forced operation” of the functions connected to the control unit.

Diagnostics, work instruction

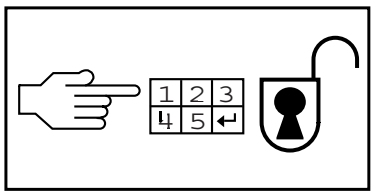
To select diagnostics, proceed as follows:



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1 Navigate to the service menu using F1 and F2.

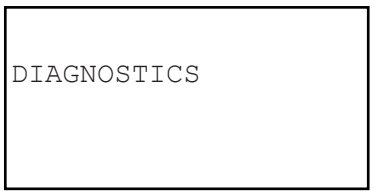
2 Select the service menu using function key F3.



000060

3 A safety menu appears where users must state a code to access the diagnosis menus.

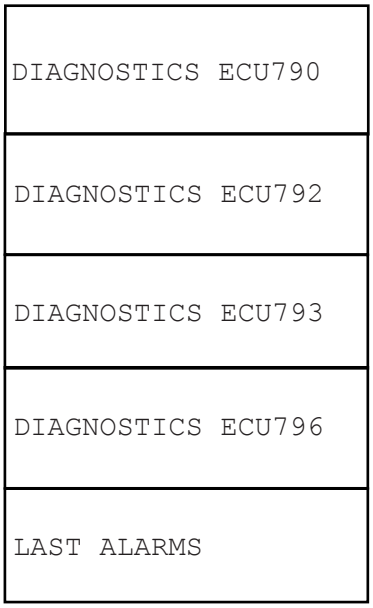
State code for diagnostics (11111).



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4 Select diagnostics by pressing F3.

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5 Main selection for diagnostics now shown on display.

Choose which control unit shall be investigated using the function keys 1 and 2 and confirm with ↵.

Only accessible control units on the machine are displayed.

Each diagnostic function comprises a sequence of a number of diagnosis menus. The first diagnosis menu for selected diagnostic group appears in the display. Choose the next diagnosis menu using 1 and 2.

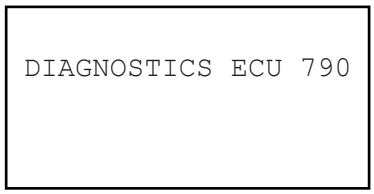
https://truckmanualshub.com/

8.4.1 ECU 790

ECU 790, diagnostic description

Select diagnostics as per *Diagnostics, work instruction page 7*.

Select diagnostics for ECU 790. This display indicates whether ECU 790 is selected. Press function key ↵ to proceed.

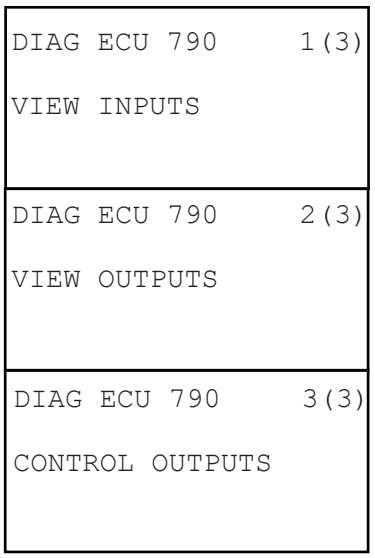


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The following alternatives can be selected in the diagnostics for ECU 790:

1. View inputs
2. View outputs
3. Control outputs

Scroll forwards to required menu using the function keys ↵1 and ↵2 and press ↵ to confirm.



002844

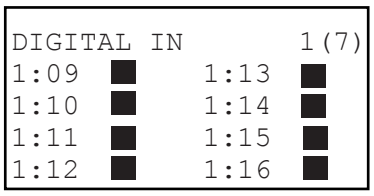
8.4.1.1 View inputs

View inputs, description

Select View inputs for ECU 790 as per *ECU 790, diagnostic description page 9*.

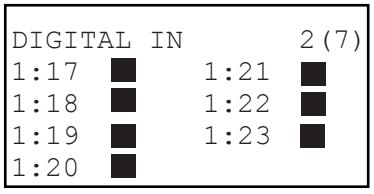
1 Check digital input for ECU 790.

1:09 involves contact 1, pin 9 on ECU 790. The box is filled if the input voltage is > 12V. The box is empty if the voltage is < 5V. This applies to all digital inputs.



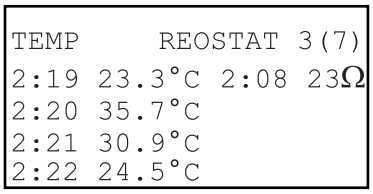
008496

2 Check digital input for ECU 790 further.



008497

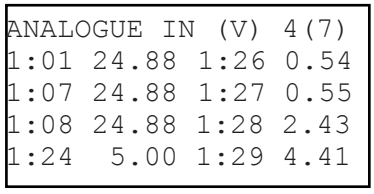
https://truckmanualshub.com/



008498

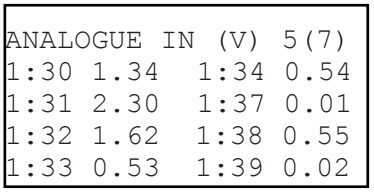
3 Check temperature input for ECU 790. (Unconnected temperature input indicates -35.2 °C.)

Check rheostat input in ohm (2:08).



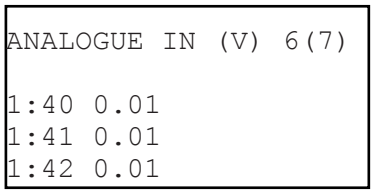
008499

4 Check analogue input for ECU 790. Measurement range: 0.00–5.50V.



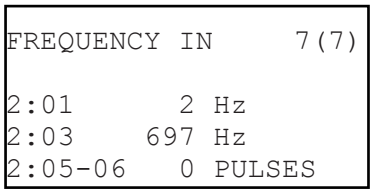
008500

5 Check analogue input for ECU 790 further.



008501

6 Check analogue input for ECU 790 further.



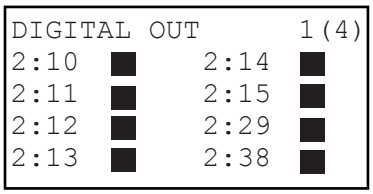
008502

7 Check frequency input for ECU 790. Measurement range: 0.5 Hz–10 kHz.

8.4.1.2 View outputs

View outputs, description

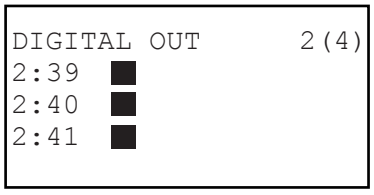
Select View outputs for ECU 790 as per *ECU 790, diagnostic description page 9*.



008503

1 Check digital output for ECU 790.

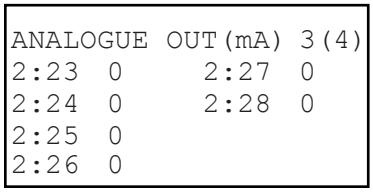
2:10 means contact 2, pin 10 on ECU 790. The box is filled if the voltage on the output is approx. 24V (active). The box is empty if the output is 0V (not active).



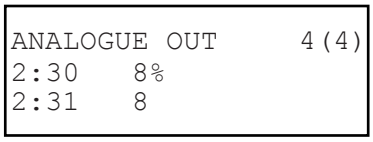
008577

2 Check digital output for ECU 790 further (for example contact 2, pin 41).

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000930



008504

3 Check analogue PWM output for ECU 790. The current on the output is indicated in mA.

4 Check analogue 20-80% of analogue outputs dedicated to Sauer Danfoss PVG valves, contact 2:30 and 2:31.

8.4.1.4 Control outputs

Control outputs, description

WARNING

When the outputs are controlled directly from the terminal, this can seriously affect machine performance.

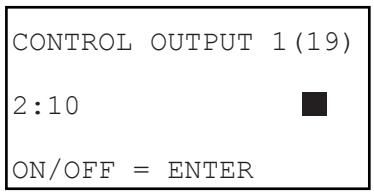
Only accredited personnel, with sufficient knowledge of the machine and the control system, must therefore use these menus.

The engine must be shut off if the test does not require otherwise.

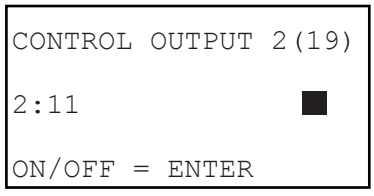
NOTE

The application program closes due to safety reasons when checking outputs. Control O/P is only possible with service code.

Select Control outputs for ECU 790 as per *ECU 790, diagnostic description page 9*.



008505



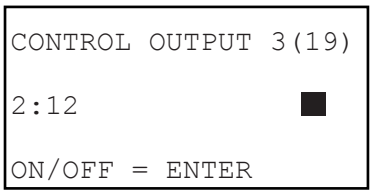
008506

1 Control digital output for ECU 790.

2:10 means contact 2, pin 10 on ECU 790. The box is filled if the voltage on the output is approx. 24V (active). The box is empty if the output is 0V (not active). Using ↵ the output can be switched between approx. 24V (active, ON) and 0V (not active, OFF).

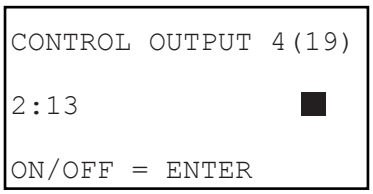
2 Control digital output for ECU 790 further.

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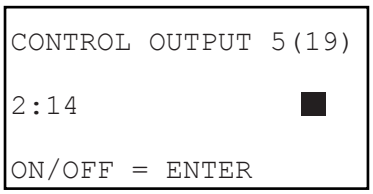
008507

3 Control digital output for ECU 790 further.



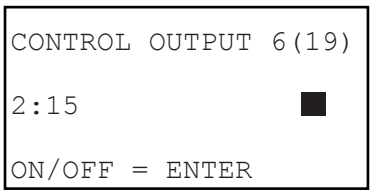
008508

4 Control digital output for ECU 790 further.



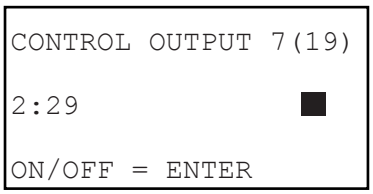
008509

5 Control digital output for ECU 790 further.



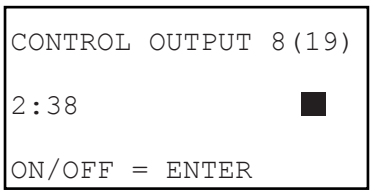
008510

6 Control digital output for ECU 790 further.



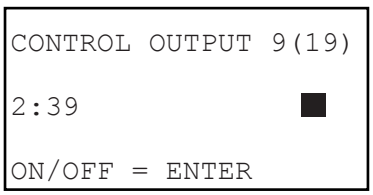
008511

7 Control digital output for ECU 790 further.



008512

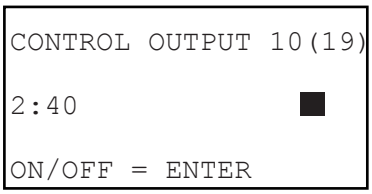
8 Control digital output for ECU 790 further.



008513

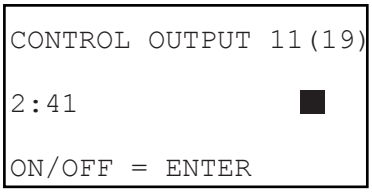
9 Control digital output for ECU 790 further.

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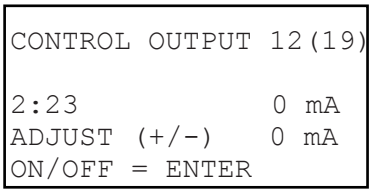
008514

10 Control digital output for ECU 790 further.



008515

11 Control digital output for ECU 790 further.

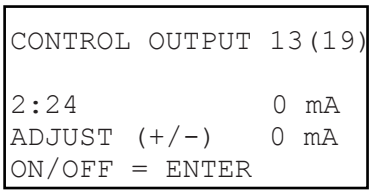


008516

12 Control PWM output for ECU 790.

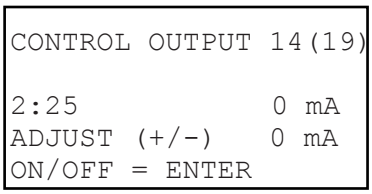
In this and the following menus the actual-value is next to the output pin designation and the set-value (what is required, adjusted value) is on the row below.

Using − and + the required current can be adjusted. ON/OFF confirmed with ↵.



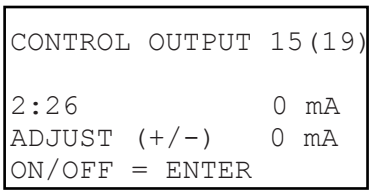
008517

13 Control PWM output for ECU 790 further.



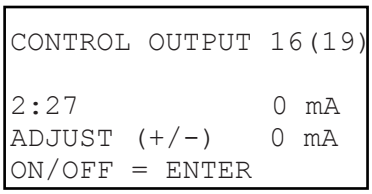
008518

14 Control PWM output for ECU 790 further.



008519

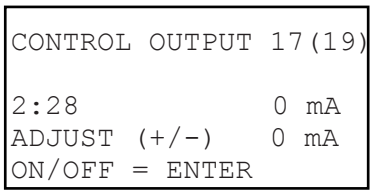
15 Control PWM output for ECU 790 further.



008520

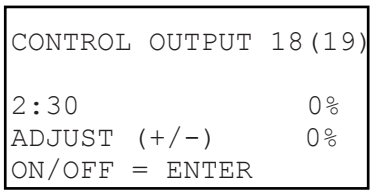
16 Control PWM output for ECU 790 further.

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008521

17 Control PWM output for ECU 790 further.

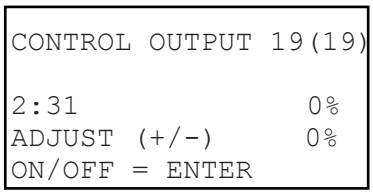


008522

18 Control analogue output for Sauer Danfoss PVG valves, 20 – 80% of main voltage. Starts at 50%.

Adjust the out signal using − 4 and + 5 .

ON/OFF confirmed with ↵



008523

19 Control analogue output for ECU 790 further, 20–80% of main voltage. Starts at 50%.

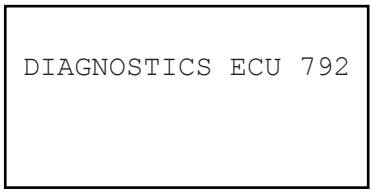
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8.4.2 ECU 792

ECU 792, diagnostic description

Select diagnostics as per *Diagnostics, work instruction page 7*.

Select diagnostics for ECU 792. This display indicates whether ECU 792 is selected. Press function key ↵ to proceed.

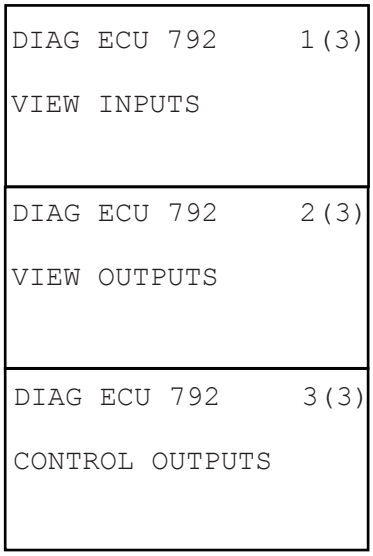


008524

The following alternatives can be selected in the diagnostics for ECU 792:

1. View inputs
2. View outputs
3. Control outputs

Scroll forwards to required menu using the function keys ↵1 and →2 and press ↵ to confirm.



008525

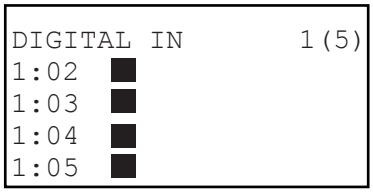
8.4.2.1 View inputs

View inputs, description

Select View inputs for ECU 792 as per *ECU 790, diagnostic description page 9*.

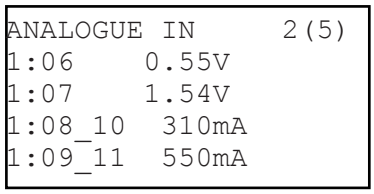
1 Check digital input for ECU 792.

1:02 involves contact 1, pin 2 on ECU 792. The box is filled if the input voltage is > 12V. The box is empty if the voltage is < 5V. This applies to all digital inputs.



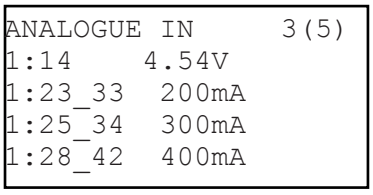
008526

2 Check analogue input for ECU 792. Measurement range: 0.00–5.00V.



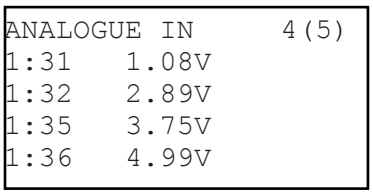
008527

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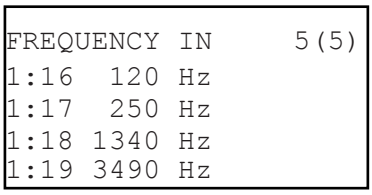
008528

3 Check analogue input for ECU 792 further. Measurement range: 0.00–5.00V.



008529

4 Check analogue input for ECU 792 further. Measurement range: 0.00–5.00V.



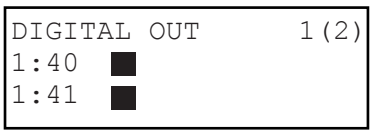
008530

5 Check frequency input for ECU 792. Measurement range: 0.5 Hz–10 kHz.

8.4.2.2 View outputs

View outputs, description

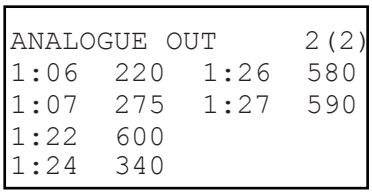
Select View outputs for ECU 792 as per *ECU 790, diagnostic description page 9*.



008531

1 Check digital output for ECU 792.

1:40 means contact 1, pin 40 on ECU 792. The box is filled if the voltage on the output is approx. 24V (active). The box is empty if the output is 0V (not active).



008532

2 Check analogue PWM output for ECU 792. The current on the output is indicated in mA.

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8.4.2.4 Control outputs

Control outputs, description

WARNING

When the outputs are controlled directly from the terminal, this can seriously affect machine performance.

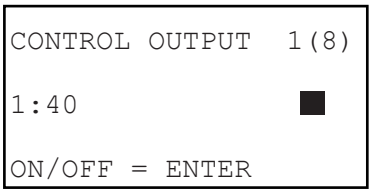
Only accredited personnel, with sufficient knowledge of the machine and the control system, must therefore use these menus.

The engine must be shut off if the test does not require otherwise.

NOTE

The application program closes due to safety reasons when checking outputs. Control O/P is only possible with service code.

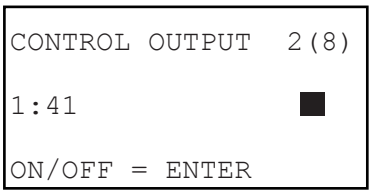
Select Control outputs for ECU 792 as per *ECU 790, diagnostic description page 9*.



008533

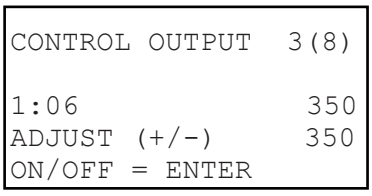
1 Control digital output for ECU 792.

1:40 means contact 1, pin 40 on ECU 792. The box is filled if the voltage on the output is approx. 24V (active). The box is empty if the output is 0V (not active). Using ↵ the output can be switched between approx. 24V (active, ON) and 0V (not active, OFF).



008534

2 Control digital output for ECU 792 further.

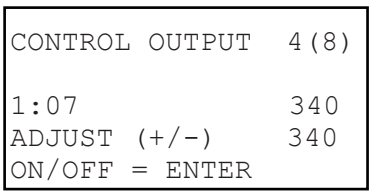


008535

3 Control PWM output for ECU 792.

In this and the following menus the actual-value is next to the output pin designation and the set-value (what is required, adjusted value) is on the row below.

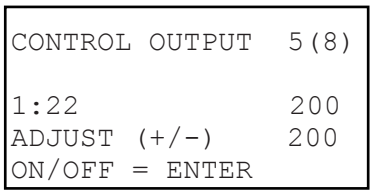
Using − and + the required current can be adjusted. ON/OFF confirmed with ↵.



008536

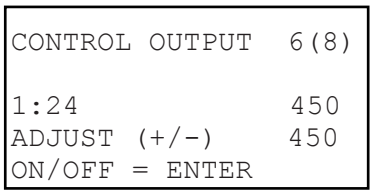
4 Control PWM output for ECU 792 further.

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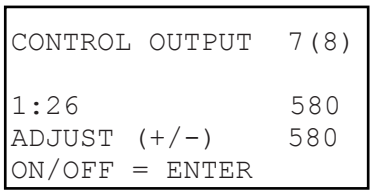
008537

5 Control PWM output for ECU 792 further.



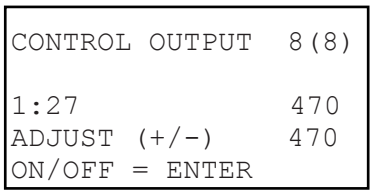
008538

6 Control PWM output for ECU 792 further.



008539

7 Control PWM output for ECU 792 further.



008540

8 Control PWM output for ECU 792 further.

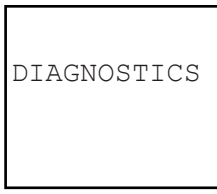
8.4.3 ECU 793

ECU 793, diagnostic description

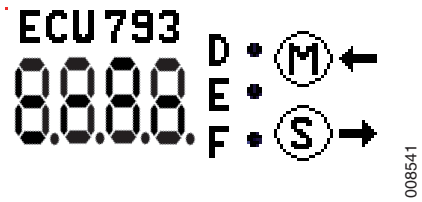
Select diagnostics as per *Diagnostics, work instruction page 7*.

Select diagnostics for ECU 793. This display indicates whether ECU 793 is selected. Press function key to proceed.

Display shows a reflection of the display in ECU 793 when it is in diagnostics mode. see section *8 Control system*; *2 Transmission*, group *2.8 Control system, transmission*.



000954



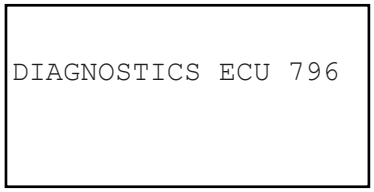
008541

8.4.4 ECU 796

ECU 796, diagnostic description

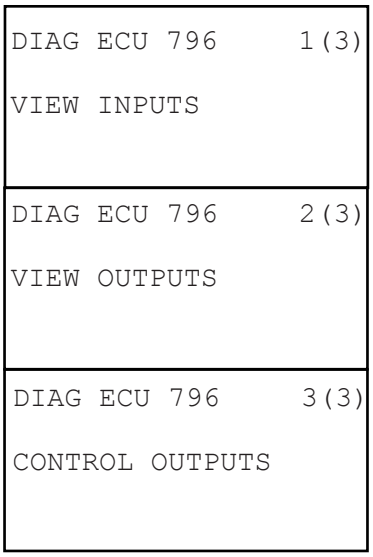
Select diagnostics as per *Diagnostics, work instruction page 7*.

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000955

Select diagnostics for ECU 796. This display indicates whether ECU 796 is selected. Press function key ↵ to proceed.



002843

The following alternatives can be selected in the diagnostics for ECU 796:

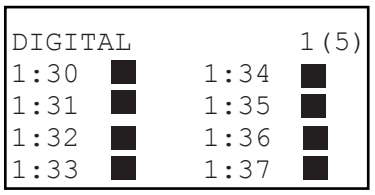
1. View inputs
2. View outputs
3. Control outputs

Scroll forwards to required menu using the function keys ↵1 and ↵2 and press ↵ to confirm.

8.4.4.1 View inputs

View inputs, description

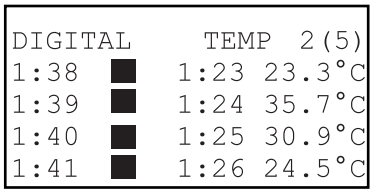
Select View inputs for ECU 796 as per *ECU 796, diagnostic description page 18*.



008542

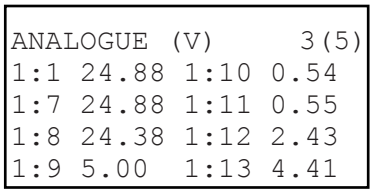
1 Check digital input for ECU 796.

1:30 means contact 1, pin 30 on ECU 796. The box is filled if the voltage in is > 12V. The box is empty if the voltage is < 5V. This applies for all digital inputs.



008543

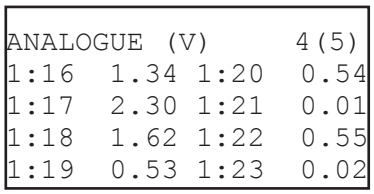
2 Check digital and temperature input for ECU 796. (Unconnected temperature input indicates -35.0 °C.)



008544

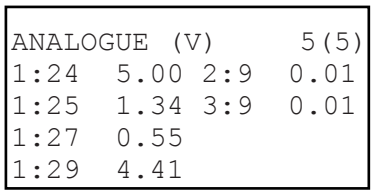
3 Check analogue input for ECU 796. Measurement range: 0.00–10.00V.

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008545

4 Check analogue input for ECU 796 further.



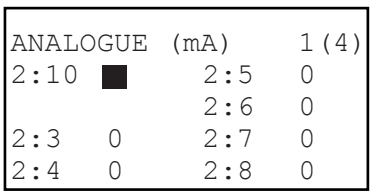
008546

5 Check analogue input for ECU 796 further.

8.4.4.2 View outputs

View outputs, description

Select View outputs for ECU 796 as per *ECU 796, diagnostic description page 18*.

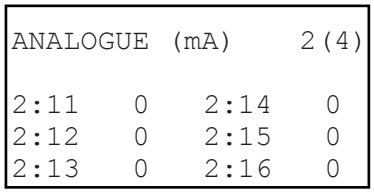


000963

1 Check analogue output K2 for ECU 796.

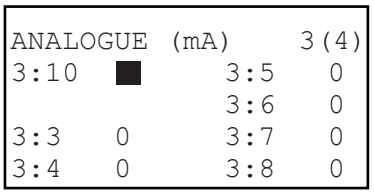
2:10 means contact 2 (K2), pin 10 on ECU 796. The box is filled if the voltage on the output is approx. 24V (active). The box is empty if the output is 0V (not active).

On output 2:3 etc. current displayed in mA.



000964

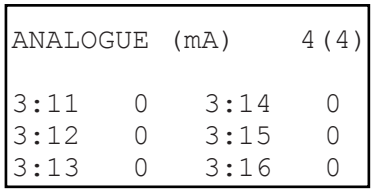
2 Check analogue output K2 for ECU 796 further.



000965

3 Check analogue output K3 for ECU 796.

This and the next menu are displayed only if ECU has 24 analogue outputs (standard is 12). These outputs are then in connector 3, K3.



000966

4 Check analogue output K3 for ECU 796 further.

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8.4.4.4 Control outputs

Control outputs K2, description

WARNING

When the outputs are controlled directly from the terminal, this can seriously affect machine performance.

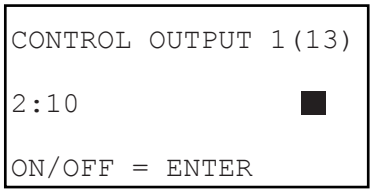
Only accredited personnel, with sufficient knowledge of the machine and the control system, must therefore use these menus.

The engine must be switched off if the test does not require otherwise.

NOTE

The application program closes due to safety reasons when checking outputs. Control O/P is only possible with service code.

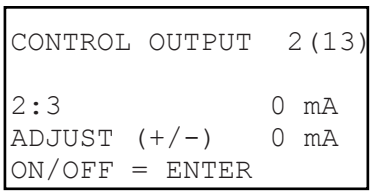
Select Control outputs for ECU 796 as per *ECU 796, diagnostic description page 18*.



000967

1 Control analogue output K2 for ECU 796.

2:10 means contact 2 (K2), pin 10 on ECU 796. The box is filled if the voltage on the output is approx. 24V (active). The box is empty if the output is 0V (not active). Using ↵ the output can be switched between approx. 24V (active, ON) and 0V (not active, OFF).

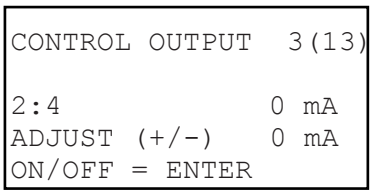


000968

2 Control analogue output K2 for ECU 796 further.

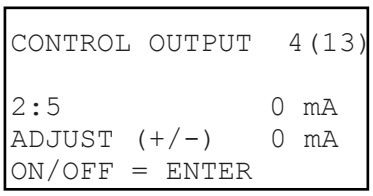
In this and the following menus the actual-value (the set value) is next to the output pin designation and the set-value (what is required, adjusted value) is on the row below.

Using − and + the required current can be adjusted. ON/OFF confirmed with ↵.



000969

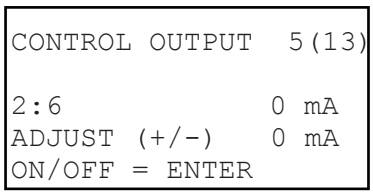
3 Control analogue output K2 for ECU 796 further.



000970

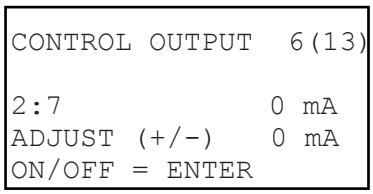
4 Control analogue output K2 for ECU 796 further.

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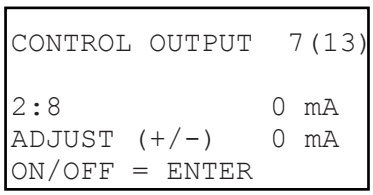
000971

5 Control analogue output K2 for ECU 796 further.



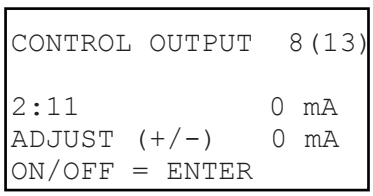
000972

6 Control analogue output K2 for ECU 796 further.



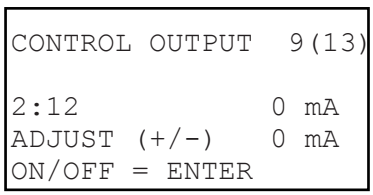
000973

7 Control analogue output K2 for ECU 796 further.



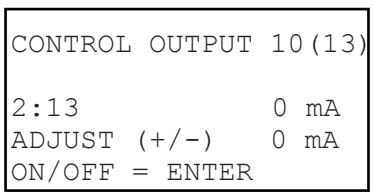
000974

8 Control analogue output K2 for ECU 796 further.



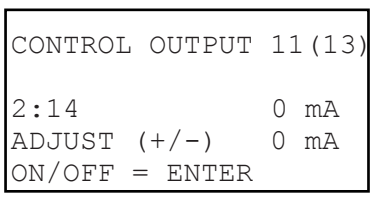
000975

9 Control analogue output K2 for ECU 796 further.



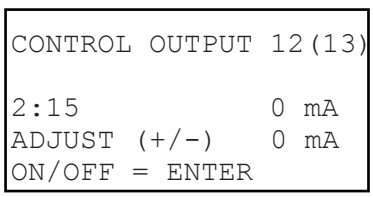
000976

10 Control analogue output K2 for ECU 796 further.



000977

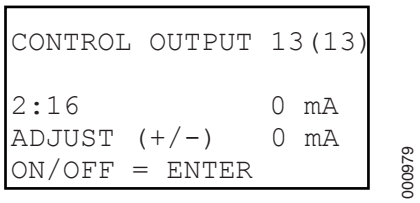
11 Control analogue output K2 for ECU 796 further.



000978

12 Control analogue output K2 for ECU 796 further.

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13 Control analogue output K2 for ECU 796 further.

Control outputs K3, description

WARNING

When the outputs are controlled directly from the terminal, this can seriously affect machine performance.

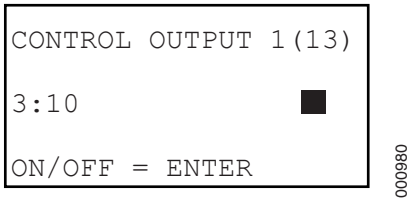
Only accredited personnel, with sufficient knowledge of the machine and the control system, must therefore use these menus.

The engine must be switched off if the test does not require otherwise.

NOTE

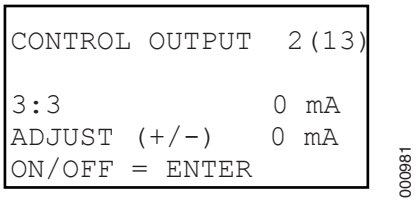
The application program closes due to safety reasons when checking outputs. Control O/P is only possible with service code.

Select Control outputs for ECU 796 as per *ECU 796, diagnostic description page 18*.

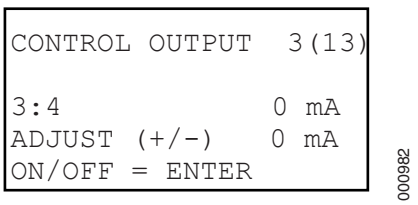


1 Control analogue output K3 for ECU 796.

This and the following menu are displayed only if ECU has 24 analogue outputs (standard is 12). These outputs are then in connector 3, K3.

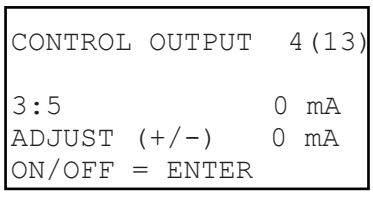


2 Control analogue output K3 for ECU 796 further.



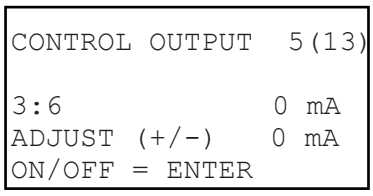
3 Control analogue output K3 for ECU 796 further.

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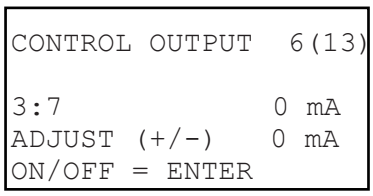
000983

4 Control analogue output K3 for ECU 796 further.



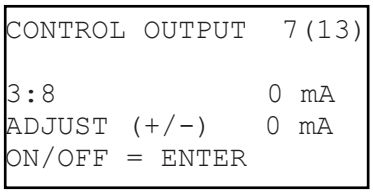
000984

5 Control analogue output K3 for ECU 796 further.



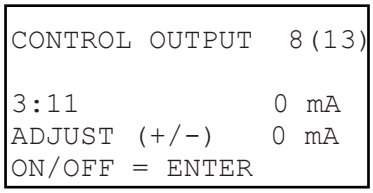
000985

6 Control analogue output K3 for ECU 796 further.



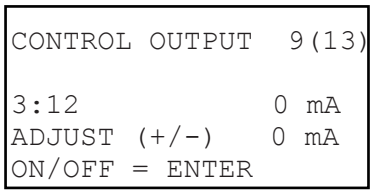
000986

7 Control analogue output K3 for ECU 796 further.



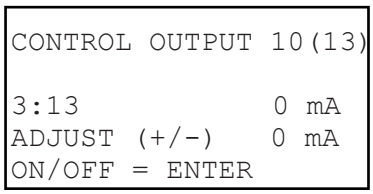
000987

8 Control analogue output K3 for ECU 796 further.



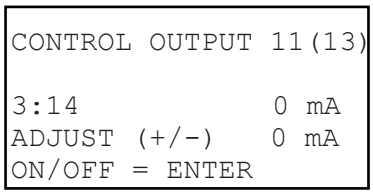
000988

9 Control analogue output K3 for ECU 796 further.



000989

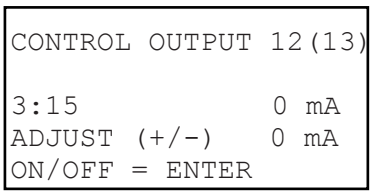
10 Control analogue output K3 for ECU 796 further.



000990

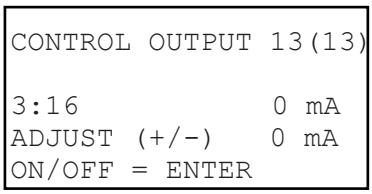
11 Control analogue output K3 for ECU 796 further.

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000991

12 Control analogue output K3 for ECU 796 further.



000992

13 Control analogue output K3 for ECU 796 further.

8.4.5 Last alarms

Last alarms, description

A history of the latest error codes generated can be seen under this menu. If the same error code is generated several times this is counted and the number of faults is shown on the display. Time and date is shown when the error code was generated.

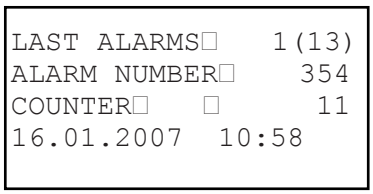
Select diagnostics and Last alarms as per *Diagnostics, work instruction page 7*. This display indicates if Last alarms is selected. Press function key ↵ to proceed.



000995

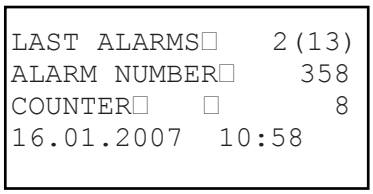
The 10 latest error codes are displayed in chronological order (with error code number), number of error codes and the respective time and date for the last error code of this type received.

If only one error code is saved there is only the menu for that fault and the last menu “Clear all alarms”. So the number of menus under Last alarms is dynamic. Max. number of error codes saved is 10.



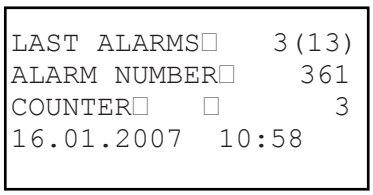
009350

1 Latest active error codes (1, latest) in chronological order.



009351

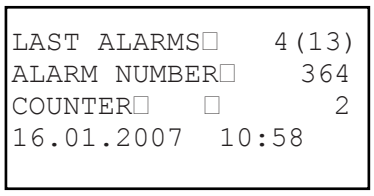
2 Latest active error codes (2) in chronological order.



009352

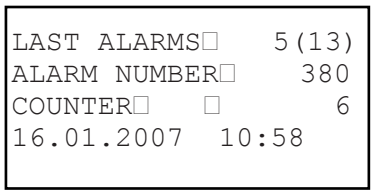
3 Latest active error codes (3) in chronological order.

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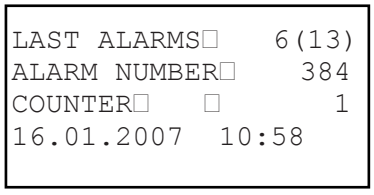
009353

4 Latest active error codes (4) in chronological order.



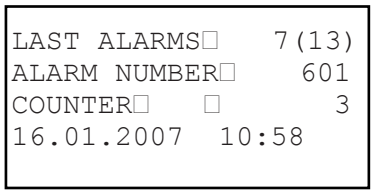
009354

5 Latest active error codes (5) in chronological order.



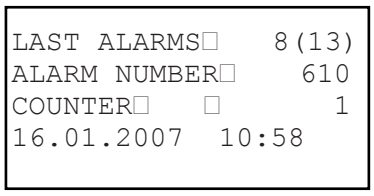
009355

6 Latest active error codes (6) in chronological order.



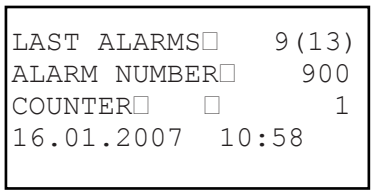
009356

7 Latest active error codes (7) in chronological order.



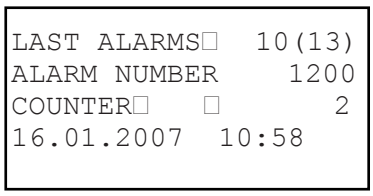
009357

8 Latest active error codes (8) in chronological order.



009358

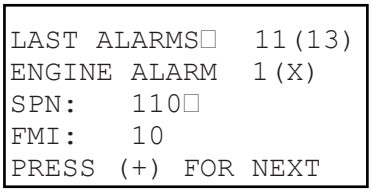
9 Latest active error codes (9) in chronological order.



009359

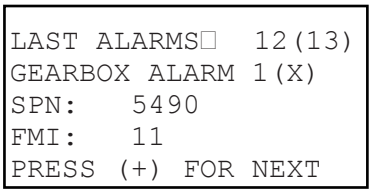
10 Latest active error codes (10) in chronological order.

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009360

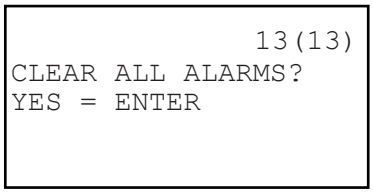
11 Latest active error codes (11) for the engine. more than one code, scroll the error codes by pressing the (+) function key.



009361

12 Latest active error codes (12) for the gearbox. more than one code, scroll the error codes by pressing the (+) function key.

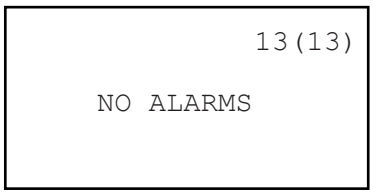
Dana TE13000/17000 don't support this.



009362

13 Clear all error codes (possible only with service code). This menu is shown if there is one or more error codes. To clear all error codes, press on function key ↵ (Yes = ↵).

Dana TE13000/17000 and Volvo TAD650VE/TAD750VE don't support this.



009364

Shown if no saved error codes exist and after reset. If no error codes from the KCS-system is present, only menus 11-13 is shown.

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8.5 Setup

Setup, description

The setup menus are used to initiate and calibrate the different functions.

Initiation means basic setting of the parameters for the different functions. Calibration means individual adjustment of the values for max. and min. of the signals for the different functions. This section describes how to proceed with initiation and calibration of respective function.

The number of menu pages per function can vary depending on the functions with which the machine's control system is equipped. Thus, the total number of menus is dynamic.

The values included in certain menus are relevant examples (guideline values) of what may appear in these positions. The real value may differ from these examples.

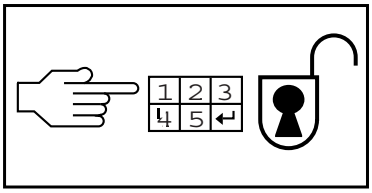
8.5.1 ETC-Electronic Throttle Control (electronic throttle)

ETC, description



000056

Go to the Setup menus by pressing function key in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.

ELECTRONIC THROTTLE CONTROL

008493

Select Electronic Throttle Control.

(Scroll to the desired menu with function keys and and press to confirm.)

For ETC, it's possible to choose initiation or calibration, see *Initiating ETC, description page 28* and *Calibrate ETC, description page 29*).

8.5.1.1 Initiating ETC-Electronic Throttle Control

Initiating ETC, description

Select Electronic throttle control, ETC, according to *ETC, description page 28*.

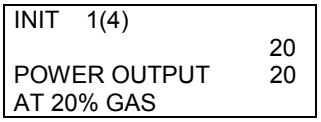
ELECTRONIC THROTTLE CONTROL

INITIATION

008494

Select initiation of ETC. To proceed, press function key .

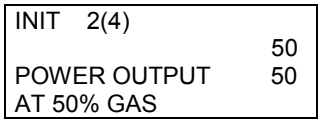
https://truckmanualshub.com/



008489

Set the amount of output signal 0-100% (use − and +) to be sent at 20% of pedal travel, (when pedal has been pressed down 20%). To proceed, press ↵.

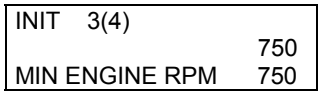
Lower value gives wider range for inching.



008490

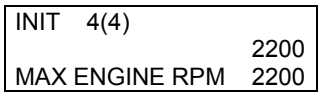
Set the amount of output signal 0-100% to be sent at 50% of pedal travel. This value can not be less than the previous setting at 20% in menu 1(4).

A lower value gives a wider range for slow speed control, for example when driving in hydrostatic mode on certain models.



008491

Set the idling speed to be sent to the engine when the pedal is released, 600-1000 rpm.



008492

Set the maximum speed to be sent to the engine when the pedal is fully depressed, 600 - 2400 rpm. This value can not be less than the previous setting in menu 3(4).

This is an example when:

“Power output at 20% gas” is set to 10%.

“Power output at 50% gas” is set to 30%.

This setting is suitable for hydrostatic transmission. It becomes easier to drive very slowly, as well as exact positioning of machine.

In other cases, the following applies:

“Power output at 20% gas” is set to 20%.

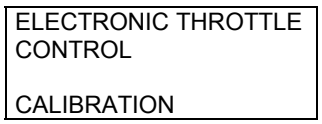
“Power output at 50% gas” is set to 50%.

8.5.1.2 Calibrate ETC-Electronic Throttle Control

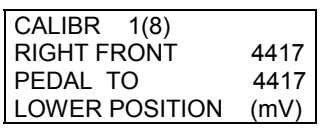
Calibrate ETC, description

Select Electronic throttle control, ETC, according to *ETC, description page 28*.

Select calibration of electronic throttle (ETC).

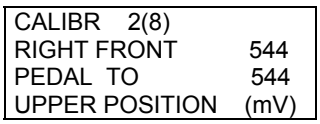


008495



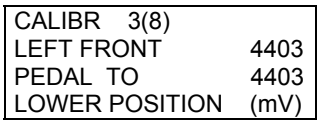
008472

Calibration of accelerator pedal right front. Press down right pedal completely and then press function key ↵.



008473

Calibration of accelerator pedal right front. Release right pedal completely and then press ↵.

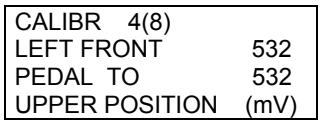


008474

Display shown if hydrostatic transmission or inching is present in the machine.

Calibration of accelerator pedal left front. Press down left pedal fully and confirm with ↵.

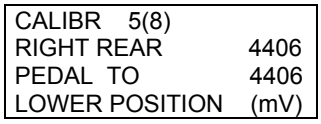
https://truckmanualshub.com/



008475

Display shown if hydrostatic transmission or inching is present in the machine.

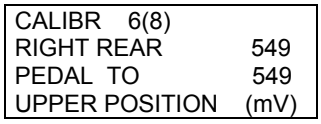
Calibration of accelerator pedal left front. Release left pedal completely and confirm with ↵.



008476

Calibration of accelerator pedal right rear. Press down right pedal completely and then press function key ↵.

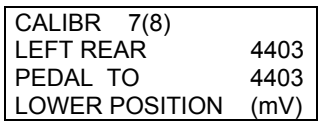
Display shown if the machine is equipped with a rotating or reversible driver's seat.



008477

Calibration of accelerator pedal right rear. Release right pedal completely and then press ↵.

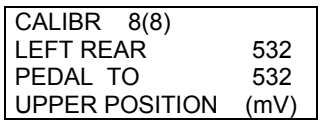
Display shown if the machine is equipped with a rotating or reversible driver's seat.



008478

Calibration of accelerator pedal left rear. Press down left pedal fully and confirm with ↵.

Display shown if the machine is equipped with hydrostatic transmission or inching and a rotating seat.



008479

Calibration of accelerator pedal left rear. Release left pedal completely and confirm with ↵.

Display shown if the machine is equipped with hydrostatic transmission or inching and a rotating seat.

8.5.2 Automatic shifting

Automatic shifting, description

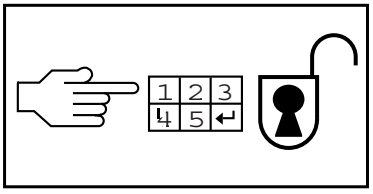
Relevant gearbox functionality can be adjusted.

Initiation settings below is general to all gearbox models and can be different depending on order, so called dynamic menus.



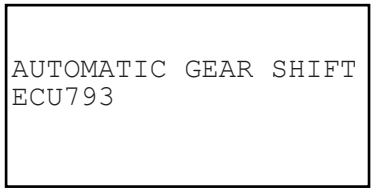
000056

Go to the Setup menus by pressing function key ↵ in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



008547

Select Automatic Gear Shift.

(Scroll to the desired menu with function keys ↵1 and ↵2 and press ↵ to confirm.)

For automatic shift, it's possible to choose initiation or calibration, see *Automatic shifting, description page 30*.

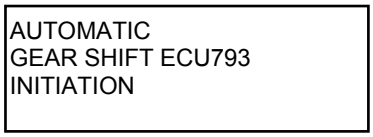
https://truckmanualshub.com/

8.5.2.1 Initiating Automatic gear shift (ECU793)

Initiating Automatic gear shift, description

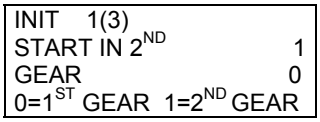
Select automatic gear shifting according to *Automatic shifting, description page 30*.

Enter initiation of automatic gearshift ECU793.



This display and the following shows only if A_GEAR_SHIFT_793 is selected.

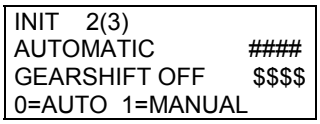
008548



Only shown if automatic gear shift is present on the machine.

Start in 2nd gear means that the gearbox always start in second gear and shifting is done between 2 and the highest available gear depending on model. Value 0 = start in 1st gear, value 1 = start in 2nd gear.

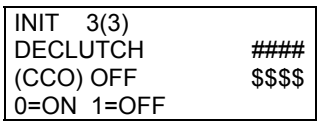
008549



Only shown if automatic gear shift is present on the machine.

This parameter is used when selecting manual shifting. Value 0 = automatic shift, value1 = manual shifting.

008550



Only shown when automatic gear shift and NOT inching is present in the machine.

This parameter can be used to disable the declutch functionality that disengage the gearbox into neutral when brake pedal is pressed.

008551

Value 0 = declutch active, value 1 = declutch disabled.

8.5.2.2 Calibrate Automatic gear shift, description

Calibrate Automatic gear shift (transmission alternative Dana), description

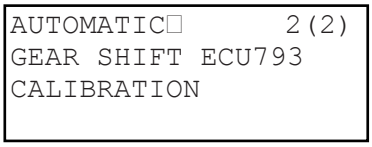
DANGER

Do not leave the machine during calibration. The machine may start to move.

1 Park the machine on level ground, engage neutral position and apply the parking brake. Run the engine at idling speed.

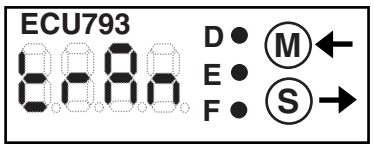
2 Select automatic gear shifting according to *Automatic shifting, description page 30*.

3 Select CALIBRATION by scrolling with the arrow keys (1 and 2) and confirm with Enter.

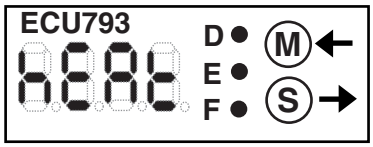


007742

https://truckmanualshub.com/



007745



007744

4 Select “hEAt” by scrolling with the arrow keys (1 and 2) and confirm with Enter.

5 Raise the temperature in the transmission by:

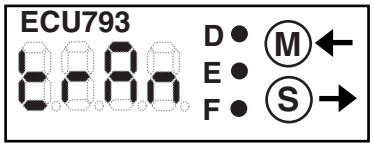
A. Apply the parking brake so that the machine is stationary.

B. Select travel direction forward or backward and apply half to maximum acceleration for 20 seconds.

C. Engage neutral position and apply half throttle for 10 seconds, run the engine at idling speed.

D. Repeat steps B and C until the oil temperature is over 60 °C or max 90 °C. The temperature display starts to flash when calibration of the clutches can start.

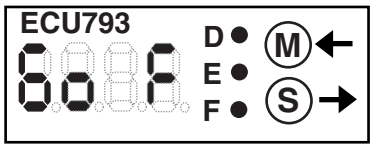
6 Check that the gear control is in neutral position.



007745

7 Select “trAn” by scrolling with the arrow keys (1 and 2) and confirm with Enter.

8 Start calibration by selecting travel direction forward.



007743

9 The current temperature is displayed if it is lower than 60°C. If not, “Go F” is displayed. If all conditions to start calibration are met, the calibration process starts.

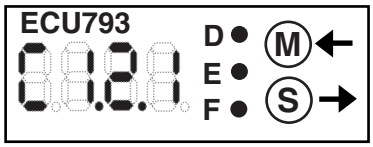
The transmission will activate different gears during calibration.

NOTE

If the machine starts to move during calibration then use the foot brake to keep the machine stationary.

IMPORTANT

The transmission calibration process can be interrupted at all times by moving the shift lever into the reverse position.



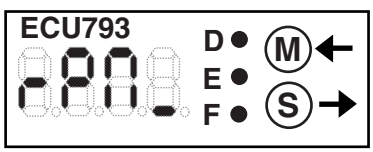
007747

10 Calibration starts (takes approx. 15 minutes).

During calibration, “c1.n1”, “c1.n2”, “c2.n1”, “c2.n2” etc. are displayed. This means clutch 1 and mode 1-2, clutch 2 and mode 1-2 etc.

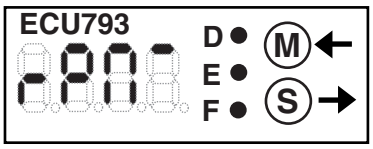
11 Depending on the actual calibrating mode, a different engine speed may be required.

– Whenever the actual engine speed is too low following display is shown:



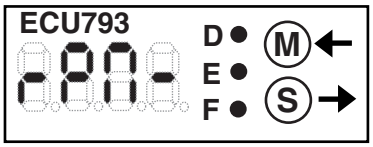
007748

https://truckmanualshub.com/



007749

– When the actual engine speed is too high, the display looks as follows:

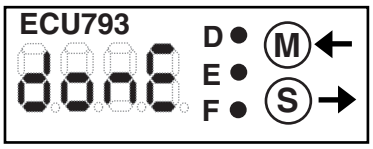


007750

12 Change the throttle pedal position until the display looks like left.

After the engine has been within limits for about three seconds, the calibration process proceeds.

After successful completion of the calibration process, the calibration results are memorised in Flash memory.



007751

13 After calibrating, donE is shown in the display.

When one or more errors were encountered during calibration the display shows vertical lines to indicate the calibration result of each clutch (the first line corresponds to clutch1, the second line to clutch2,…). A blinking line indicates the calibration of the corresponding clutch was no successful.

14 Turn off the ignition to store the values.

For further information see *section 2 Transmission, group 2.8.11 Calibration.*

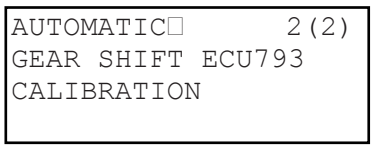
Calibrate Automatic gear shift (transmission alternative ZF), description

DANGER

Do not leave the machine during calibration. The machine may start to move.

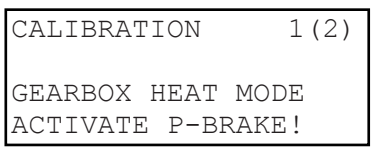
1 Park the machine on level ground, engage neutral position and apply the parking brake. Run the engine at idling speed.

2 Select automatic gear shifting according to *Automatic shifting, description page 30*.



007742

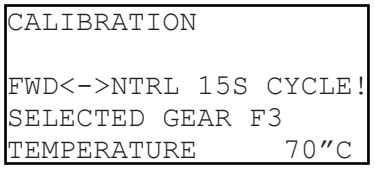
3 Select CALIBRATION by scrolling with the arrow keys (1 and 2) and confirm with Enter.



009098

4 Only shown when the engine is running.

The signals for the parking brake and clutch disengagement have been temporarily disconnected to make it possible to run “Heat Mode”. The highest possible gear is always selected.



009541

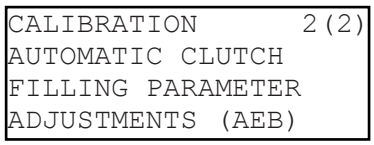
5 “Heat mode” is a function for heating the transmission with the transmission stationary, by using the parking brake to brake the machine and let the torque converter heat the transmission oil.

https://truckmanualshub.com/

NOTE

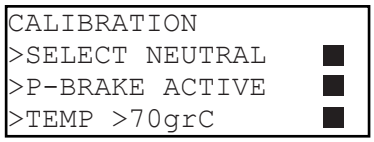
Stall the transmission for 15 sec., then select neutral to flush the oil round and cool it for 10 sec. Repeat the procedure until the desired oil temperature (70° C) has been reached.

When the transmission has reached the desired temperature, the temperature value in the display will flash.



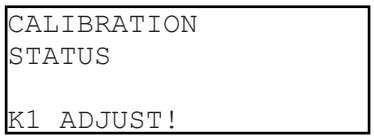
009100

6 Only shown when the engine is running. Press “Enter” to come to the next menu.



009101

7 The following requirements must be complied with, to start calibration. Transmission in neutral and parking brake applied. Check that all requirements are complied with and that the oil temperature is 70° before you go on to the next menu by pressing Enter.



009103

8 When the TCU has started calibration, the display shows information in plain language about the calibration procedure. Any fault messages are also displayed.

9 During calibration, engine speed is automatically regulated to the default value which suits each transmission.

After calibration is completed, the display will show the text: “ADJUSTMENT FINISHED SWITCH OFF IGNITION FOR 5 SECONDS!”, for saving the new parameters.



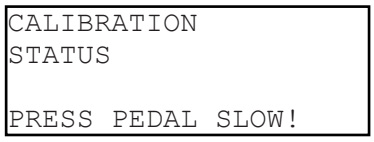
009104

10 This is only shown when the engine is switched off and inching is installed. This is an optional feature.

The requirement for seeing “CALIBRATION INCH PEDAL” is that the engine is already switched off. This will not be displayed at all otherwise.

--> Engine switched off = INCH PEDAL CALIBRATION

Engine running = AEB CLUTCH CALIBRATION



009105

11 When the TCU has started calibration, the display shows information in plain language about the calibration procedure. Any fault messages are also displayed.

12 Depress the pedal slowly and keep it depressed until the text shown on the display changes to “Release pedal slow!”. Release the pedal slowly.

After successful calibration, switch off ignition for 5 s for saving the new parameters.

https://truckmanualshub.com/

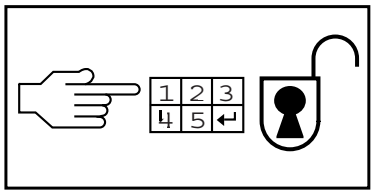
8.5.4 Feedback lever steering

Feedback lever steering, description



000056

Go to the Setup menus by pressing function key in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



000741

Select Lever steering.

(Scroll to the desired menu with function keys and and press to confirm.)

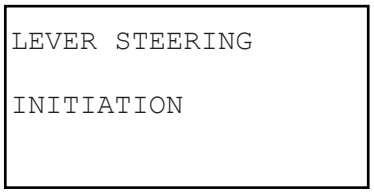
For Lever steering, it's possible to choose initiation or calibration, see *Initiating Feedback lever steering, description page 35* and *Calibrating Feedback lever steering, description page 39*).

8.5.4.1 Initiating Feedback lever steering

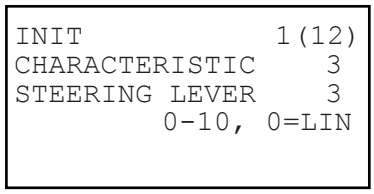
Initiating Feedback lever steering, description

Select Lever steering according to *Feedback lever steering, description page 35*.

Select initiation for Lever steering.



000742



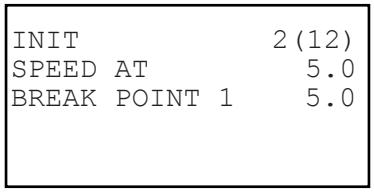
004754

Indicates steering lever's linearity.

0 = the wheel angle is equal in relation to the lever deflection during the entire lever movement.

10 = the wheel angle is small at the beginning of the lever movement and large at the end.

Recommended value: 3



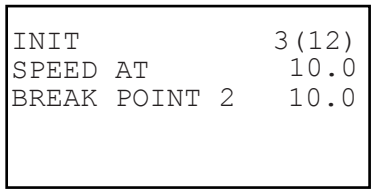
008565

Setting of speed at reference point 1. Affects steering characteristics.

Recommended value: 5 km/h or acc. to operator's wishes.

For adjusting, see *Adjusting lever steering page 37*.

https://truckmanualshub.com/

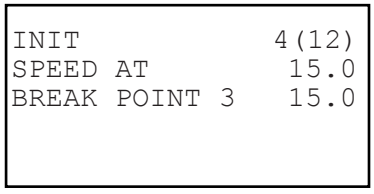


008566

Setting of speed at reference point 2. Affects steering characteristics.

Recommended value: 10 km/h or acc. to operator's wishes.

For adjusting, see *Adjusting lever steering page 37*.

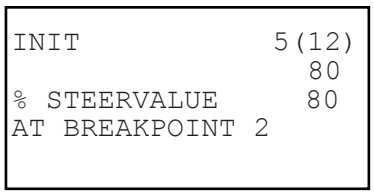


008567

Setting of speed at reference point 3. Affects steering characteristics.

Recommended value: 15 km/h or acc. to operator's wishes.

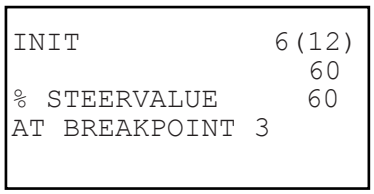
For adjusting, see *Adjusting lever steering page 37*.



008617

Percent of max. steering capacity (% steering value) at reference point 2. Reduces the steering lever's influence when speed increases.

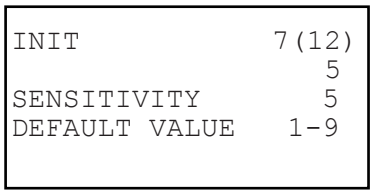
For adjusting, see *Adjusting lever steering page 37*.



008618

Percent of max. steering capacity (% steering value) at reference point 3. Reduces the steering lever's influence when speed increases.

For adjusting, see *Adjusting lever steering page 37*.



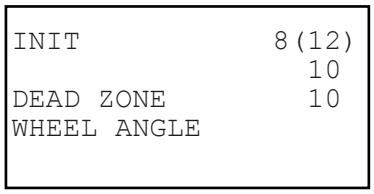
004753

Sensitivity of steering lever's change.

Low value gives slow change.

High value gives fast change.

Recommended value: 5, if 0 = the latest adjusted value is memorised and used when starting the machine.

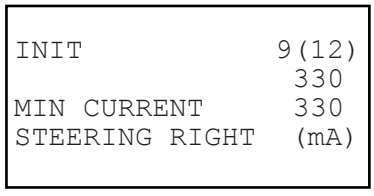


000750

This display is shown if feedback is included.

Indicates the wheel angle that is accepted when triggering begins. Normally not adjusted.

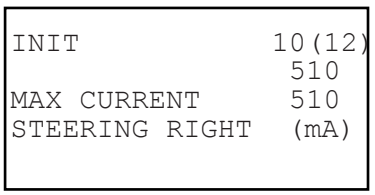
Recommended value: 10



008619

Start current for when the valve starts to move (where the valve precisely starts to open and gives a small flow to the steering cylinder).

For adjusting, see *Adjusting lever steering page 37*

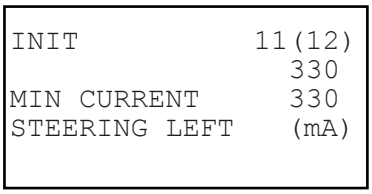


000752

Current for fully open valve.

For adjusting, see *Adjusting lever steering page 37*.

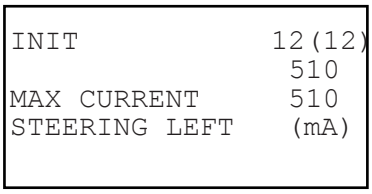
https://truckmanualshub.com/



008620

Same setting as in menu 9 but for left steering angle.

For adjusting, see *Adjusting lever steering page 37*.



000754

Same setting as in menu 10 but for left steering angle.

For adjusting, see *Adjusting lever steering page 37*.

Adjusting lever steering

For adjusting, see

1. Adjusting currents for lever steering/mini-wheel
2. Possible setting of dead zone (only for feedback lever steering)
3. Setting of sensitivity
4. Setting of speed dependence
5. Setting of characteristics (Characteristic steer lever)
6. Test-run

Adjusting currents for lever steering/mini-wheel

To find the best value for start currents:

- Set MIN CURRENT STEERING LEFT and MAX CURRENT STEERING LEFT to the same value. Start with 300 mA. Start current and final current are set to the same value to know exactly what current the steering valve receives.
- Steer to the left (with lever/mini-wheel). The wheels should move slowly. If the wheels don't move, increase the current values a couple of steps and try again. When this is done, one has to stand on the footstep to assess how the wheels move. When the correct value has been found, the wheels move slowly.
- Repeat for control current right.
- Note that steering speed should be the same in both directions.
- The final value is used for MIN CURRENT STEERING LEFT and RIGHT.

To find the best value for final currents:

- Set MAX CURRENT STEERING LEFT to 510 mA and MAX CURRENT STEERING RIGHT to 510 mA.
- Check that the machine has the same steering speed in both directions when the steering lever is deflected completely (or mini-wheels is turned fast, approx. one steering wheel turn per second). When this is done, one has to stand on the footstep to assess how the wheels move. Steering speed may vary slightly depending on if the engine is running at idle or at a higher rpm.

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- Test-run the machine and try to assess if the steering capacity is sufficient at low speeds, can the machine be turned fast enough? If not, increase final currents slightly and try again.

Possible setting of dead zone (only for feedback lever steering)

If the steering axle oscillates (difficult remaining stationary) it may be due to the dead zone being set to low. Increase it slightly.

Setting of sensitivity

If fast steering is desired with high sensitivity, set “SENSITIVITY” to high. Slow steering is given with a low value.

A new inexperienced operator often wants slow, forgiving steering.

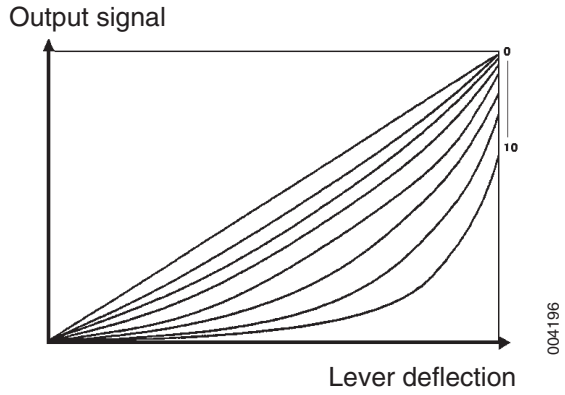
An experienced operator expects fast reactions from lever/steering wheel to the steering axle.

Setting of characteristics (Characteristic steer lever)

Indicates steering lever’s characteristics.

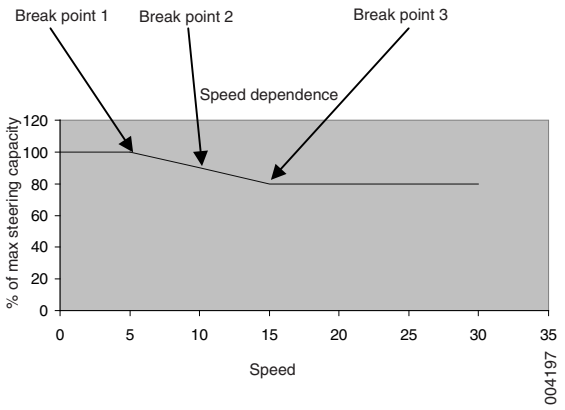
0= steering angle is equal in relation to the lever deflection during the entire steering movement (linear).

10= steering angle is small at beginning of the lever movement and greater at the end.



Setting of speed dependence

The diagram explains how speed dependence can be adjusted using the break points.



For break point 1, indicated at what speed it applies (for example, 5 km/h), but steering capacity is always 100% For break point 2, enter speed (for example, 10 km/h) and steering capacity (for example, 90%). For break point 3, enter speed (for example, 15 km/h) and steering capacity (for example, 80%).

If one wants steering to be even more “careful” at high speed, the value shall be changed as follows:

For break point 1, enter speed 5 km/h For break point 2, enter speed 10 km/h and steering capacity 75%. For break point 3, enter speed 15 km/h and steering capacity 50%.

If one wants steering to be completely without speed dependence, the value shall be changed as follows:

For break point 1, enter speed 5 km/h For break point 2, enter speed 10 km/h and steering capacity (100%). For break point 3, enter speed 15 km/h and steering capacity (100%).

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The speed limits and break points may be adjusted according to customers' wishes. However, it's important to not "stretch the limits" too far. Change and test.

Test-run

Don't forget to test-run the machine in different situations. Setting of the start currents is very sensitive. The machine must steer even when the steering wheel is turned slowly, otherwise it's impossible to travel straight at full speed. The result may be that regardless of how much one steers, at first nothing happens, then the machine turns sharply. Then the cause is that the start currents are set too low, see above.

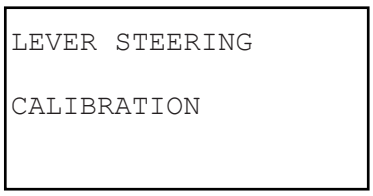
If start currents are set too high, the machine's steering feels very unstable and erratic at high speeds. It's impossible to steer carefully as the smallest turn of the steering wheel results in a large wheel angle.

8.5.4.2 Calibrating Feedback lever steering

Calibrating Feedback lever steering, description

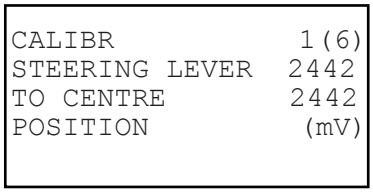
Select Lever steering according to *Feedback lever steering, description page 35*.

Select calibration for lever steering.



000755

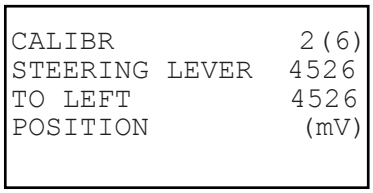
Don't touch the steering lever when calibrating the middle position.



000756

Display shows steering lever's middle position. Press ↵ to save this position as "middle position".

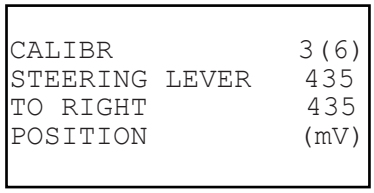
Move the lever to the far left. Display shows steering lever's position.



000757

Press ↵ to save this position.

Move the lever to the far right. Display shows steering lever's position.

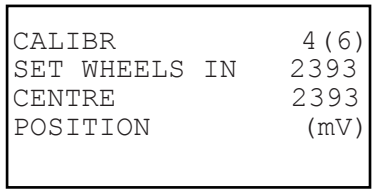


000758

Press ↵ to save this position.

The following displays are shown if feedback is included.

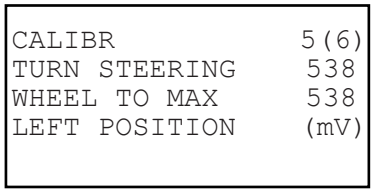
Adjust the wheels until they are parallel with the machine. (To obtain best result, run the machine straight with the normal steering wheel).



000759

Display shows wheel's position. Press ↵ to save this value.

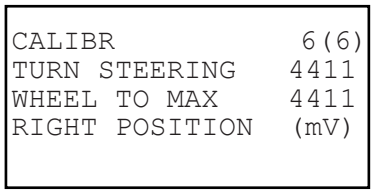
https://truckmanualshub.com/



000760

Turn the steering wheel to max. left. Display shows wheel's position.

Press ↵ to save this value.



000761

Turn the steering wheel to max. right. Display shows wheel's position.

Press ↵ to save this value.

8.5.5 NON feedback lever steering

NON feedback lever steering, description

See *Feedback lever steering, description page 35*.

8.5.5.1 Initiating NON feedback lever steering

Initiating NON feedback lever steering, description

See *Initiating Feedback lever steering, description page 35*.

8.5.5.2 Calibrating NON feedback lever steering

Calibrating NON feedback lever steering, description

See *Calibrating Feedback lever steering, description page 39* menu 1-3.

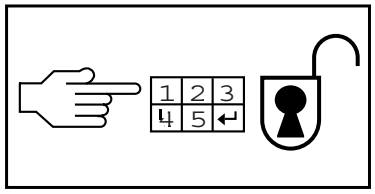
8.5.6 Mini-wheel

Mini-wheel, description



000056

Go to the Setup menus by pressing function key ↵ in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



000769

Select Mini steering.

(Scroll to the desired menu with function keys ↵1 and ↵2 and press ↵ to confirm.)

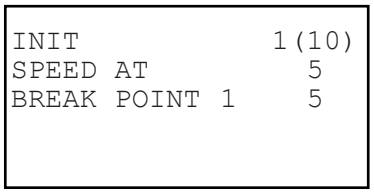
For Mini-wheel (Mini steering), it's only possible to select initiation, see *Initiating Mini-wheel, description page 41*).

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8.5.6.1 Initiating Mini-wheel

Initiating Mini-wheel, description

Select Mini steering according to *Mini-wheel, description page 40*.

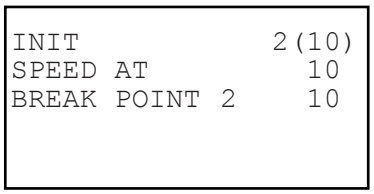


000770

Setting of speed at reference point 1 (BP1). Affects steering characteristics.

Recommended value: 5km/h.

For adjusting, see *Adjusting lever steering page 37*.

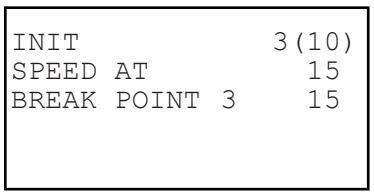


000771

Setting of speed at reference point 2 (BP2). Affects steering characteristics.

Recommended value: 10km/h.

For adjusting, see *Adjusting lever steering page 37*.

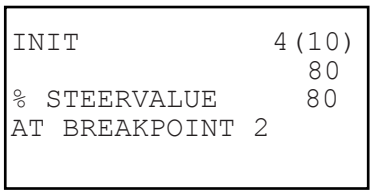


000772

Setting of speed at reference point 3 (BP3). Affects steering characteristics.

Recommended value: 15km/h.

For adjusting, see *Adjusting lever steering page 37*.

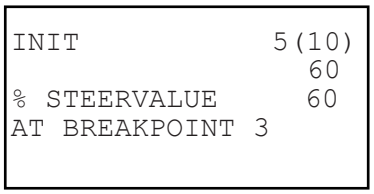


008621

Percent of max. steering capacity (% steering value) at reference point 2. Reduces the mini-wheel's influence when speed increases.

Recommended value: 80%.

For adjusting, see *Adjusting lever steering page 37*.

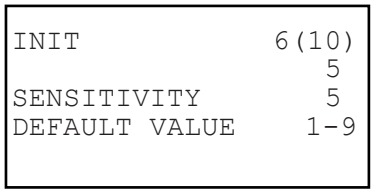


008622

Percent of max. steering capacity (% steering value) at reference point 3. Reduces the mini-wheel's influence when speed increases.

Recommended value: 60%.

For adjusting, see *Adjusting lever steering page 37*.



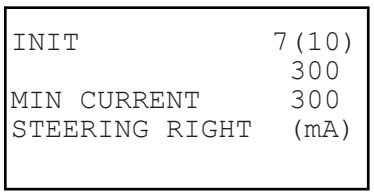
004545

Sensitivity of mini-wheel's change.

Low value gives many steering wheel turns from lock-to-lock.

High value gives few steering wheel turns from lock-to-lock.

Recommended value: 5, if 0 = the latest adjusted value is memorised and used when starting the machine.

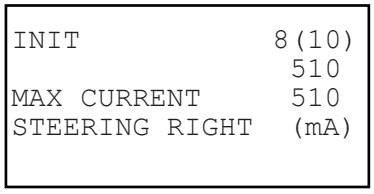


004532

Start current for when the valve starts to move (where the valve precisely starts to open and gives a small flow to the steering cylinder).

For adjusting, see *Adjusting lever steering page 37*.

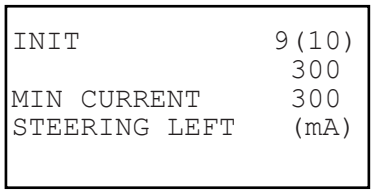
https://truckmanualshub.com/



000777

Current for fully open valve.

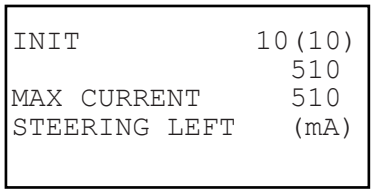
For adjusting, see *Adjusting lever steering page 37*.



004533

Same setting as in menu 7 but for left steering angle.

For adjusting, see *Adjusting lever steering page 37*.



000779

Same setting as in menu 8 but for left steering angle.

For adjusting, see *Adjusting lever steering page 37*.

Adjusting mini-wheel

See *Adjusting lever steering page 37*.

8.5.7 Electro-hydraulic servo

Electro-hydraulic servo, description

Each function can be set individually and must be calibrated. Thus, 10 solenoid valves have to be calibrated and initiated for 5 hydraulic functions.

The first step for activating the electric servo is a basic setting called Initiation. That's where the dead zone is indicated for the levers, as well as min. and max. currents for the solenoid valves.

The procedure for setting the min. current for the solenoid valves is to set both min. and max. currents to the same value, for example 260mA, and then increase successively until a movement is obtained for each hydraulic function. The value one has stopped at shall be the value for the min. current.

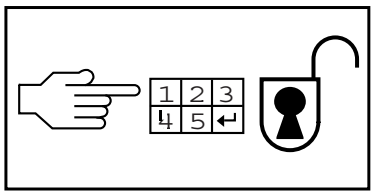
Max. current should be the one specified as max. by the valve manufacturer. For Parker L90, the range is 260 – 510 mA. In certain cases, a lower max. current may be set for better adaptation of hydraulic movement speed and synchronisation with engine performance and capacity of the hydraulic pumps.



000056

Go to the Setup menus by pressing function key ↵ in this menu.

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000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.

```
ELHYDRAULIC SERVO
```

000780

Select Electro-hydraulic servo.

(Scroll to the desired menu with function keys and and press to confirm.)

For Electro-hydraulic servo, it's possible to choose initiation or calibration, see *Initiating Electro-hydraulic servo, description page 43* and *Calibrating Electro-hydraulic servo, description page 46*).

8.5.7.1 Initiating Electro-hydraulic servo

Initiating Electro-hydraulic servo, description

Select electric servo according to *Electro-hydraulic servo, description page 42*.

Select initiation of electric servo.

```
ELHYDRAULIC SERVO

INITIATION
```

000781

```
INIT              1(25)
                    30
DEAD ZONE           30
LEVERS          30-1000
```

008569

Indicate how much of the steering lever's movement around the middle position should be interpreted as middle position (dead zone). The range is 30 – 1000 of the total lever movement's +/-1000. The value should be set as small as possible. Rec. value is 30. The dead zone range is necessary so that the hydraulic movements don't vibrate when operating the machine, especially on rough surfaces.

```
INIT              2(25)
FUNCTION 1A        260
(LOWER)            260
MIN CURRENT         (mA)
```

004547

Start value, min. current, for lowering movement's control valve. This display is shown if one or more hydraulic functions have been selected.

```
INIT              3(25)
FUNCTION 1A        510
(LOWER)            510
MAX CURRENT         (mA)
```

004548

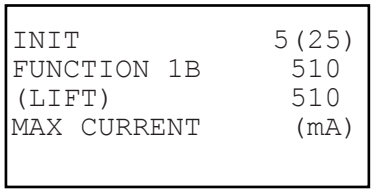
Stop value, max. current, for lowering movement's control valve. This display is shown if one or more hydraulic functions have been selected.

```
INIT              4(25)
FUNCTION 1B        260
(LIFT)             260
MIN CURRENT         (mA)
```

004549

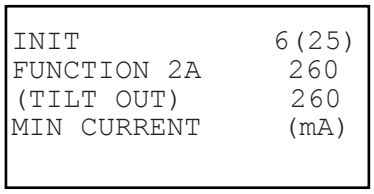
Start value, min. current, for lifting movement's control valve. This display is shown if one or more hydraulic functions have been selected.

https://truckmanualshub.com/



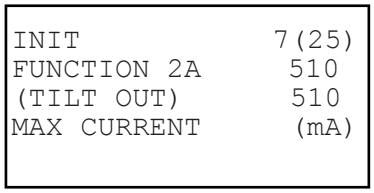
004550

Stop value, max. current, for lifting movement's control valve. This display is shown if one or more hydraulic functions have been selected.



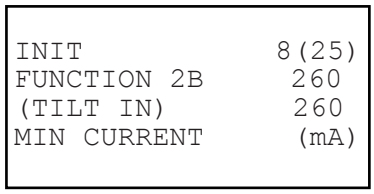
004551

Start value, min. current, for tilt out movement's control valve. This display is shown if two or more hydraulic functions have been selected.



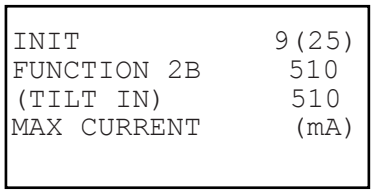
004552

Stop value, max. current, for tilt out movement's control valve. This display is shown if two or more hydraulic functions have been selected.



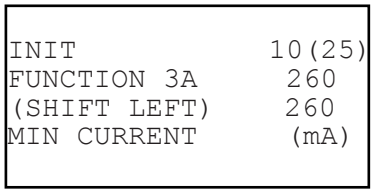
004553

Start value, min. current, for tilt in movement's control valve. This display is shown if two or more hydraulic functions have been selected.



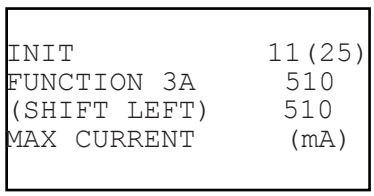
004554

Stop value, max. current, for tilt in movement's control valve. This display is shown if two or more hydraulic functions have been selected.



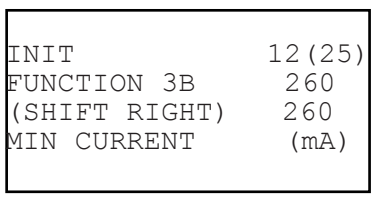
008573

Start value, min. current, for left side shift movement's control valve. This display is shown if three or more hydraulic functions have been selected.



004556

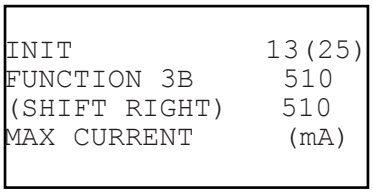
Stop value, max. current, for left side shift movement's control valve. This display is shown if three or more hydraulic functions have been selected.



004557

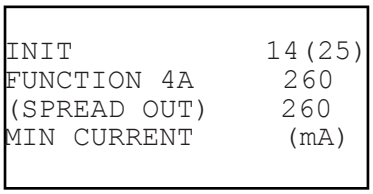
Start value, min. current, for right side shift movement's control valve. This display is shown if three or more hydraulic functions have been selected.

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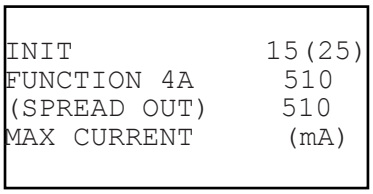
004558

Stop value, max. current, for right side shift movement's control valve. This display is shown if three or more hydraulic functions have been selected.



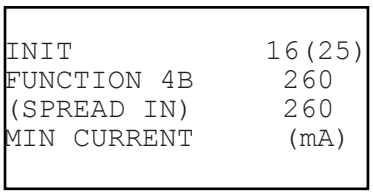
004559

Start value, min. current, for positioning outward movement's control valve. This display is shown if four or more hydraulic functions have been selected.



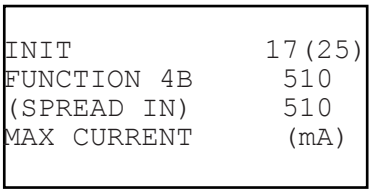
004560

Stop value, max. current, for positioning outward movement's control valve. This display is shown if four or more hydraulic functions have been selected.



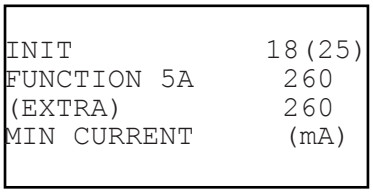
004561

Start value, min. current, for positioning inward movement's control valve. This display is shown if four or more hydraulic functions have been selected.



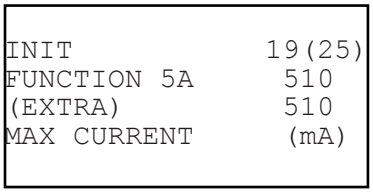
008570

Stop value, max. current, for positioning inward movement's control valve. This display is shown if four or more hydraulic functions have been selected.



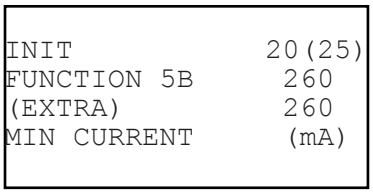
004563

Start value, min. current, for upward levelling movement's control valve. This display is shown if five or more hydraulic functions have been selected.



004564

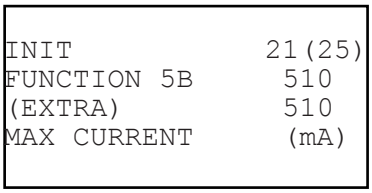
Stop value, max. current, for upward levelling movement's control valve. This display is shown if five or more hydraulic functions have been selected.



004565

Start value, min. current, for downward levelling movement's control valve. This display is shown if five or more hydraulic functions have been selected.

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004566

Stop value, max. current, for downward levelling movement's control valve. This display is shown if five or more hydraulic functions have been selected.

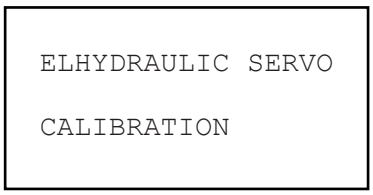
8.5.7.2 Calibrating Electro-hydraulic servo

Calibrating Electro-hydraulic servo, description

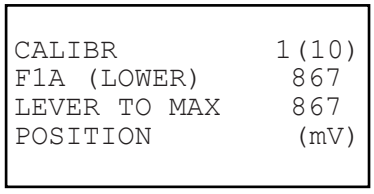
This is the second step after basic setting in the initiation menus. Calibration has to be performed to adapt the lever's output signal and so that maximum range from the lever can be used by KCS. This must also be done after replacing a lever.

Select electric servo according to *Electro-hydraulic servo, description page 42*.

Select calibration for electro-hydraulic servo.

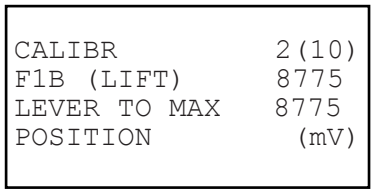


000679



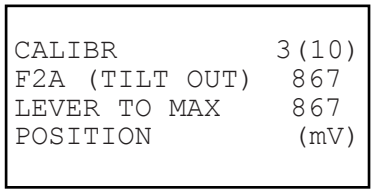
004757

Calibration of voltage for lowering function. When the lever is in max. position for lower, press function key ↵.



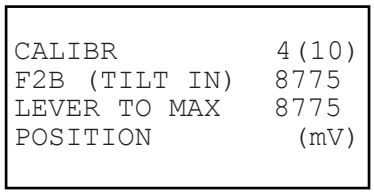
004758

Calibration of voltage for lifting function. When the lever is in max. position for lift, press function key ↵.



004759

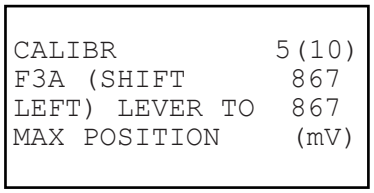
Calibration of voltage for tilt out function. When the lever is in max. position for tilt out, press function key ↵.



004760

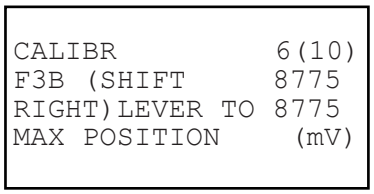
Calibration of voltage for tilt in function. When the lever is in max. position for tilt in, press function key ↵.

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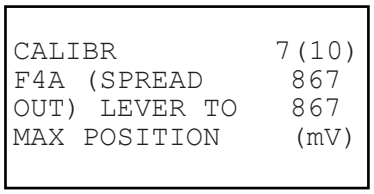
004761

Calibration of voltage for side shift left function. When the lever is in max. position for left side shift, press function key ↵.



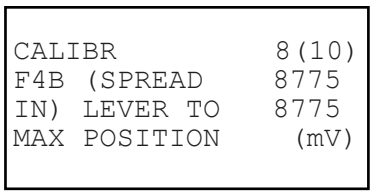
004762

Calibration of voltage for side shift right function. When the lever is in max. position for right side shift, press function key ↵.



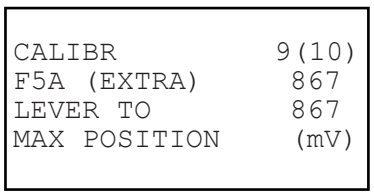
004763

Calibration of voltage for fork positioning out function. When the lever is in max. position for positioning outward, press function key ↵.



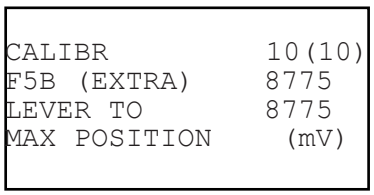
004764

Calibration of voltage for fork positioning in function. When the lever is in max. position for positioning inward, press function key ↵.



004765

Calibration of voltage for levelling up function. If 4 hydraulic functions have been selected in setup, this display is not shown. When the lever is in max. position for upward levelling, press function key ↵.



004766

Calibration of voltage for levelling down function. If 4 hydraulic functions have been selected in setup, this display is not shown. When the lever is in max. position for downward levelling, press function key ↵.

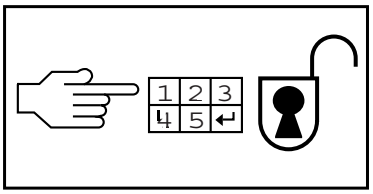
https://truckmanualshub.com/

8.5.8 Scale

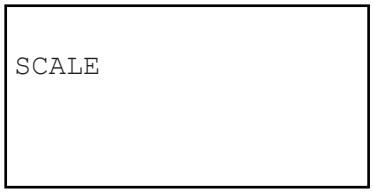
Scale, description



Go to the Setup menus by pressing function key in this menu.



To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



Select Scale.

(Scroll to the desired menu with function keys and and press to confirm.)

For Scale, it's only possible to select calibration, *Calibrating scale, description page 48*).

8.5.8.1 Calibrating Scale

Calibrating scale, description

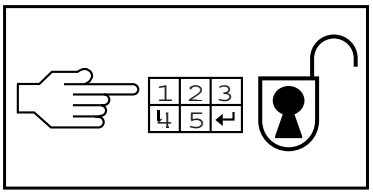
See *Maintenance manual for DCE 90–80, DCE 70-32E3–70-35E4*.

8.5.9 Monitoring

Monitoring, description



Go to the Setup menus by pressing function key in this menu.



To access the setup menus, the service code has to be entered (authorization required). Thereafter, the settings can be accessed to perform settings.



Select Monitoring.

(Scroll to the desired menu with function keys and and press to confirm.)

For Monitoring, it's only possible to select initiation, see *Initiating Monitoring, description page 49*).

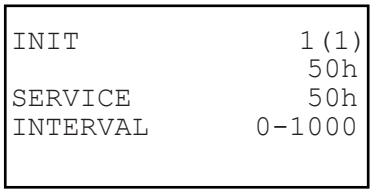
https://truckmanualshub.com/

8.5.9.1 Initiating Monitoring

Initiating Monitoring, description

Select Monitoring according to *Monitoring, description page 48*.

Menu for setting service interval. Access directly via the service code.



008568

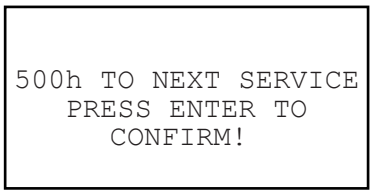
Enter new interval with − and + and press function key ↵ to confirm. On delivery from the factory, this should be set to 50 h.

Resetting the service interval

NOTE

This menu can only be accessed by entering the special code (authorization required) instead of the service code.

Menu for resetting service time (time to next service).



000808

Press function key ↵ to confirm.

8.5.10 Pre-selected lifting height

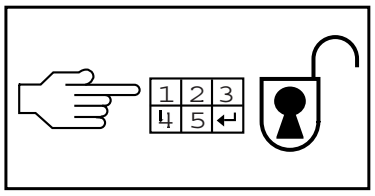
Pre-selected lifting height, description

Go to the Setup menus by pressing function key ↵ in this menu.



000056

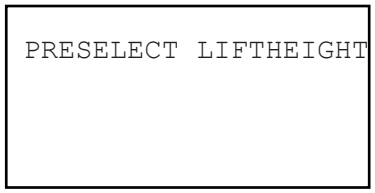
To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



000060

Select Preselect lift height.

(Scroll to the desired menu with function keys ← and → and press ↵ to confirm.)



001233

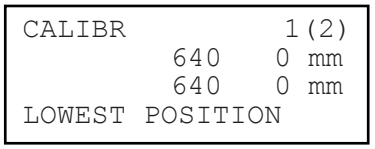
For Pre-selected lifting height, it's only possible to select calibration, see *Calibrating Pre-selected lifting height, description page 49*).

8.5.10.1 Calibrating Pre-selected lifting height

Calibrating Pre-selected lifting height, description

Select Preselect lift height according to *Pre-selected lifting height, description page 49*.

Lower the carriage to the lowest position and adjust with key − and + to the measured lift height in question.

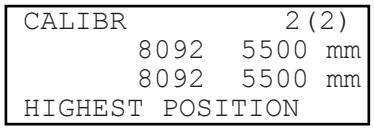


008574

Press function key ↵ to confirm lowest position.

Min. lift height (in millimetres) can be read off at the bottom right.

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008575

Min. lift height (in millivolt) can be read off at the bottom left.

Lift the carriage to the highest position and adjust with key 4 and 5 to the measured lift height in question.

Press function key ↵ to confirm highest position.

Max. lift height (in millimetres) can be read off at the bottom right.

Max. lift height (in millivolt) can be read off at the bottom left.

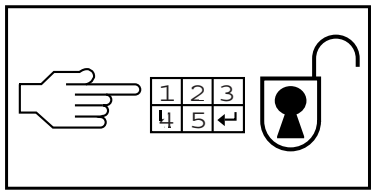
8.5.11 Tilt control

Tilt control, description



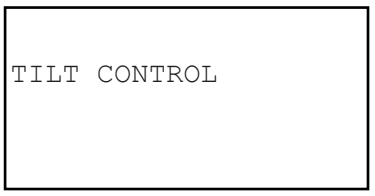
000056

Go to the Setup menus by pressing function key ↵ in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



001236

Select Tilt control.

(Scroll to the desired menu with function keys 1 and 2 and press ↵ to confirm.)

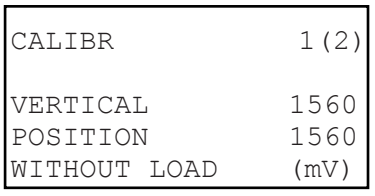
For Tilt control, it's only possible to select calibration, see *Calibrating Tilt control, description page 50*).

8.5.11.1 Calibrating Tilt control

Calibrating Tilt control, description

Select Tilt control according to *Tilt control, description page 50*.

Move the mast to vertical position without load.

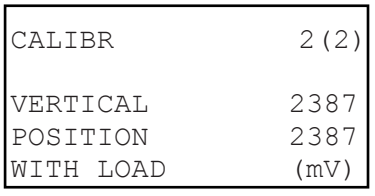


001237

Press function key ↵ to confirm vertical position.

Angle without load (in millivolt) can be read off at the bottom.

Move the mast to vertical position with load. It is a good idea to select a load which is frequently used for work with the tilt control.



001238

Press function key ↵ to confirm vertical position.

Angle with load (in millivolt) can be read off at the bottom.

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8.5.12 OptimumLift

OptimumLift, description

As with all variable pumps, it is essential to ensure that it is filled with oil before and after the engine is started, so that the rotating components are lubricated. If this is missed, and the pump is run dry for only a few minutes, this can lead to pump failure. One tip is to use the diagnostic function in KCS and “Control Outputs” to force the variable pump when the engine is first started, and ensure that the pump receives oil.

Force the pump by going into “Control outputs”, set a voltage on K2:12 and allocate 600 mA to K2:28 to set the pump to maximum delivery.

NOTE

The fork trolley starts to move!

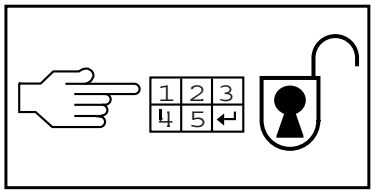
When the fork trolley starts to move, the pump has received enough oil. Forcible operation of the pump can now be shut off. For more detailed information, please refer to *Diagnostics, description page 6*.

Please refer to the information below, for setting the basic parameters.



000056

Go to the Setup menus by pressing function key in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



0014868

Select OptimumLift.

(Scroll to the desired menu with function keys and and press to confirm.)

For OptimumLift, it’s possible to choose initiation or calibration, see *OptimumLift, description page 51* and *Initiating OptimumLift, description page 52*).

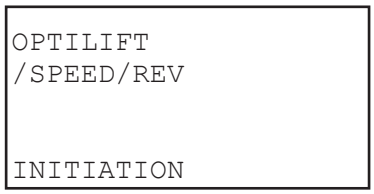
https://truckmanualshub.com/

8.5.12.1 Initiating OptimumLift

Initiating OptimumLift, description

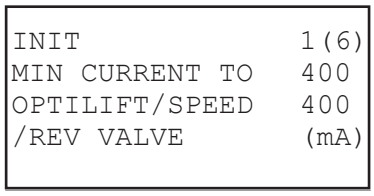
Select OptimumLift according to *OptimumLift, description page 51*.

Select initiation of OptimumLift.



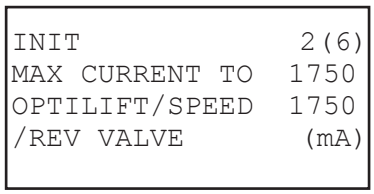
014869

Initiation of min. current to OptimumLift valve monitoring a variable pump. Relevant value is 400 mA.



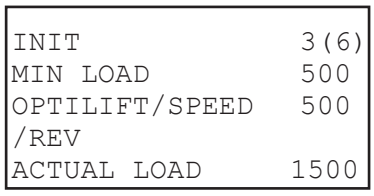
014870

Initiation of max. current to OptimumLift valve monitoring a variable pump. This value decides which speed the lift function gets. If Parker DF161C direction valve with 42 W coil is used and maximum lift speed is wanted, then the value is set to 1750 mA.



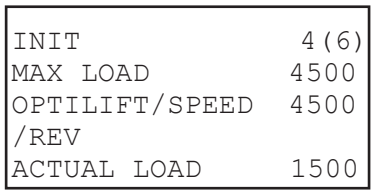
014871

Initiation of the min. load where OptimumLift or OptimumRev starts steering down the variable pump towards min. current. Change with − 4 and + 5.



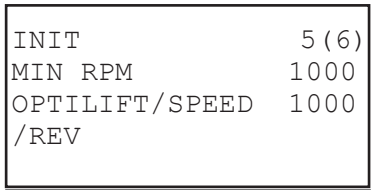
014872

Initiation of the max. load where OptimumLift has steered down the variable pump to min. current. Change with − 4 and + 5.



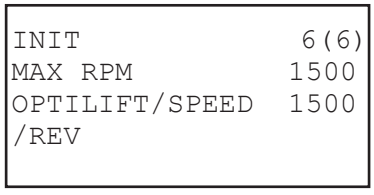
014873

Initiation of the min. rpm when OptimumLift starts steering out the variable pump. Relevant value is 900–1000 rpm.



014874

Initiation of the max. rpm when OptimumLift steers out the variable pump max. or the work speed that limits OptimumRev at drive break. Relevant value is 1500 rpm.



014875

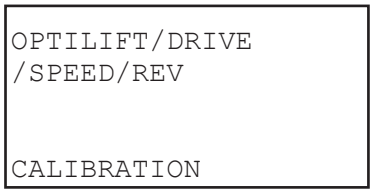
https://truckmanualshub.com/

8.5.12.2 Calibrating OptimumLift

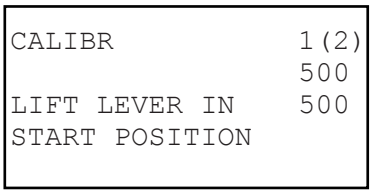
Calibrating OptimumLift, description

Select OptimumLift according to *OptimumLift, description page 51*.

Select calibration of OptimumLift.



014876

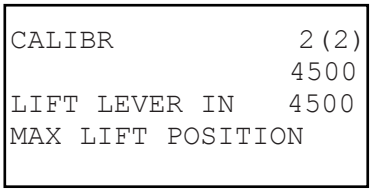


002300

Calibration of the pressure sensor signal from the lift lever (start movement).

The starting value should be when the lifting cylinders have just started to move, with the Optipump disconnected.

Not shown if an electro-hydraulic servo is installed.



002301

Calibration of the pressure sensor signal from the lift lever (end movement).

The signal must not exceed 4.5 V. If it does so, the hydraulic pressure can be set too high, above 40 bar.

Not shown if electro-hydraulic servo is installed.

8.5.14 Clamp and lift function/lower and open function

8.5.14.1 Initiating Clamp and lift function/lower and open function

Initiating Clamp and lift function/lower and open function, description

No extra setting is needed, apart from what is needed for the scale, please refer to *Scale, description page 48* and the automatic clamping function, *Automatic clamping function, description page 54*.

8.5.14.2 Calibrating Clamp and lift function/ lower and open function

Calibrating Clamp and lift function/lower and open function, description, description

No extra setting is needed, apart from what is needed for the scale, please refer to *Scale, description page 48* and the automatic clamping function, *Automatic clamping function, description page 54*.

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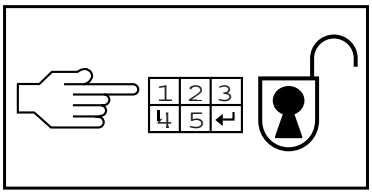
8.5.15 Automatic clamping function

Automatic clamping function, description



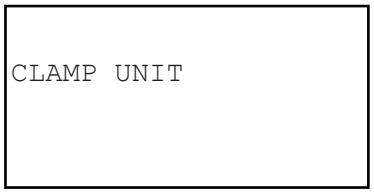
000056

Go to the Setup menus by pressing function key in this menu.



000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.



004239

Select Clamp unit.

(Scroll to the desired menu with function keys and and press to confirm.)

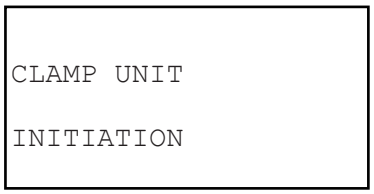
For the Automatic clamping function, it is possible to choose initiation or calibration, see *Initiating Automatic clamping function, description page 54* and *Calibrating Automatic clamping function, description page 55*).

8.5.15.1 Initiating Automatic clamping function

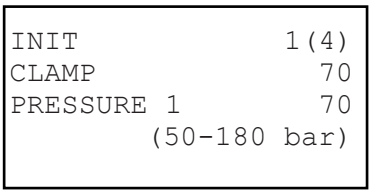
Initiating Automatic clamping function, description

Select Automatic clamping function according to *Automatic clamping function, description page 54*.

Select initiation of Automatic clamping function.

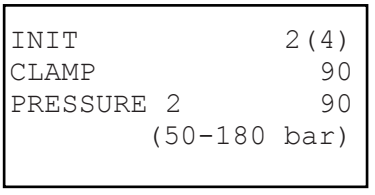


004340



008553

Select the pressure for position 1. Confirm with .

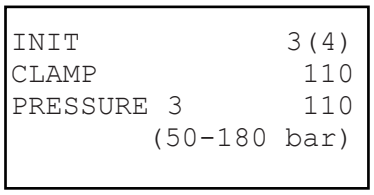


008554

Select the pressure for position 2. Confirm with .

Only displayed if the automatic clamping function with four positions is used.

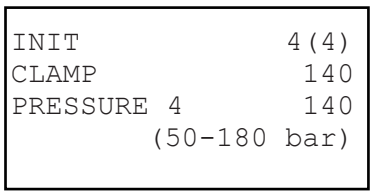
https://truckmanualshub.com/



008555

Select the pressure for position 3. Confirm with ↵.

Only displayed if the automatic clamping function with four positions is used.



008556

Select the pressure for position 4. Confirm with ↵.

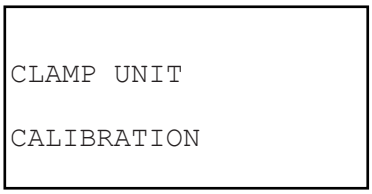
Only displayed if the automatic clamping function with four positions is used.

8.5.15.2 Calibrating Automatic clamping function

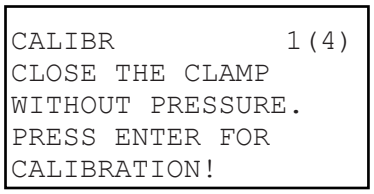
Calibrating Automatic clamping function, description

Select Automatic clamping function according to *Automatic clamping function, description page 54*.

Select calibration of Automatic clamping function.



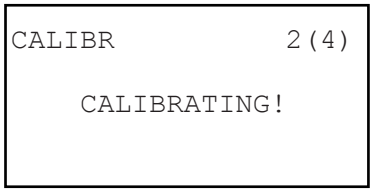
004345



008557

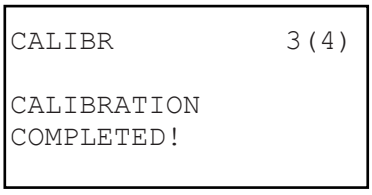
Close the automatic clamping unit completely. Open slightly, so that the clamp is almost in the closed position, but has no pressure. Press ↵ to start the automatic calibration.

It is a good idea to do calibration with a roll. The clamping pressure will rise to 160 bar during calibration, which can damage the roll, so use an already damaged roll.



008558

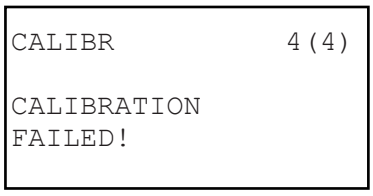
The automatic clamping function is calibrated. The current on the “cartridge” is slowly increased. Current and pressure are registered.



008559

Calibration completed. The values are stored in the ECU memory.

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008560

Calibration failed. The values are not saved.

The reason for this is that the pressure was too high when calibration started (p>40 bar), or that the pressure did not reach 160 bar during calibration.

8.5.16 Protection against loose chain tension

8.5.16.1 Initiating Protection against loose chain tension

Initiating Protection against loose chain tension, description

No extra setting is needed, apart from what is needed for the scale, please refer to *Scale, description page 48*.

8.5.16.2 Calibrating Protection against loose chain tension

Calibrating Protection against loose chain tension, description

No extra setting is needed, apart from what is needed for the scale, please refer to *Calibrating scale, description page 48*.

8.5.17 Protection against inadvertent opening of the clamp

8.5.17.1 Initiating Protection against inadvertent opening of the clamp

Initiating Protection against inadvertent opening of the clamp, description

No extra setting is needed, apart from what is needed for the scale, please refer to *Scale, description page 48*.

8.5.17.2 Calibrating Protection against inadvertent opening of the clamp

Calibrating Protection against inadvertent opening of the clamp, description

No extra setting is needed, apart from what is needed for the scale, please refer to *Calibrating scale, description page 48*.

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8.5.18 Automatic lowering stop

Automatic lowering stop, description

Can only be installed on vehicles equipped with paper handling equipment

The vehicle is equipped with a sensor which “senses” when a roll is lowered past the sensing range of the sensor (K1:41 switches to 24V). Lowering is stopped if the roll is a pre-determined distance from the ground and vehicle speed exceeds 0.5 km/h.

Lowering the last part of the distance is only permitted when the vehicle speed is less than 0.5 km/h (stationary).

8.5.19 Driving interlock

Driving interlock, description

The function prevents driving faster than 3 km/h after the roll/bale has been clamped but not lifted. The roll must first be lifted 100 mm, if lift-height sensor is present, and the scales must indicate at least 10% load before driving is permitted.

The function uses the scales and a distance sensor for lifting height if present.

8.5.20 Speed limitation related to lift height

Speed limitation related to lift height, description

Vehicle speed is limited as follows (may vary depending on customers request):

- Up to 3 m lift height (depending on the vehicle’s lift height), vehicle speed is limited to 20 km/h.
- At maximum lift height, vehicle speed is limited to 5 km/h
- Between 3 m and maximum lift height (depending on the vehicle’s lift height), the maximum speed of the vehicle is limited in proportion to lift height.

8.5.21 Reversible driver’s station

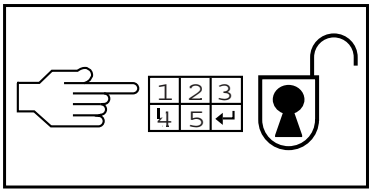
Reversible driver’s station, description



000056

Go to the Setup menus by pressing function key in this menu.

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000060

To access the setup menus, the service code has to be entered (authorization required). Thereafter, the setups can be accessed to perform settings.

```
 SEAT POSITION
```
004225

Select Seat position.

(Scroll to the desired menu with function keys and and press to confirm.)

For Reversible driver's station, it's possible to choose calibration, see *Calibrating Reversible driver's station, description page 58*).

8.5.21.2 Calibrating Reversible driver's station

Calibrating Reversible driver's station, description

Select Reversible driver's station according to *Reversible driver's station, description page 57*.

Select calibration of Reversible driver's station.

```
SEAT POSITION


CALIBRATION
```
004232

```
CALIBR          1(4)
P-BRAKE MUST BE ON!
PRESS ENTER FOR
CALIBRATION!
```
008561

To calibrate the Reversible driver's station, the parking brake must be applied. Press to come further.

```
CALIBR          2(4)
                1104
FWD END         1104
POSITION        (mV)
```
008562

Turn the driver's seat so that it is at the end position, facing straight ahead. Press to confirm/save the position.

```
CALIBR          3(4)
                2464
SHIFT F/R       2464
POSITION        (mV)
```
008563

Turn the driver's seat so that it is in the position that should shift the forward facing driver's seat to a backwards facing driver's seat. This should be within the range of 80-120°. Press to confirm/save the position.

```
CALIBR          4(4)
                3895
REV END         3895
POSITION        (mV)
```
008564

Turn the driver's seat so that it is at the end position, facing straight behind. Press to confirm/save the position.

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8.6 Software

Software, general

The firmware in Kalmar machines is handled by a PC tool called Kalmar Smart Link. This is developed by Kalmar to be able to create the functionality in the machine depending on the customer selected options and to be able to download parameters and firmware into the system in the machine.

8.6.1 Kalmar Smart Link

Kalmar Smart Link, general

Kalmar Smart Link (hereby called KSL) is Kalmars' internally developed software for managing KCS, Kalmar Control System. The program's uses include:

- Downloading basic program to the ECUs' FLASH memory.
- Setting current functions.
- Calibrating current functions. Both basic and fine-tuning calibration.
- Giving clear diagnosis for each function.
- After test or service, load the system's settings for saving centrally at Kalmar.

The program has different authority levels to ensure that no unauthorised person accesses the system and changes the software in a manner undesirable to Kalmar.

Requirements

To use KSL, you need to fulfil following requirements:

Operating system:	Microsoft version NT4.0, NT2000 or XP.
Hardware:	Intel PIII - 700 MHz or better, 64 MB RAM,
	Screen resolution - 1024x768 or higher
	At least 80 MB free on the hard disk
	Serial COM port, RS232 (COM1-COM4)
Other:	Internet connection

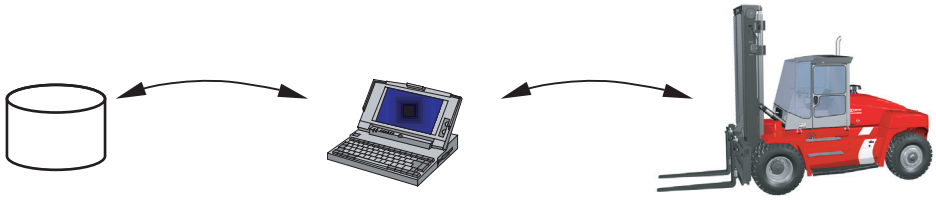
Data transferring

It is very important to understand the principles of data exchange in KSL. Parameters and data can be stored in two ways, see figure.

1. In a database.
2. In the KCS-system in the truck

This means that you can read and write information from both places.

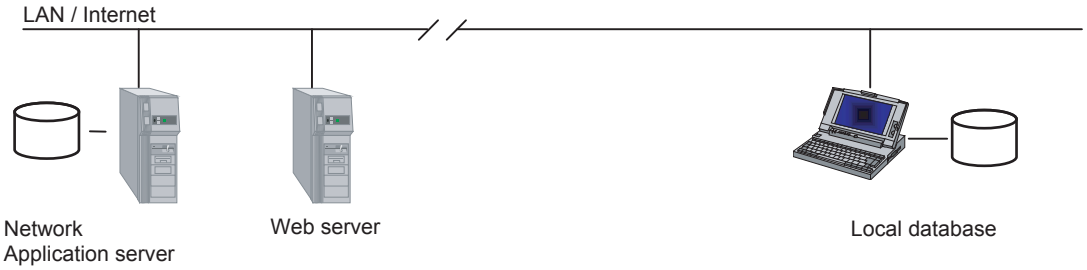
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The database contains a lot of data structured in different tables. Most of the data is encrypted.

Kalmar Smart Link data infrastructure

With KSL it is possible to share data with other users, to do this an application server is used. The application server is connected to the Internet through a web server and handles all data used in the KSL system. To share data with other users you have to use the replication function inside KSL, this function downloads all relevant updates to the local computer and uploads all new data stored in the local computer.



KCS-memory and parameters

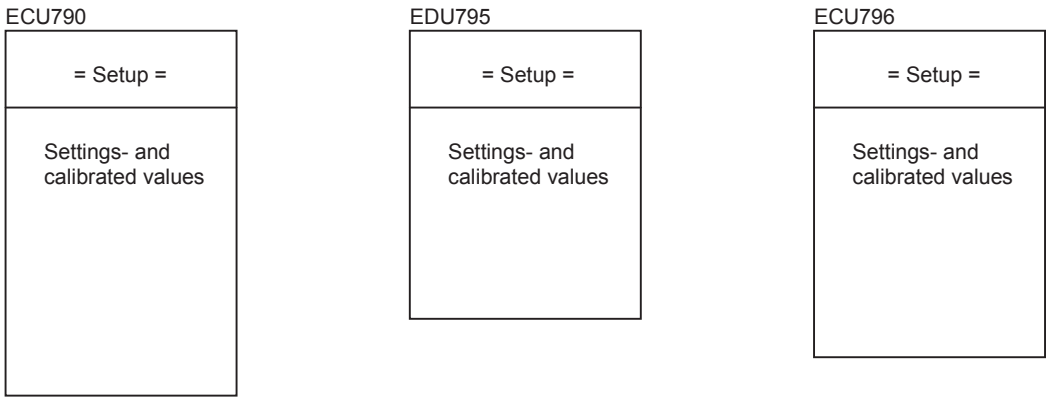
In the KCS-system we have three different kinds of parameters:

1. Setup parameters. These parameters define the configuration of the complete system. This data is identical in all ECUs and can normally not be changed on the field by a service engineer. An example can be which ECUs is present in the system.
2. Settings parameters. These parameters are connected to a special function and are unique for actual ECU. An example can be start- and stop current for valves etc. Normally the service engineers can change these parameters.
3. Calibrated parameters. These parameters are connected to a special function and are unique for actual ECU. An example is the lever positions, lever steering. Normally the service engineers can change these parameters.

See the memory map in figure.

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Memory map KCS-system



How to connect Kalmar Smart Link to the truck.

To connect your computer to the truck use a null-modem cable, Kalmar P/N 923994.0001. Connect one end of the cable to the serial COM-port at the computer and the other end to the 9-pin D-sub connector in the electrical distribution box, located to the left behind the driver's seat in the cab. To be sure that it will work define the right COM-port in the KSL-menu, Config -> Setup COM-port.

How to start the Kalmar Smart Link

To start KSL double-click on the icon on the desktop named Kalmar Smart Link - 2006 or use the Windows start button - Start-> Programs -> Kalmar Smart Link - 2006.

How to find help for Kalmar Smart Link

To find help for Kalmar Smart Link use the Windows start button - Start-> Programs -> Kalmar Smart Link - 2006 -> Help Kalmar Smart Link or visit our web site **www.kalmarind.com/ksl** or simply press the F1-button on the computer keyboard.

How to apply for user account to Kalmar Smart Link

Visit **www.kalmarind.com/ksl** and click on Join the KSL user team, after you have received your user account you can login on Kalmar Smart Link Online and for example find more user instructions, download recent updates etc.

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9 Frame, body, cab and accessories

Frame, body, cab and accessories, general

Component supplier documentation

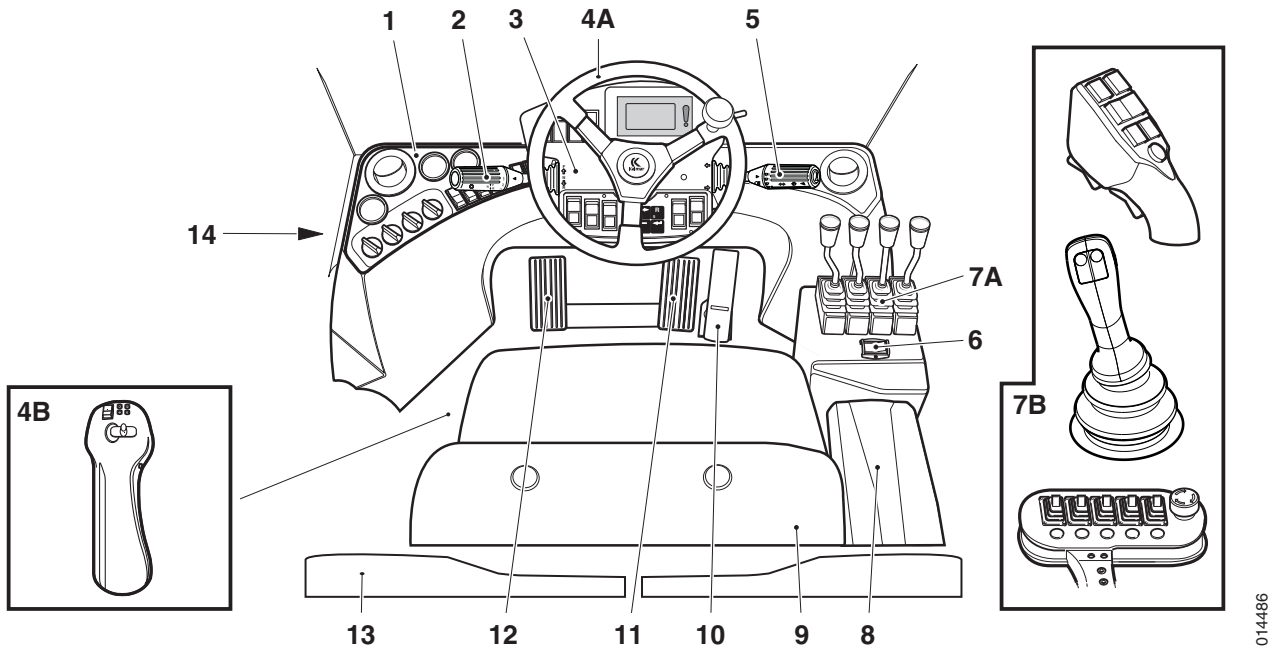
The workshop manual only describes components and job descriptions related to installation in the machine. Please refer to the component supplier documentation for descriptions and instructions of the frame, body, cab and accessories components and systems.

References to component supplier documentation are only provided in exceptional cases. If information about a component is not found, the component supplier documentation should be used.

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9.1 Controls and instruments

Cab overview Spirit Delta



1 Left-hand instrument panel

2 Gear and direction of travel selector

3 Steering wheel panel

4A Steering wheel

4B Joystick or mini-wheel ✚

5 Multi-function lever

6 Parking brake

7A Control for load handling

7B Alternative control for load handling ✚

8 Arm rest

9 Driver’s seat

10 Accelerator pedal

Accelerator with function for selecting travel direction (forward/reverse) ✚

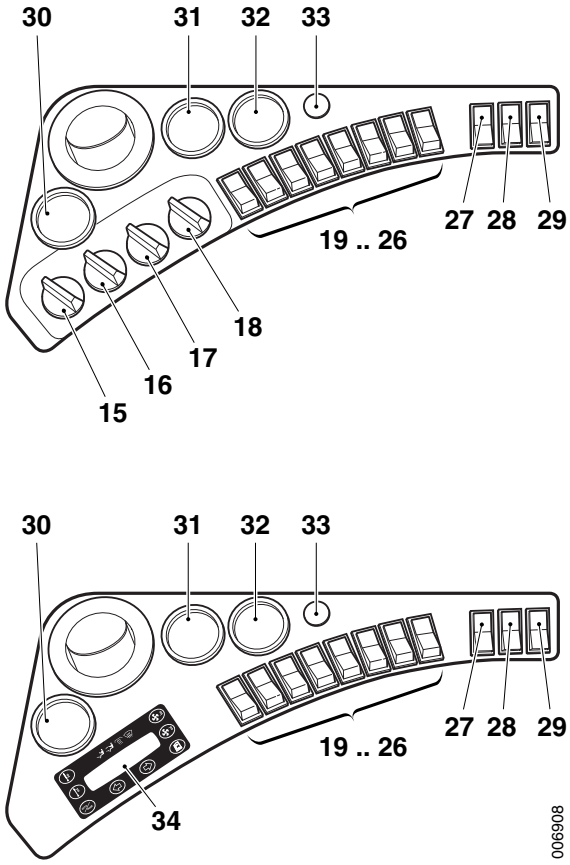
11 Brake pedal

12 Brake pedal

13 Fuse box with fuses and relays

14 Operating time gauge

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Left-hand instrument panel, upper with heater unit and lower with climate control system

Left-hand instrument panel

15 Control for heating

16 Controls for fan

17 Controls for defroster/cab

18 Controls for cooling AC ⊕

19 Switch for recirculation/fresh air ⊕
(Only for heater unit with cooling AC)

20 Switch for cooling AC ⊕

Switch for extra working lamps ⊕

21 Switch for working lamps on mast

22 Switch for extra working lamps ⊕

23 Switch for extra working lamps ⊕

24 Switch for rotating warning lamp ⊕

25 Switch for warning lamp

26 Switch for headlamps

27 Switch for seat heating ⊕
(May appear in driver's seat)

28 Switch for central lubrication ⊕

29 Switch for pause heater ⊕

30 Spare

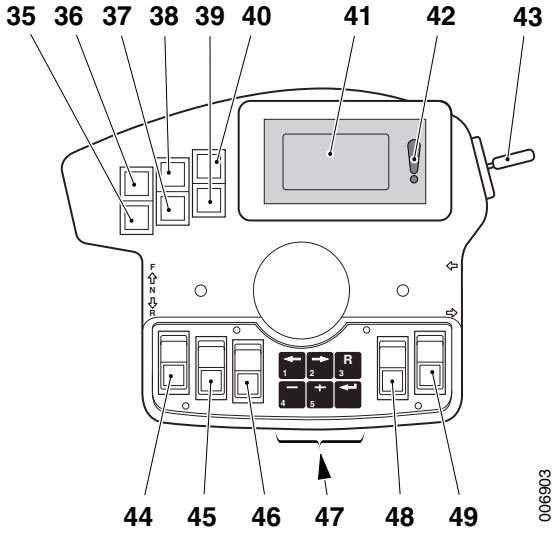
31 Spare

32 Spare

33 Socket for 12/24V ⊕

34 Climate control system ECC ⊕

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Steering wheel panel

Steering wheel panel

35 Warning lamp for exhaust cleaning (particle filter) ✚

36 Warning lamp for air filter replacement ✚

37 Indicator lamp for vertical hold ✚

38 Warning lamp for low battery charging

39 Indicator lamp for main beam

40 Indicator lamp for direction indicators

41 Display control system, KCS

42 Alarm indicator for control system, KCS

43 Ignition switch

44 Switch for reversible driver's seat ✚

45 Switch for engagement and disengagement of alternative direction of travel selector ✚

Switch for engagement/disengagement of alternative gear selector ✚

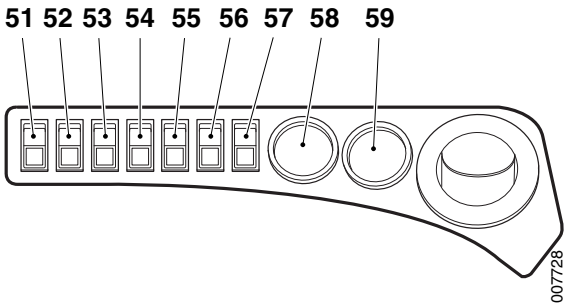
46 Switch for inching ✚

47 Function keys for control system, KCS

48 Switch for windscreen wiper, rear

49 Switch for windscreen wiper, roof

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Right-hand instrument panel

Right-hand instrument panel

51 Switch for switching off reversing alarm ⊕

52 Switch for raising/lowering driver's seat ⊕

53 Switch for extra working lamps ⊕

54 Switch for electrically heated rear-view mirrors ⊕

55 Spare

56 Spare

57 Spare

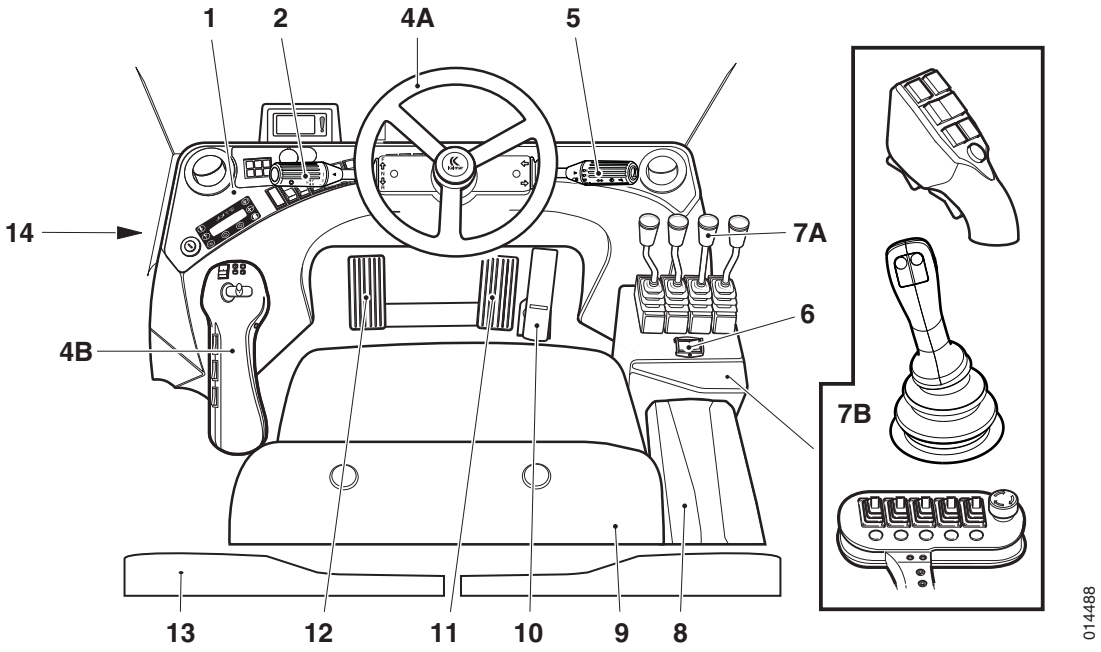
58 Spare

59 Spare

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Cab overview Spirit Delta

(+) (applies to cab with moved KCS display).



1 Left-hand instrument panel

2 Gear and direction of travel selector

3 Not used

4A Steering wheel

4B Joystick or mini-wheel (+)

5 Multi-function lever

6 Parking brake

7A Control for load handling

7B Alternative control for load handling (+)

8 Arm rest

9 Driver's seat

10 Accelerator pedal

Accelerator with function for selecting travel direction (forward/reverse) (+)

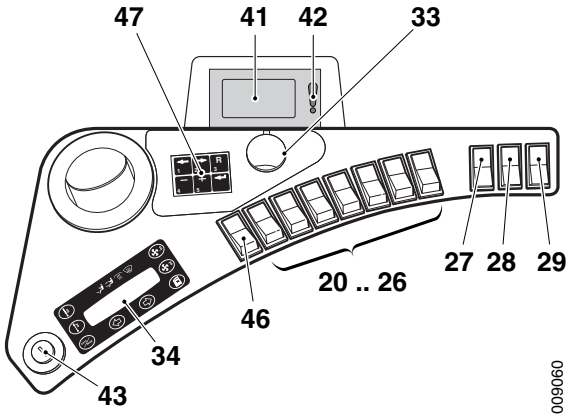
11 Brake pedal

12 Brake pedal

13 Distribution box with fuses and relays

14 Operating time gauge

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Left-hand instrument panel

Left-hand instrument panel

A buzzer is built in under the left-hand dashboard panel (not visible). It is activated if:

- starting attempts are made with a gear engaged and parking brake not activated
- the parking brake is not activated when the operator leaves the driver's seat
- the machine has low coolant level, low brake pressure or a parking brake fault
- an error code is generated, at which point a short sound signal is emitted

20 Switch for extra working lamps ⊕

21 Switch for working lamps on mast

22 Switch for extra working lamps ⊕

23 Switch for extra working lamps ⊕

24 Switch for rotating warning lamp ⊕

25 Switch for warning lamp

26 Switch for headlamps

27 Switch for seat heating ⊕
(May appear in driver's seat)

28 Switch for central lubrication ⊕

29 Switch for pause heater ⊕

33 Socket for 12/24V ⊕

34 Climate control system ECC ⊕.

41 Display control system, KCS

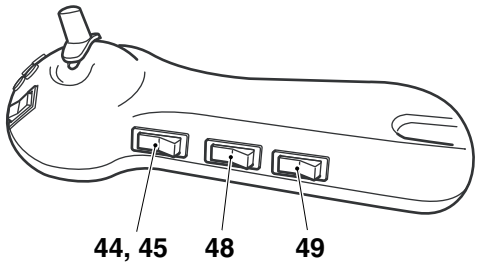
42 Alarm indicator for control system, KCS

43 Ignition switch

46 Switch for inching ⊕

47 Function keys for control system, KCS

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Arm rest

Arm rest

44 Switch for reversible driver's seat ✚

45 Switch for engagement and disengagement of alternative direction of travel selector ✚

Switch for engagement/disengagement of alternative gear selector ✚

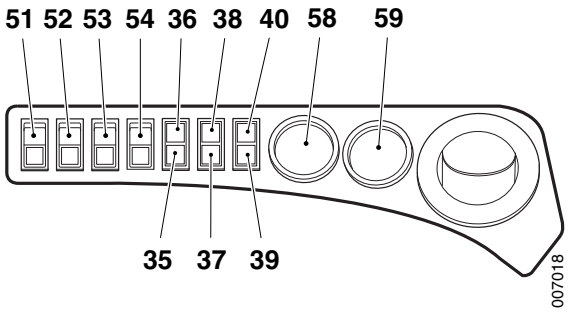
48 Switch for windscreen wiper, rear

49 Switch for windscreen wiper, roof

Right-hand dashboard panel

A buzzer is built in under the left-hand dashboard panel (not visible). It is activated if:

- starting attempts are made with a gear engaged and parking brake not activated
- the parking brake is not activated when the operator leaves the driver's seat
- the machine has low coolant level, low brake pressure or a parking brake fault
- an error code is generated, at which point a short sound signal is emitted



Right hand instrument panel

35 Warning lamp for exhaust cleaning (particle filter) ✚

36 Warning lamp for air filter replacement ✚

37 Indicator lamp for vertical hold ✚

38 Warning lamp for low battery charging

39 Indicator lamp for main beam

40 Indicator lamp for direction indicators

51 Switch for switching off reversing alarm ✚

52 Switch for raising/lowering driver's seat ✚

53 Switch for extra working lamps ✚

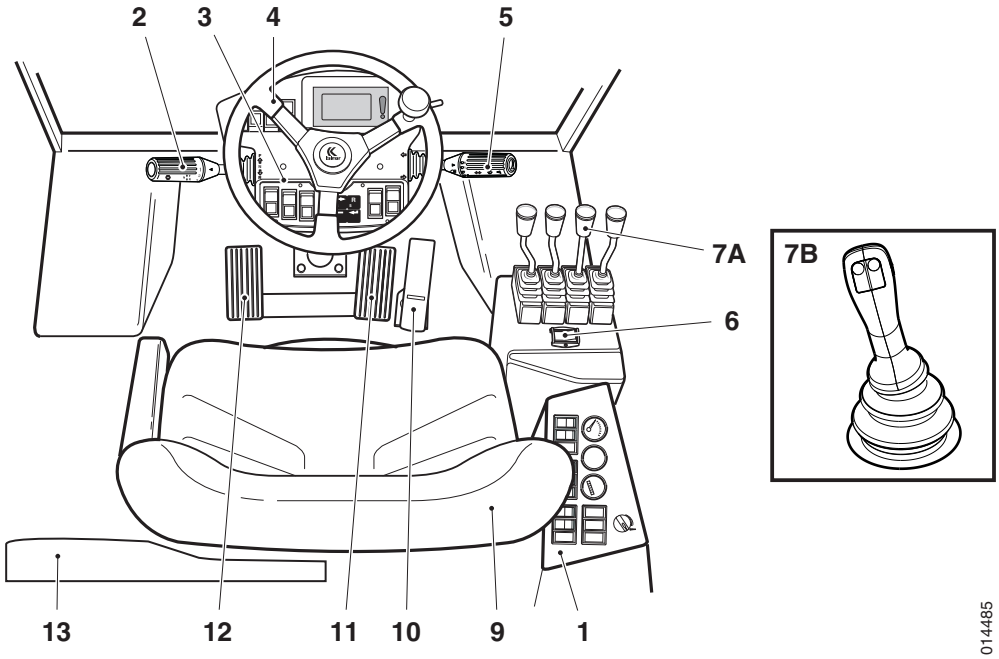
54 Switch for electrically heated rear-view mirrors ✚

58 Spare

59 Spare

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Cab overview FlexGuard and FlexCab



1 Instrument panel

2 Gear and direction of travel selector

3 Steering wheel panel

4 Steering wheel

5 Multi-function lever

6 Parking brake

7A Control for load handling

7B Alternative control for load handling ⊕

9 Operator’s seat

10 Accelerator pedal

Accelerator with function for selecting travel direction (forward/reverse) ⊕

11 Brake pedal

12 Brake pedal

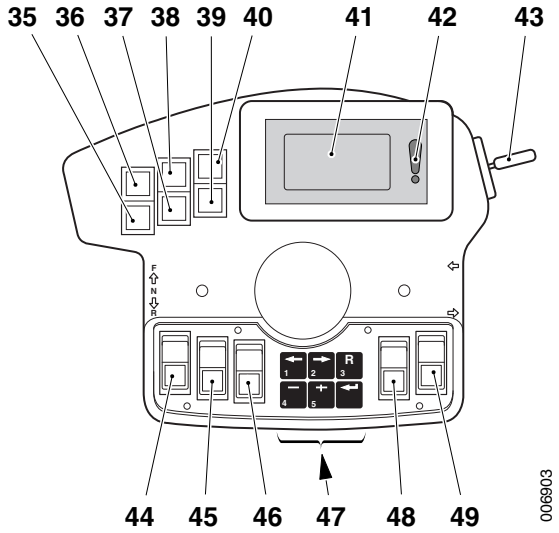
13 Distribution box with fuses and relays

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Steering wheel

A buzzer is built in under the steering wheel panel (not visible). It is activated if:

- starting attempts are made with a gear engaged and parking brake not activated
- the parking brake is not activated when the operator leaves the driver's seat
- the machine has low coolant level, low brake pressure or a parking brake fault
- an error code is generated, at which point a short sound signal is emitted



Steering wheel panel

35 Spare

36 Spare

37 Indicator lamp for vertical hold ⊕

38 Warning lamp for low battery charging

39 Indicator lamp for main beam

40 Indicator lamp for direction indicators

41 Display control system, KCS

42 Alarm indicator for control system, KCS

43 Ignition switch

44 Spare

45 Switch for engagement and disengagement of alternative direction of travel selector ⊕

Switch for engagement/disengagement of alternative gear selector ⊕

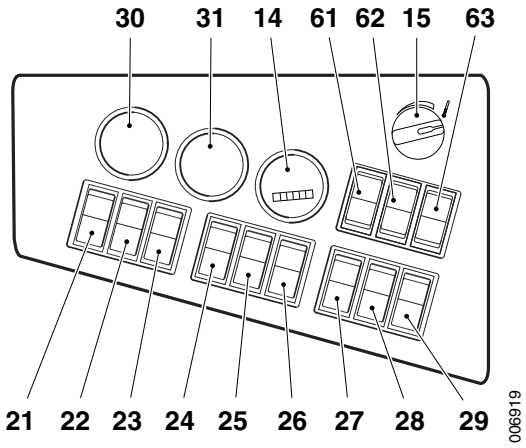
46 Switch for inching ⊕

47 Function keys for control system, KCS

48 Switch for windscreen wiper, rear ⊕

49 Switch for windscreen wiper, roof ⊕

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Instrument panel

Dashboard panel

14 Operating time gauge

15 Controls for heating ✚

21 Switch for working lamps on mast

22 Switch for extra working lamps ✚

23 Switch for extra working lamps ✚

24 Switch for rotating warning lamp ✚

25 Switch for warning lamp

26 Switch for headlamps

27 Switch for seat heating ✚
(May appear in driver's seat)

28 Switch for central lubrication ✚

29 Spare

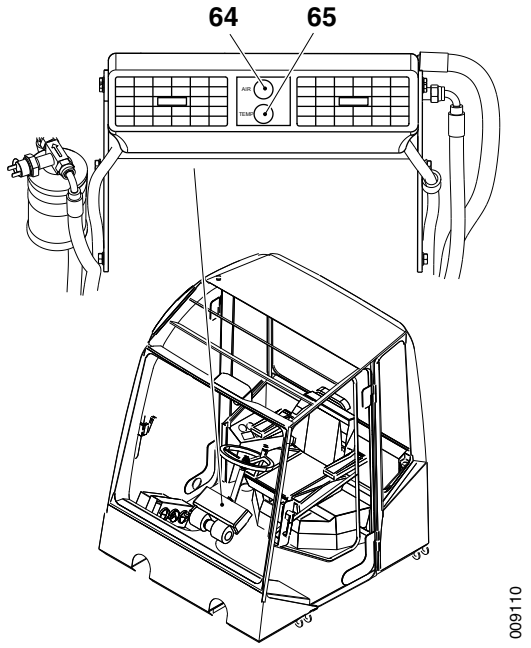
30 Spare

31 Spare

61 Spare

62 Spare

63 Switch for fan ✚



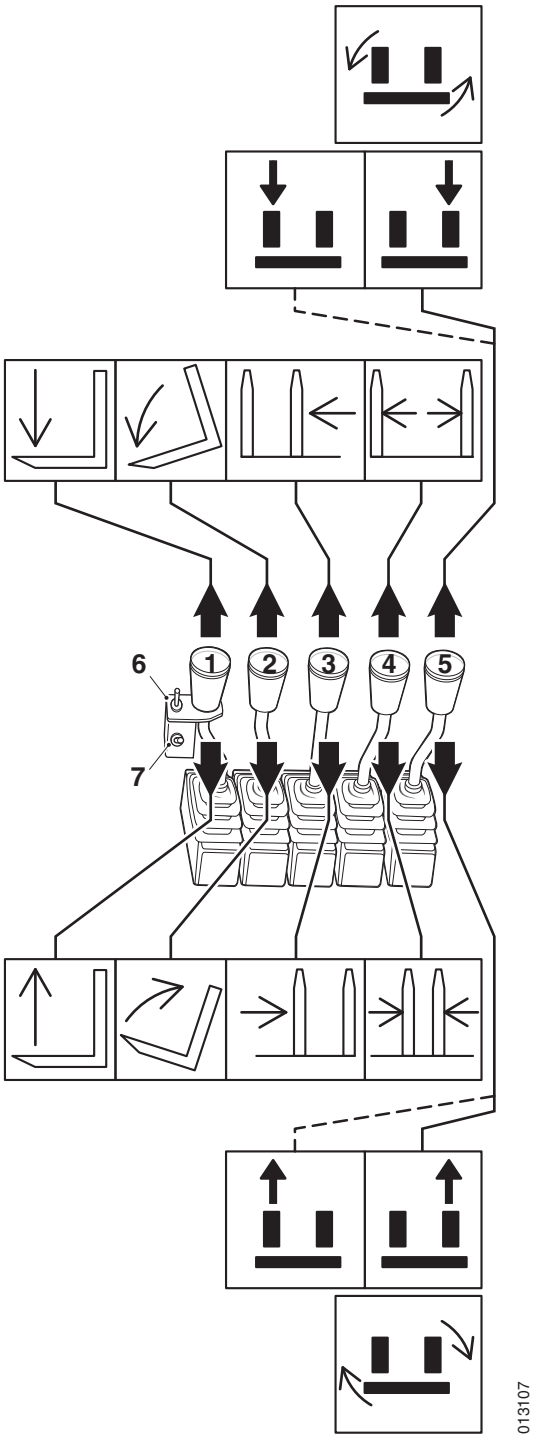
Cooling unit in the cab

Controls for air conditioning

64 Controls for fan ✚

65 Controls for cooling ✚

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Control for load handling

Control with up to 5 levers

1. Lift / lower

   LIFT – pull the lever backwards.

   LOWER – push the lever forwards.

   The lowering speed can be varied only with the lever angle – the engine speed has no influence.

2. Tilt

   BACK – pull the lever backwards.

   FORWARD – push the lever forwards.

3. Side shift

   LEFT – push the lever forwards.

   RIGHT – pull the lever backwards.

   The forks cannot be side-shifted if fork spreading is at maximum.

4. Spreading (positioning)

   OUT – move the lever forwards.

   IN – pull lever backwards.

   Spreading locks when one of the forks reaches its end position. Side shift to the centre and spread again.

   Spreading sidelift attachment ⊕

   INCREASE SPREADING – move the lever forward.

   DECREASE SPREADING – pull the lever backwards.

5. Levelling ⊕

   FORK UP – pull the lever backwards.

   FORK DOWN – move the lever forwards.

   Levelling acts on the right or left fork.

   Central levelling ⊕

   CENTRAL LEVELLING ANTICLOCKWISE– push the lever forwards.

   CENTRAL LEVELLING CLOCKWISE– pull the lever backwards.

   Locking/releasing twistlocks for sidelift attachments ⊕.

   RELEASE TWISTLOCKS – push the lever forwards.

   LOCK TWISTLOCKS – pull the lever backwards.

6. Selecting direction of travel ⊕

   Travel direction FORWARD – set switch forward.

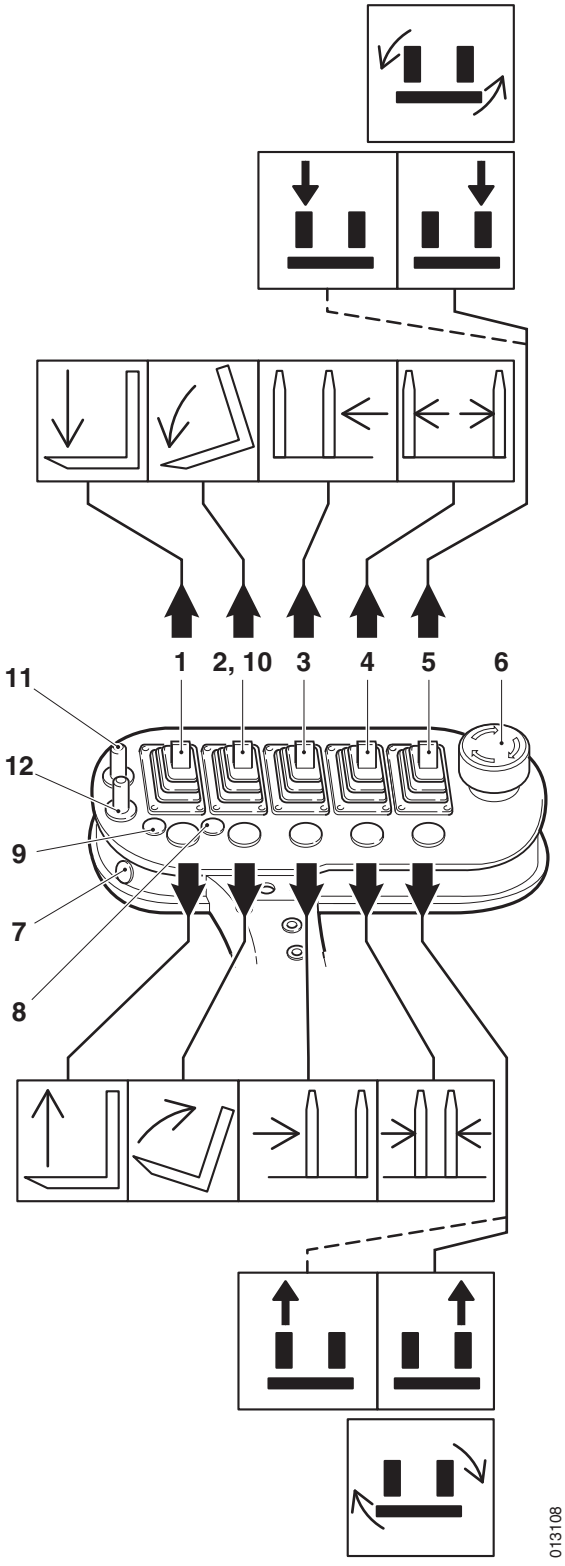
   Travel direction NEUTRAL – set switch in middle.

   Travel direction REVERSE – set switch backward.

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7. Selecting gear ⊕
   GEAR 1 – set the switch down.
   GEAR 2 – set the switch in the centre.
   GEAR 3 – set the switch up.

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Electric servo with up to 5 levers

⊕

Electric servo uses fingertip-controlled linear levers.

1. Lift / lower

   LIFT – pull the lever backwards.

   LOWER – push the lever forwards.

   The lowering speed can only be varied with the lever deflection – the engine speed has no influence.

2. Tilt

   BACK – pull the lever backwards.

   FORWARD – pull the lever FORWARDS.

   Function for tilt control is deactivated in the event of lever movement.

3. Side shift

   LEFT – pull the lever forwards.

   RIGHT – pull the lever backwards.

   The forks cannot be side-shifted if fork spreading is at maximum.

4. Spreading (positioning)

   OUT – move the lever forwards.

   IN – pull lever backwards.

   Spreading locks when one of the forks reaches its end position. Side shift to the centre – spread again.

5. Levelling ⊕

   FORK UP – pull the lever backwards.

   FORK DOWN – move the lever forwards.

   Fork levelling acts on the right or left fork.

   Central levelling ⊕

   CENTRAL LEVELLING ANTICLOCKWISE– push the lever forwards.

   CENTRAL LEVELLING CLOCKWISE– pull the lever backwards.

6. Breaker switch for load handling (servo circuits)
7. Switch for lifting height preset (off/on) ⊕
8. Selecting lifting height preset, decrease ⊕
9. Selecting lifting height preset, increase ⊕
10. Switch for vertical holding (off/on) ⊕
11. Selecting direction of travel ⊕

    Travel direction FORWARD – set switch forward.

    Travel direction NEUTRAL – set switch in middle.

    Travel direction REVERSE – set switch backward.

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12. Selecting gear ⊕

    GEAR 1 – set the switch backward.

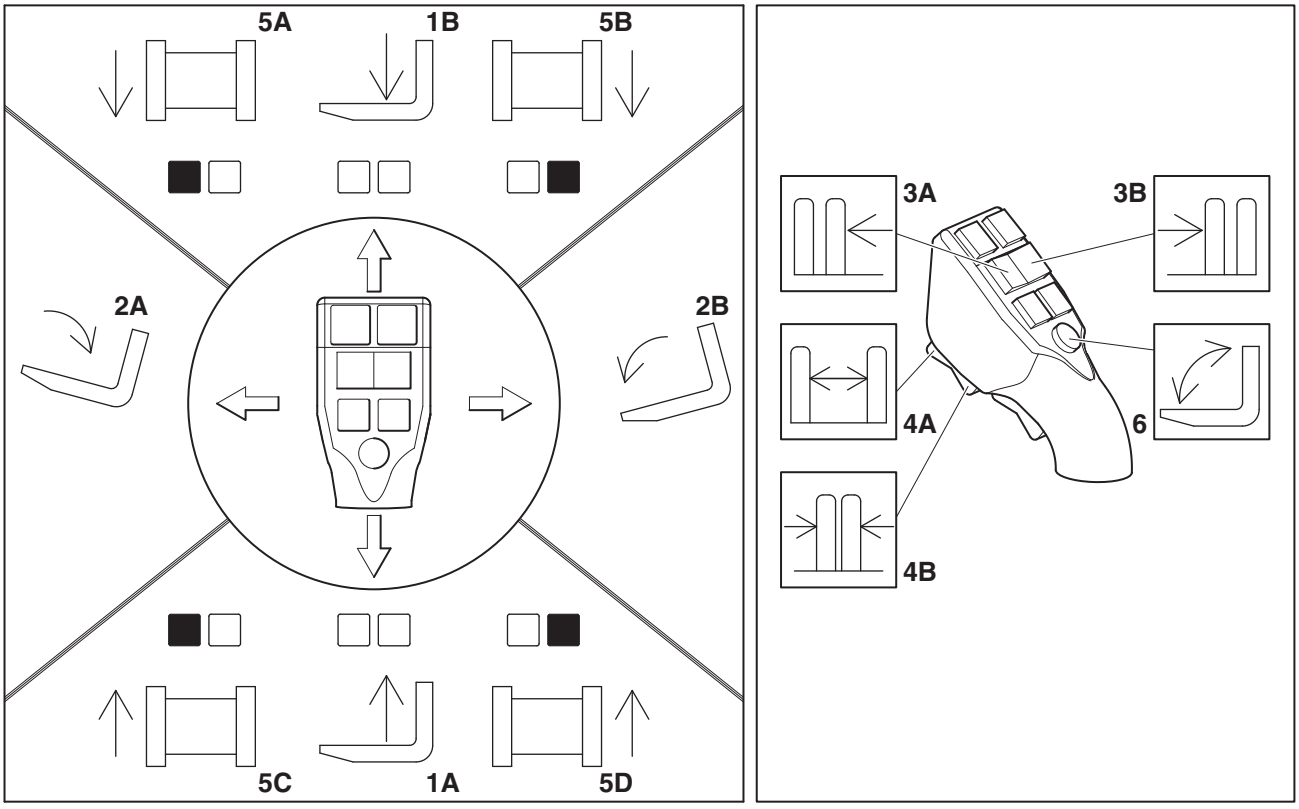
    GEAR 2 – set the switch in the centre.

    GEAR 3 – set the switch forward.

Electric servo with control lever

⊕

The control lever controls functions when handling forks and side lift attachment. Its function pattern is need-adapted and may thus differ from this section. See plates on machine.



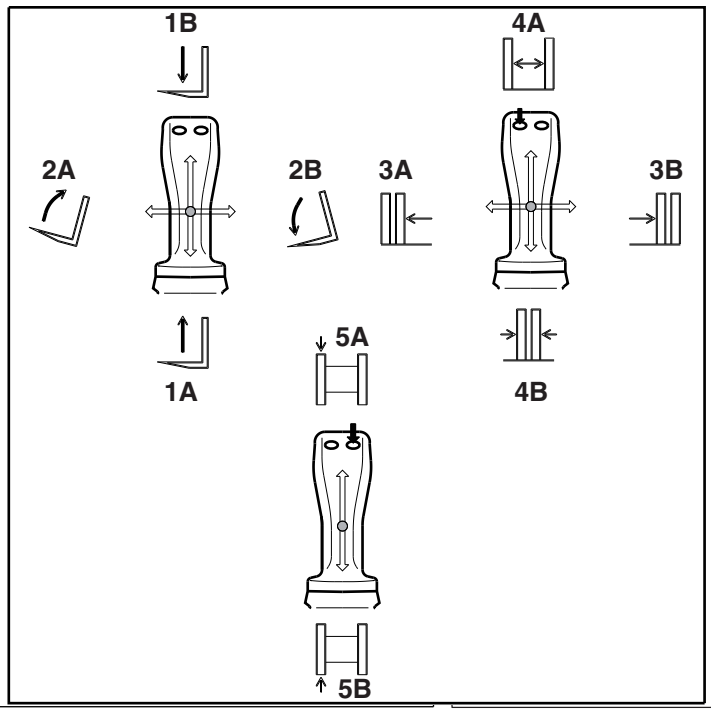
1A. Lift
1B. Lower
2A. Tilt backwards
2B. Tilt forwards
3A. Side shift, left
3B. Side shift, right
4A. Spreading, increase
4B. Spreading, decrease
5A. Levelling, left, down
5B. Levelling, right, down
5C. Levelling, left, up
5D. Levelling, right, up

6. Switch for vertical hold (off/on) ⊕

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Control lever

The control lever controls functions when handling the forks and sidelift attachments. Its function diagram is need-adapted and may therefore differ from this section. See the plates on the machine.



1A. Lift

1B. Lower

2A. Tilt backwards

2B. Tilt forwards

3A. Side shift, left

3B. Side shift, right

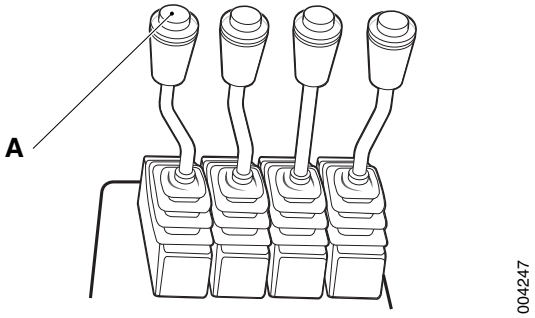
4A. Spreading increase

4B. Spreading decrease

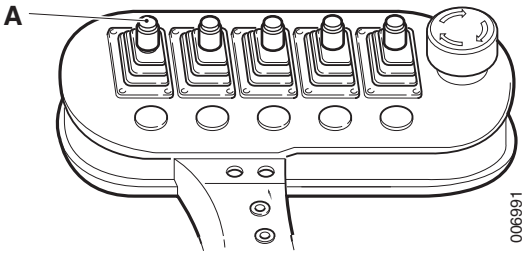
5A. Levelling, fork down

5B. Levelling, fork up

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Hydraulic servo controls



Electric servo controls

Buttons for optional functions

Buttons for optional functions are found on the control lever (position A), as needed. Function and number of buttons are need-adapted.

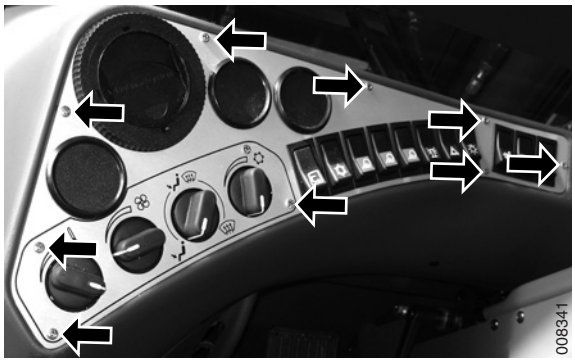
https://truckmanualshub.com/

Switch, replacement

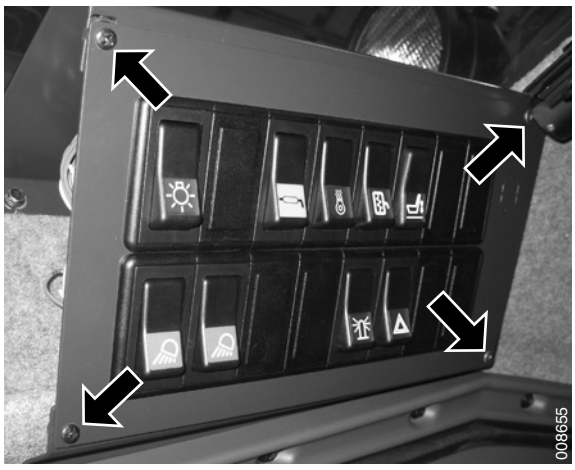
1 Machine in service position, see section *B Safety*.



Flex Guard and Flex Cab



Spirit Delta



Spirit Delta Space

2 Remove the screws securing the instrument panel and lift up the panel.

3 Disconnect the pin terminal from the switch and any bulb socket.

4 Remove the bulb socket using a pliers.

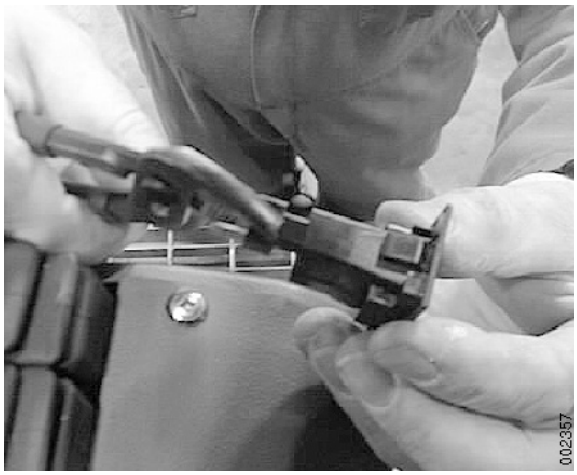
5 Replace the switch.

6 Fit in the reverse order.

Indicator lamp, replacement

1. Machine in service position, see section *B Safety*.
2. Remove the screws securing the instrument panel and lift up the panel.
3. Disconnect the bulb socket pin terminal.

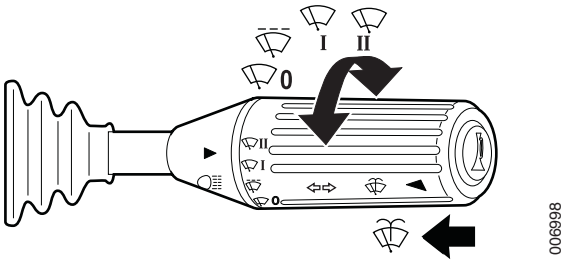
https://truckmanualshub.com/



4. Open the bulb holder using a pliers.
5. Replace the bulb.
6. Fit in reverse order.

9.1.1 Multi-function lever

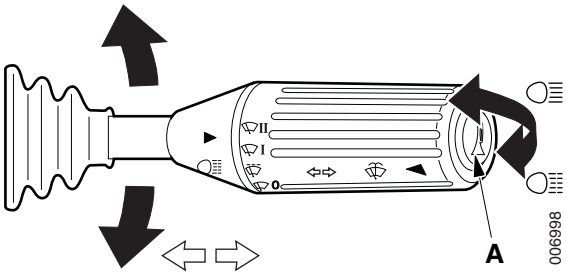
Windscreen wiper and washer



The windscreen wipers and washer are controlled by the multi-function lever (position 5). Turn the control to the following positions:

- 0 - No wiper action
- J - Intermittent wiper
- I – Continuous wiper action
- II – Continuous wiper action
- Push the control towards the steering wheel to wash windscreen, roof window and rear window.

Light control, horn and direction indicators



Headlamps and horn are controlled with the multi-function lever (position 5).

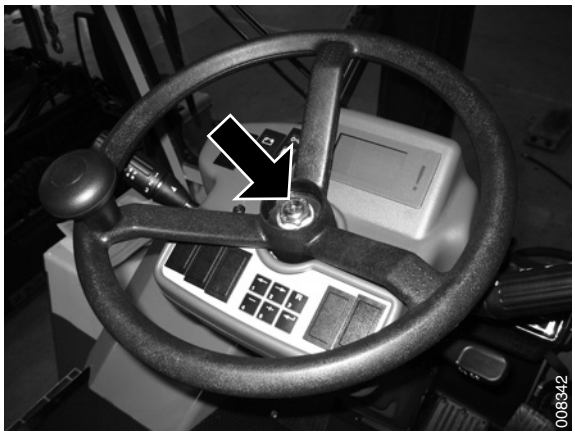
- With headlamps on: Multi-function lever is used to switch between main and low beams. Move the control towards yourself to switch between main and low beams.
- With headlamps off: Multi-function lever is used to flash with the headlamps (high beams). Move the control away from yourself for main beam flash, return is automatic.
- Press the button (position A) for horn.
- Move the lever rearward or forward for the left and right-hand direction indicator.

Multi-function lever, replacement

1 Machine in service position, see section *B Safety*.

2 There are two different types of steering wheel/steering wheel columns and two different methods of removing the steering wheel which are described below.

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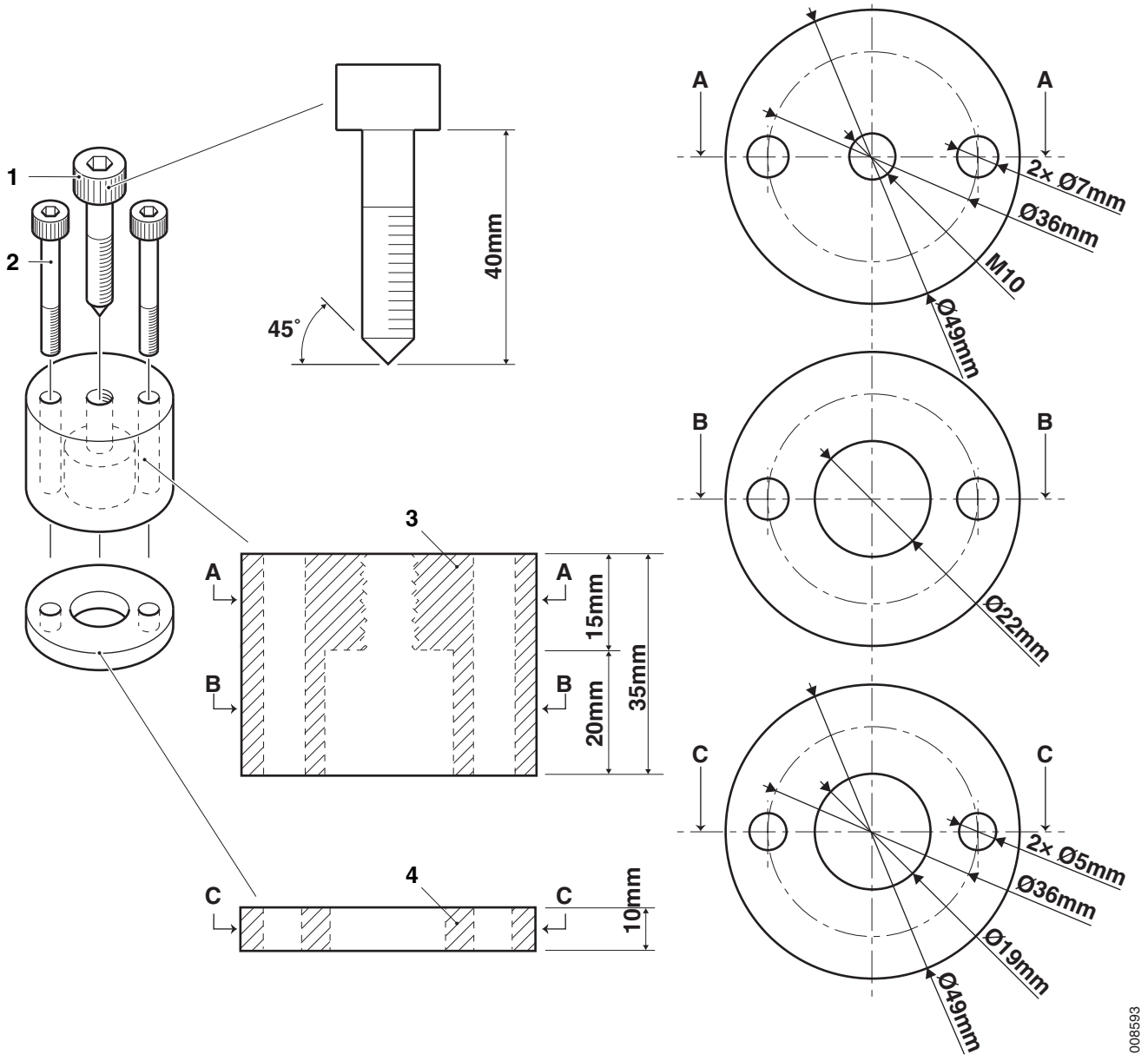


a) Early model, up to march 2007:

Remove the centre cover from the steering wheel and unscrew the nut securing the steering wheel. Remove the steering wheel. (If the steering wheel is firmly fixed to the steering column, tap carefully with a mandrel the same diameter as the steering column, and lift the steering wheel at the same time.) If this does not loosen the steering wheel:

a) Fabricate a withdrawing tool for the steering wheel according to the drawing, and use the withdrawing tool to loosen the steering wheel.

1. 1 pc. socket head cap screw M10×40 (with point).
2. 2 pc. socket head cap screw M6 × 45.
3. Withdrawing tool (body)
4. Template for tapped hole in the steering wheel hub.



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Drawing for fabrication of withdrawing tool for the steering wheel.



b) Use the washer (position 4) as a template for drilling two holes in the steering wheel hub. Remove the washer (position 4) and cut M6 threads in the holes.



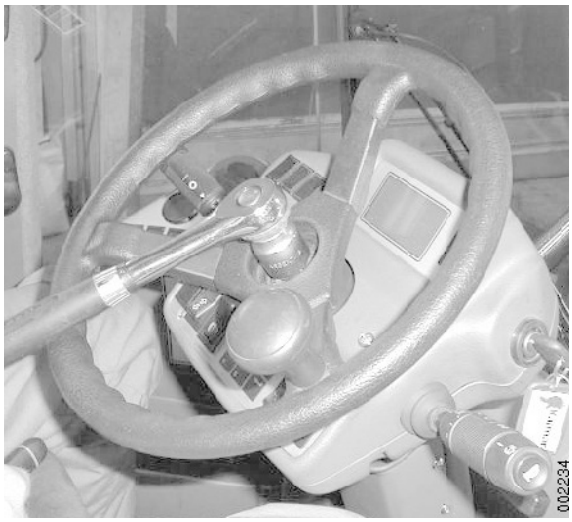
c) Place the withdrawing tool (position 3) over the steering wheel hub and fix the withdrawing tool to the steering wheel hub with the two screws (position 2).



d) Screw the centre screw (position 1) into the withdrawing tool (position 3) and tighten it until the steering wheel comes loose from the steering wheel column.

e) Remove the steering wheel.

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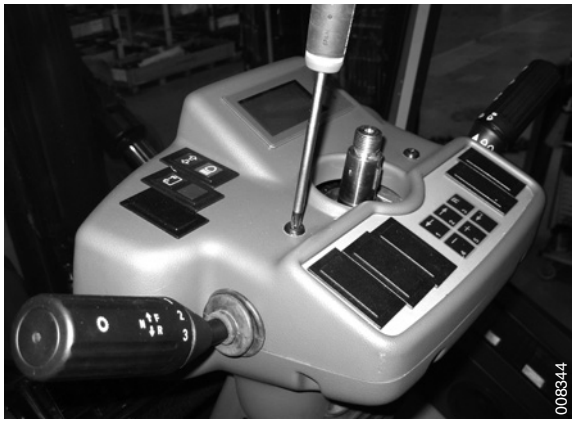


b) Late model, from March 2007:

Remove the centre cover from the steering wheel and unscrew the nut securing the steering wheel. Remove the steering wheel. (If the steering wheel is firmly fixed to the steering column, tap carefully with a mandrel the same diameter as the steering column, and lift the steering wheel at the same time.)



3 Remove the lower steering panel cover (six screws).



4 Remove the upper steering panel cover (two screws).

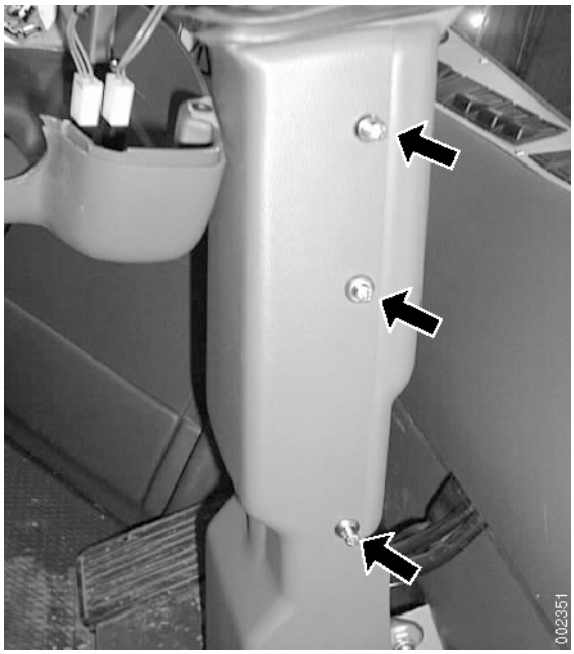
NOTE

Open cabs (FlexGuard) is equipped with an extra upper steering panel cover for improved weather protection.

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5 Remove the Allen screws securing the both levers.



6 Remove the covers from the steering column (seven screws).

7 Thread the lever through the lower cover.



8 Remove the nine clips holding the instrument panel. Pressing in the centre pin on the clip (about 3 mm) unlocks the clip.

NOTE

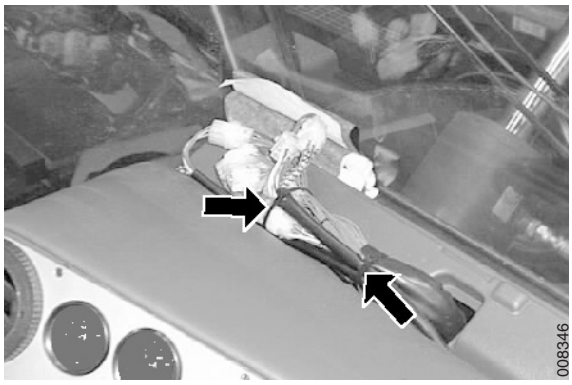
Reuse the clips by re-inserting the centre pin and pressing this flush with the head on fitting.

9 Raise the instrument panel slightly.

NOTE

This only applies to cab Spirit Delta.

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10 Cut the cable ties securing the cable harness.

11 Unplug the connector for the multi-function lever in question.

12 Withdraw the cables and multi-function lever.

13 Replace the multi-function lever.

14 Fit in the reverse order.

NOTE

*Torque the socket cap screws that hold the multi-function lever to the steering column to **2.5-3.0 Nm.***

*Torque the nut in the centre of the steering wheel to **40 Nm (±5 Nm).***

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9.2 Safety and emergency equipment

Safety and emergency equipment, description

Safety components for protecting the driver.

The driver's cab contains equipment designed to fulfil safety requirements imposed by authorities, customers, drivers and Kalmar Industries.

9.2.1 Control switch

Control switch, description

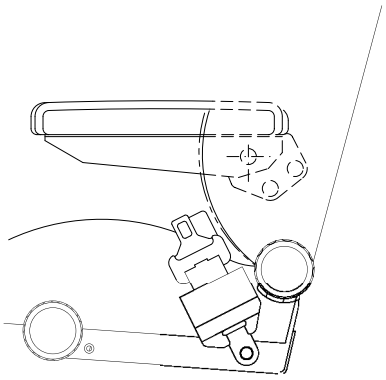
Only with electrically controlled control lever, electrical servo.

See section *7 Load handling*, group *7.1.1 Control levers load handling*.

9.2.2 Seat belt

Seat belt, description

Single-point type belt. Mounted in the seat.



000765

9.2.3 Fire extinguisher

Fire extinguisher, description



008339

There are user instructions on the fire extinguisher.

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9.2.4 Seat buzzer

Seat buzzer, description

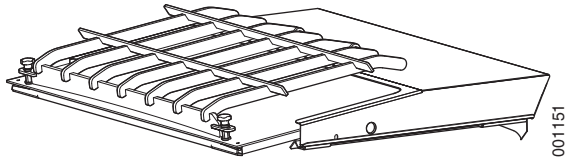
The seat buzzer is located on the underside of the operator's seat and its seat cushion. The buzzer sounds if the parking brake is not applied when:

- the engine is switched off and the operator's seat is not occupied.
- the ignition switch is in operating position and the operator's seat is not occupied.

(A buzzer sound also indicates that the parking brake pressure is too low.)

9.2.5 Roof grating

Roof grating, description



⊕

The roof grating protects the operator from falling objects. This constitutes protection that goes beyond the legal requirements.

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9.3 Seat

Seat, general

This section describes the operator's seat. The following alternative seats are available:

- Operator's seat Grammer MSG 20. Available with:
  - mechanical adjustment
  - adjustable angle
  - seat belt
- Operator's seat Isringhausen 6000. Available with:
  - mechanical adjustment
  - seat belt, 2-point
  - head restraint ⊕
  - adjustable armrest, right
  - adjustable armrest, left ⊕
- Driver's seat Grammer Maximo XXL. ⊕
  The seat is equipped with:
  - air suspension (height)
  - air-adjusted lower back (lumbar) support
  - mechanically adjustable seat angle
  - mechanically adjustable seat length
  - mechanically adjustable damping
  - integrated horizontal suspension
  - seat belt, 2-point
  - adjustable armrest, right
  - seat heating
  - integrated compressor
- Operator's seat Be-Ge. Available with:
  - mechanical adjustment
  - air suspension ⊕
  - integrated horizontal suspension (can be switched off) ⊕
  - rotatable 40° ⊕
  - rotatable right and left for easier cab exiting ⊕
  - hydraulically rotatable 180° ⊕
  - mechanically adjustable lumbar support
  - seat belt, 2-point
  - seat belt, 3-point ⊕
  - head restraint ⊕

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- adjustable armrest, right
- adjustable armrest, left ✚
- seat heater ✚
- ventilated seat and backrest cushions (air-vent). Also equipped with an external compressor ✚

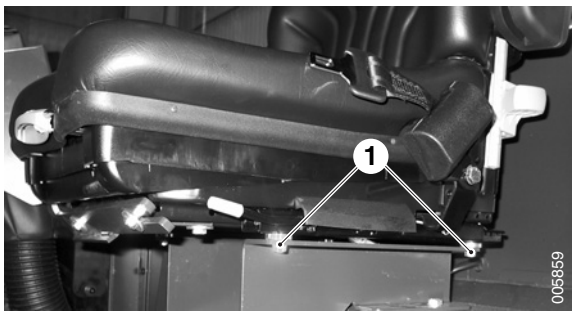
- Operator's seat Isringhausen 6500. Available with:
  - air suspension
  - air adjustable lumbar support
  - seat belt, 2-point
  - seat belt, 3-point ✚
  - head restraint ✚
  - adjustable armrest, right
  - adjustable armrest, left ✚
  - seat heater
  - integrated compressor
- Operator's seat Grammer Actimo XXL. Available with mechanical adjustment.
  - air suspension
  - air adjustable lumbar support
  - seat belt, 2-point
  - head restraint ✚
  - adjustable armrest, right
  - adjustable armrest, left ✚
  - seat heater
  - integrated compressor

NOTE

A different driver's seat version may be installed.

Seat Grammer MSG20, replacement

1. Machine in service position, see section *B Safety*.
2. Remove the four screws that hold the seat in place.
3. Unplug the electrical connections.
4. Remove the drivers seat.
5. Fit in reverse order. See also *Wiring to seat, installing page 33*.



1. Screws and washers

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Grammer Maximo XXL, Actimo XXL and Be-Ge seats, replacement

1. Machine in service position, see section *B Safety*.
2. Slide the seat fully backwards, remove the two front screws that hold the seat in place.





3. Slide the seat fully forwards, remove the two rear screws that hold the seat in place.
4. Undo the necessary connectors for the cables.
5. Remove the seat.
6. Fit in reverse order. See also *Wiring to seat, installing page 33*.

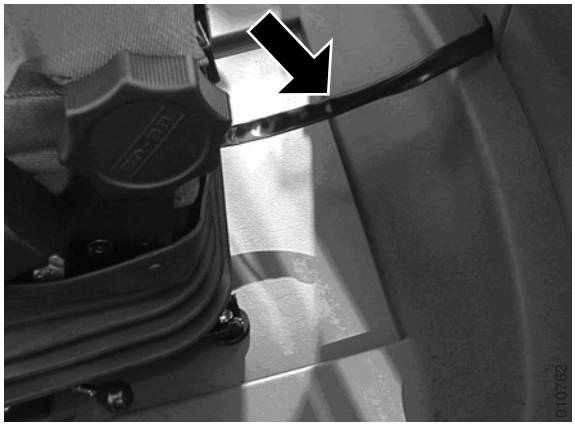
Wiring to seat, installing

NOTE

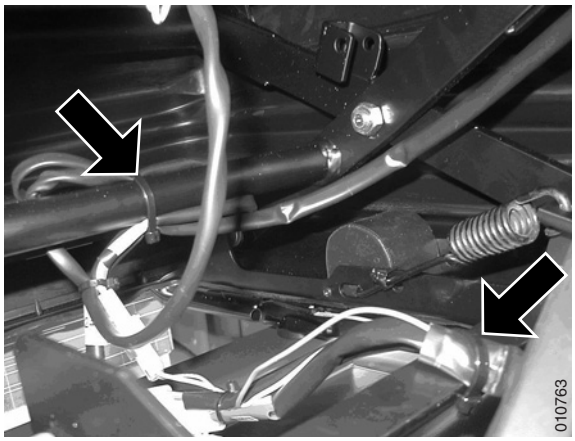
The description below shows attachment of wiring at the BE-GE driver's seat. Wiring for other seat options is attached according to the same principle, but some details may be different.

Seat without seat column

1. Machine in service position, see section *B Safety*.
2. Check that the wiring has sufficient slack when the seat is in the forward position. If the wiring is too slack, it can end up between the rails when the seat is slid back.
3. Position the seat in the max. upward position.



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4. Strap the wiring in place in the seat cross-bar, with the wiring forming a sufficient slack arch across the cross-bar.

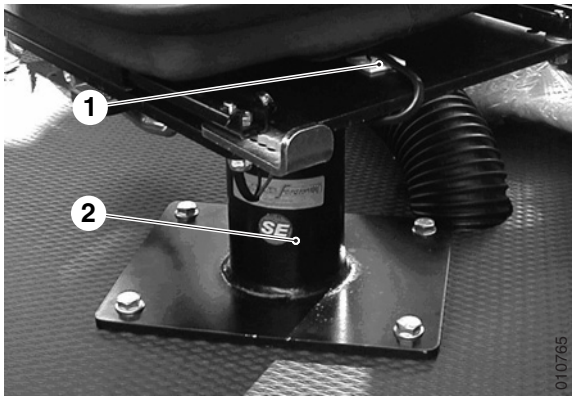
NOTE

Check that the wiring is not pinched between the rails when seat height or length is adjusted.

5. Strap the wiring in the rear edge of the seat undercarriage.

Seat with seat column

1. Machine in service position, see section *B Safety*.
2. Secure the wiring for the seat orientation sensor (1) with self-adhesive cable tie mounting. The seat switch wiring is routed inside the seat column (2).
3. Position the seat in the max. upward position.



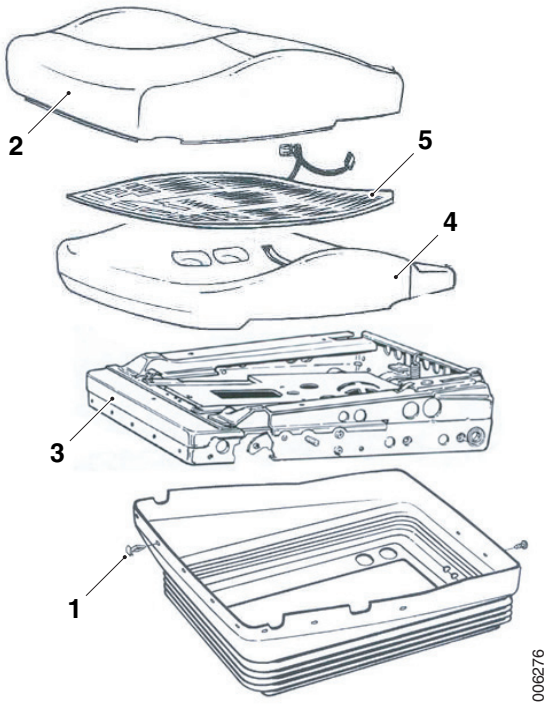


4. Strap the wiring in place in the seat cross-bar, with the wiring forming a sufficient slack arch across the cross-bar.

NOTE

Check that the wiring is not pinched between the rails when seat height or length is adjusted.

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9.3.1 Seat cushion

Seat cushion, description

The seat cushion's filling and upholstery are replaceable. These should be replaced if they show signs of wear.

Seat cushion Be-Ge, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the protective bellows by undoing the plastic rivets (position 1).

3 Unhook the upholstery fastening section (position 2) from the seat frame (position 3) and remove the upholstery. After this, the seat cushion (position 4) can be removed.

4 If the seat is equipped with electric heating (position 5), unplug this before removal

NOTE

The seat heater element is glued to the seat cushion, so be careful if the cushion foam is going to be replaced, but the seat heater element reused, or if only the seat heater element is going to be replaced.

5 Fit in the reverse order.

9.3.2 Back cushion

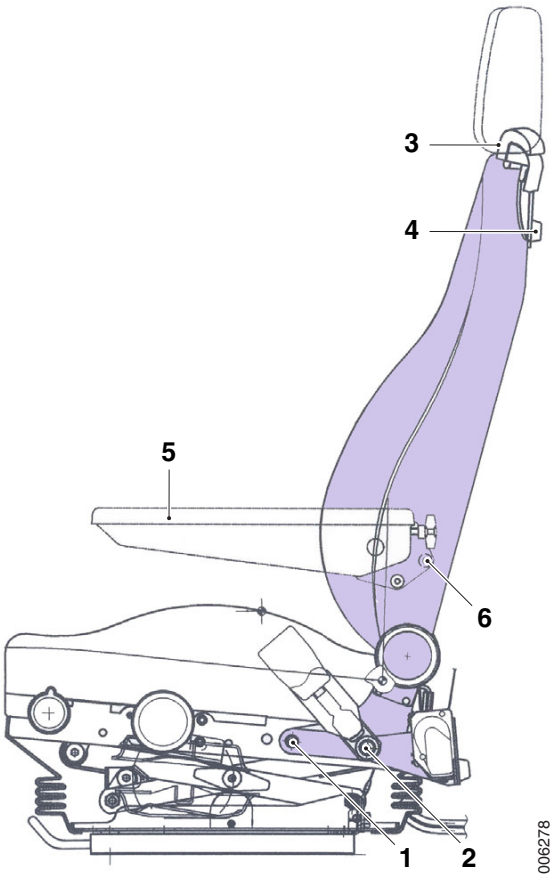
Back cushion, description

The back cushion's filling and upholstery are replaceable. These should be replaced if they show signs of wear.

Back cushion Be-Ge, replacement

1 Machine in service position, see section *B Safety*.

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2 Undo the protective bellows by removing the plastic rivets on the rear of the seat, and fold the rubber bellows down. *Seat cushion Be-Ge, replacement page 35*.

3 Remove the backrest by first removing the socket cap screws (position 1) on the right and left sides of the seat, then remove the seat belt screws (position 2) on the right and left sides of the seat.

4 If the seat is equipped with a 3-point seat belt, move the top belt guide (position 3) to the new backrest by removing the cover and undoing the screw (position 4).

5 If the seat is equipped with an arm rest (position 5), move it to the new backrest by removing the three screws for the arm rest (position 6).

6 When the new backrest is installed, first install the front socket cap screws (position 1) without tightening them, then the rear seat belt screws (position 2).

Then torque the rear seat belt screws to **42 Nm** and the front socket cap screws to **33 Nm.**

7 On the new backrest, make the corresponding holes in the upholstery with a knife, scissors etc. before installing the seat belt or armrest.

8 Fit in the reverse order.

9.3.3 Electric heater

Electric heater, description

Used for seat and backrest heating.

9.3.4 Shock absorbers

Shock absorbers, description

The shock absorbers are integrated in the suspension unit and are self-adjusting, that is, adjust automatically to the operator's weight.

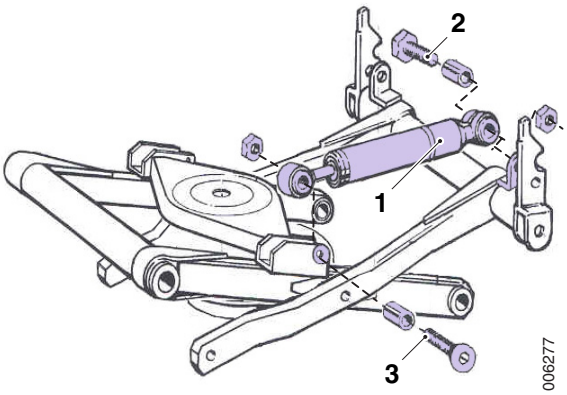
Shock absorbers Be-Ge, replacement

If the shock absorber does not function satisfactorily, makes a noise or leaks, it should be replaced.

1 Machine in service position, see section *B Safety*.

2 Unscrew the driver’s seat and lift it out of the truck. See *Grammer Maximo XXL, Actimo XXL and Be-Ge seats, replacement page 33*.

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3 Unscrew the backrest (see *Back cushion Be-Ge, replacement page 35*) and remove the seat (see *Seat cushion Be-Ge, replacement page 35*).

4 Remove the nuts and screws for the shock absorber (positions 2 and 3).

5 Replace the shock absorber.

6 Fit in the reverse order.

9.3.5 Air suspension

Air suspension, description

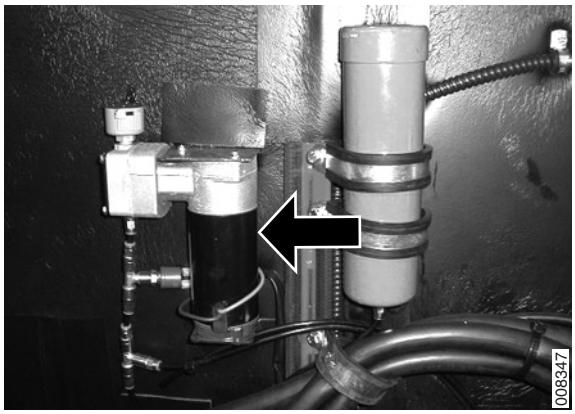
A seat with air suspension has rubber bellows and a compressor. Air suspension is self-adjusting, that is, adjusts automatically to the operator's weight. The compressor supplies the suspension unit with compressed air.

9.3.6 Compressed air-suspended seat

Compressed air-suspended seat, description

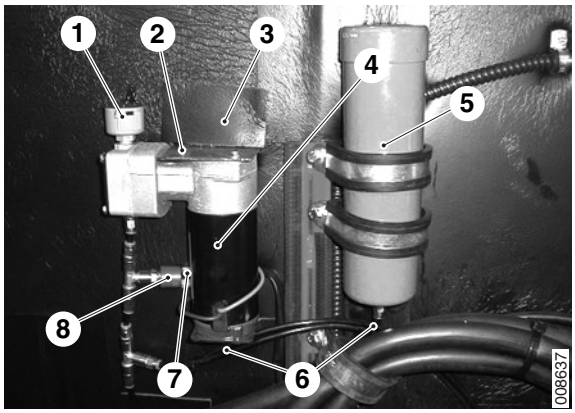
The compressor can be part of the air-suspended seat. It is in this case located inside the seat's suspension unit.

The compressor and compressed air tank can also be located on the truck or attached to the underside of the cab floor. In this case, compressed air is led to the control valve on the seat via a compressed air hose. The design of the compressor may vary.



Compressor located on the truck.

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1. Air filter
2. Screw
3. Compressor bracket
4. Compressor
5. Compressed air tank
6. Air hose
7. Electric connectors
8. Pressure switch

Compressor located under the cab floor, replacement

1. Machine in service position, see section *B Safety*.
2. Undo the air hoses and the electric connectors for the compressor.
3. Remove the screws that hold the compressor in place on the compressor bracket.
4. Remove the compressor.
5. Fit in the reverse order.

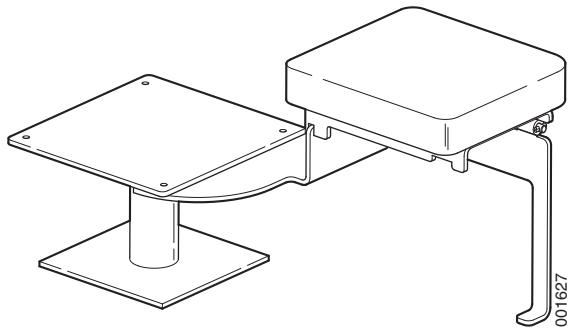
9.3.7 Mechanical seat adjustment

Mechanical seat adjustment, description

Se *Seat, general page 31*

9.3.8 Passenger seat

Passenger seat, description

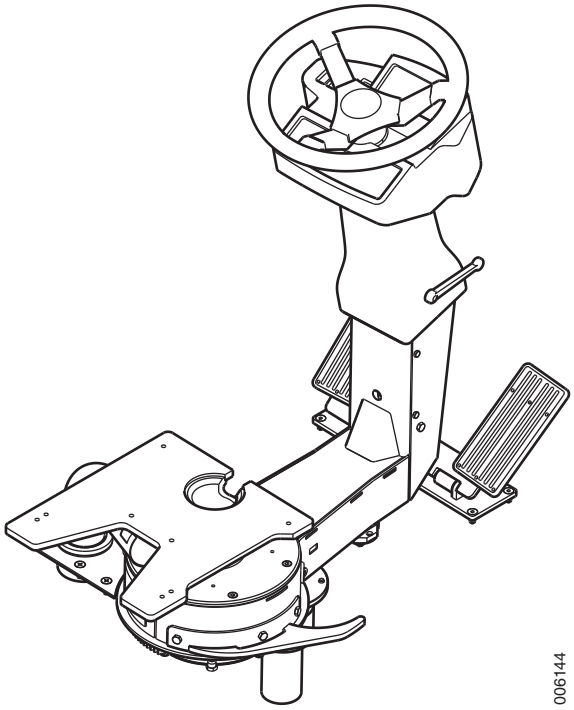


Console with folding passenger seat.

Passenger seat are available in several different designs.

The seat folds (vertically) in order not to obstruct the entrance when not in use. Located to the left of the operator's seat.

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9.3.9 Reversible operator's seat

Reversible operator's seat, description

This seat is electrically reversible and is only available for Spirit Delta cabs. On the Spirit Delta, the electric motor reduction gear adjusts the driver’s seat position via a gear drive. On the Spirit Delta Space, the electric motor reduction gear adjusts the driver’s seat position via a toothed belt.

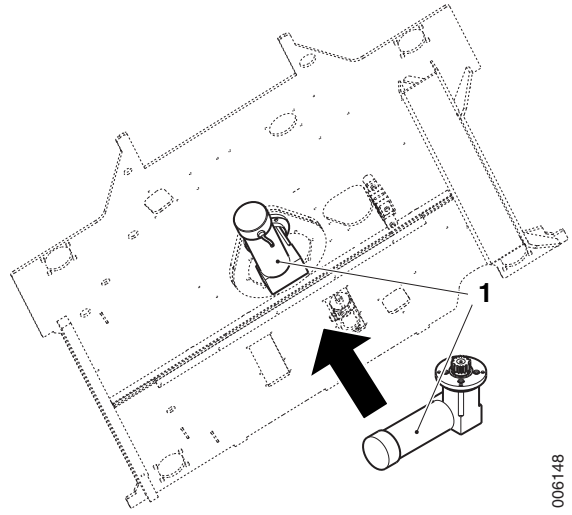
The seat console has an integrated steering wheel column with panel. This follows with the console when the seat is reversed. The seat itself does not differ from the others.

Spirit Delta cabs with a reversible operator's seat have dual controls and pedals, the steering wheel and hand controls follow the console. A change-over valve shifts steering so that the steering wheels react logically. The lighting (brake, indicator, side and tail lamps) and the direction of travel switch over. The front of the truck then becomes the direction in which the driver’s seat is pointing.

The steering column operates the steering valve via a chain. The chain has a tensioner which can be adjusted from the outside. It is located on the side of the bracket.

Reversible operator's seat, electrical motor, replacement

1. Machine in service position, see section *B Safety*.



006148

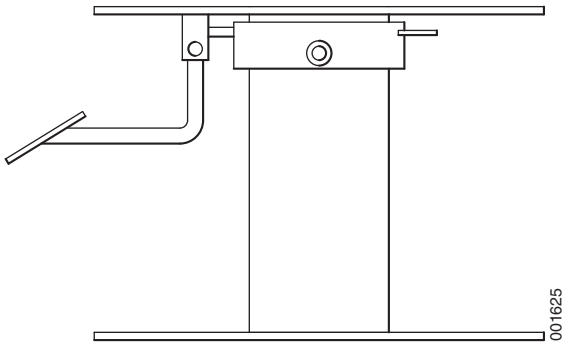
1. Electrical motor

2. Undo the connector for the electric motor.
3. Remove the four screws that hold the electric motor in place.
4. Remove the electric motor.
5. Fit in the reverse order.

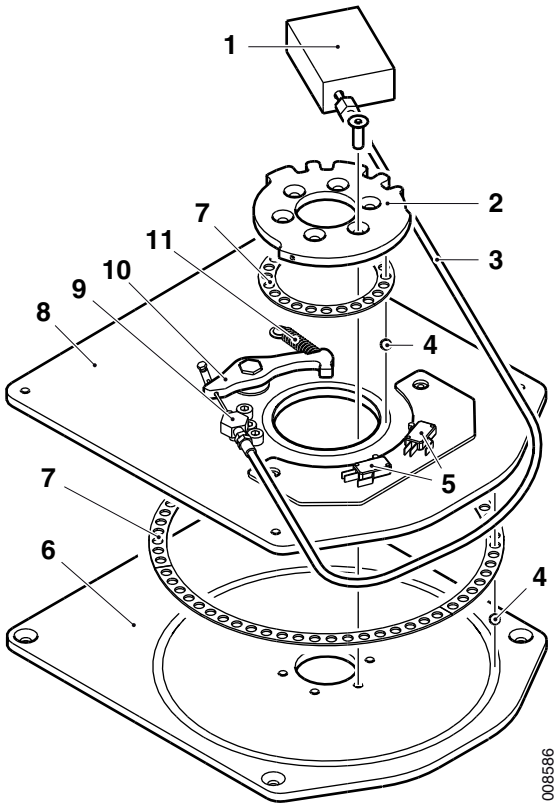
https://truckmanualshub.com/

9.3.10 Rotating operator's seat

Rotating operator's seat, description



Console for manual rotating operator's seat.



Console for electrically rotating operator's seat

1.	Servo-motor	7.	Ball distance ring
2.	Top plate	8.	Central plate
3.	Wire	9.	Wire screw
4.	Ball	10.	Lock lever
5.	Micro switch (left)	11.	Spring
6.	Base plate		

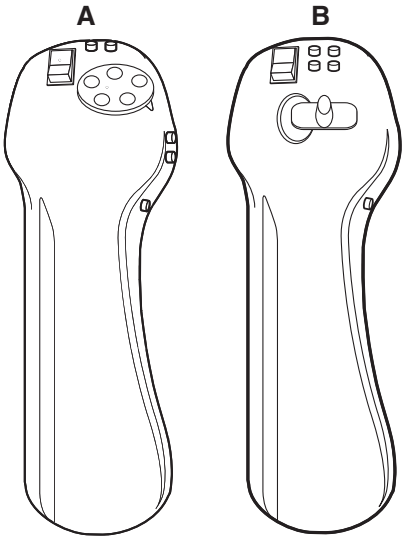
Often foot operated to manual rotate 10 degrees to the left or 40 degrees to the right, but also available with electrically controlled locking for configurable rotation: left 0, 20 or 35 degrees or right 35 or 55 degrees. This is primarily intended to facility entry and exit and eliminate the need to turn your head when reversing. The pedal (in the bracket) is released with the foot.

This seat console is available in different reversible alternatives, with or without doubled pedals.

NOTE

Avoid reversing the seat while operating.

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9.3.11 Armrest

Armrests, description

The armrests are attached to the seat backrest. Their height can be adjusted individually (around mounting point).

Depending on the options, a left armrest is also available:

A. Mini-wheel ⊞

B. Lever steering ⊞

9.3.12 Direction valve, reversible driver's seat

Direction valve, reversible driver's seat, description

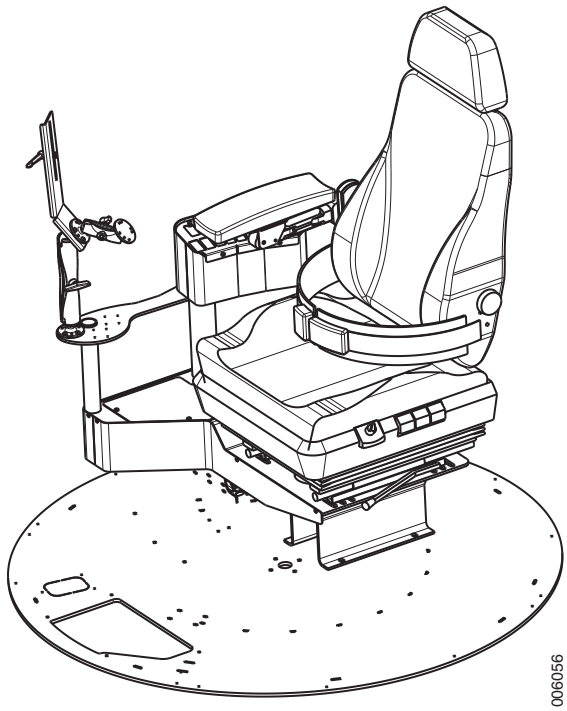
⊞ See section *5 Steering*, group *5.2.15 Direction valve, reversible driver's seat*.

9.3.13 Sensor, reversible driver's seat

Sensor, reversible driver's seat, description

⊞ See section *5 Steering*, group *5.2.16 Sensor, reversible driver's seat*.

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9.3.14 Reversible driver’s station

Reversible driver’s station, description

Only Spirit Delta Space.

This driver’s station is electrically reversible and is only available for Spirit Delta Space cabs. The seat console has an integrated steering wheel column with panel. This follows with the console when the seat is reversed. The seat itself does not differ from the others.

The steering column operates the steering valve and a toothed belt operates the platform reversing function. The toothed belts are self-adjusting and are automatically tensioned when necessary.

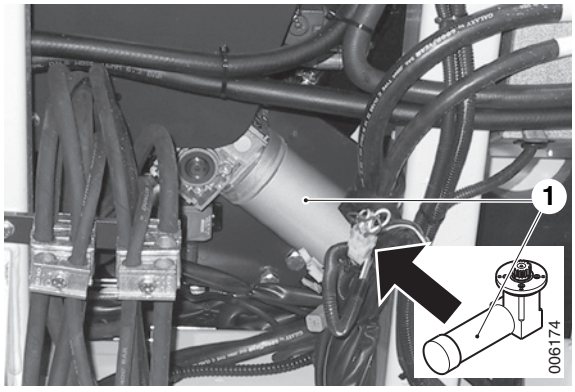
The steering wheel shaft act directly on the steering valve, attached to the underside of the reversible console.

A change-over valve shifts steering so that the steering wheels react logically, the lighting (brake, indicator, side and tail lamps) and the direction of travel switch over. The front of the truck then becomes the direction in which the driver’s seat is pointing.

In some trucks, the default setting allows the driver to drive and control the truck at reduced speed with the seat console is at an angle other than facing the lifting mast or 180° in the opposite direction. Load handling is only possible when the driver is facing the lifting mast.

Reversible driver's station, electrical motor, replacement

1. Machine in service position, see section *B Safety*.



1. Electric motor

2. Tilt the cab.
3. Undo the connector for the electric motor.
4. Remove the four screws that hold the electric motor in place.
5. Remove the electric motor.
6. Fit in the reverse order.

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9.3.15 Directional valve, reversible driver's station

Directional valve, reversible driver's station, description

Only Spirit Delta Space.

See section *5 Steering*, group *5.2.15 Directional valve, reversible driver's seat*.

9.3.16 Potentiometer, reversible driver's seat

Potentiometer, reversible driver's seat, description

Only Spirit Delta Space.

See section *5 Steering*, group *5.2.19 Potentiometer reversible driver's station*.

9.3.17 Head restraint

Head restraint, description

Some models of seat can be adjusted with a head restraint for increased comfort.

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9.4 Heating, ventilation and air conditioning

Heating, ventilation and air conditioning, function description

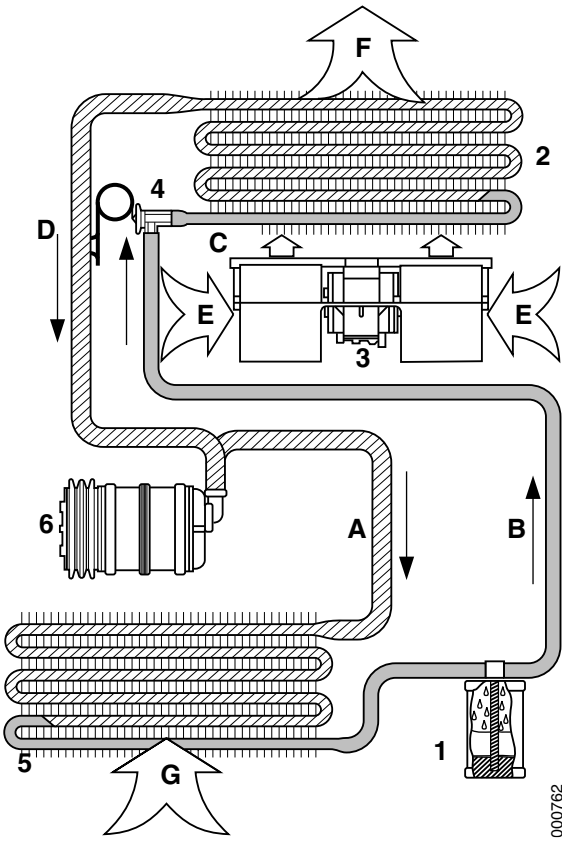
A standard truck with FlexGuard has no heating or defroster system. FlexCab (weather-protected, covered FlexGuard) has a simple heating/defroster system. A separate cooling system is available for FlexCab as an option.

Standard truck with Spirit Delta cab has only heating/defroster. The heating unit (cab/defroster) is connected to the engine cooling system and provides heat when the engine is warm. The heating unit comprises fan and elements for warming the air. The air is then distributed through integrated ducts in the cab's interior equipment and can be guided to defroster or floor for example.

Climate control available in different types:

- Climate control, AC (manual control of cooling, dehumidifying and heating) ⊞
- Climate control, ECC (Electronic Climate Control, electronic control of cooling, dehumidifying and heating) ⊞

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1. Fluid reservoir/receiver dryer
2. Evaporator
3. Fan
4. Expansion valve
5. Condenser
6. Compressor

A. High pressure gas
B. High pressure fluid
C. Low pressure fluid
D. Low pressure gas
E. Heat, cab air
F. Cooled air to cab
G. Outdoor air for removal of heat

Air conditioning includes the parts presented in the illustration and ensures the driver's cab climate is as comfortable as possible. Air conditioning function is to:

- heat the air when it is cold
- dehumidify the air when it is damp
- clean the air of impurities
- cool the air when it is hot
- defrost (defroster function)

The unit is controlled with switches and controls on the instrument panel.

The unit's fan is controlled in steps 0-I-II-III (with the fan control). With climate control ECC the fan is variable 0–100%.

IMPORTANT

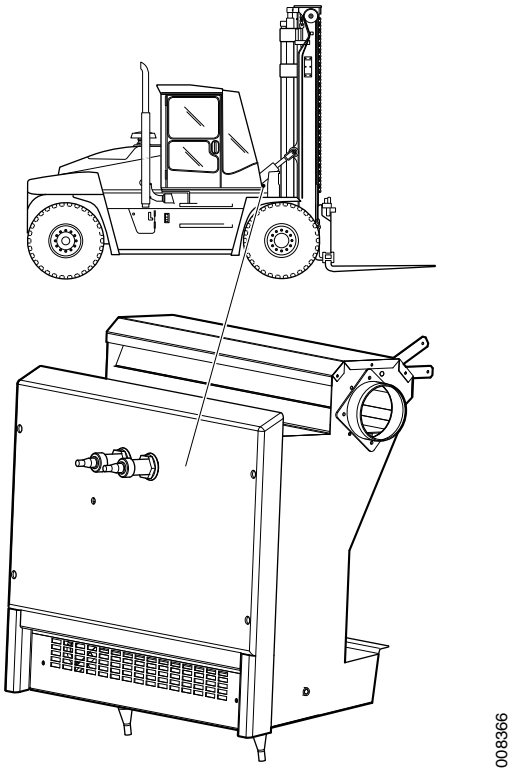
On machines with ECC or AC, it is extremely important that the engine cooling system is filled with coolant with the right antifreeze content. Otherwise, there is a risk that the air conditioning system's heating element will freeze when cooling is used during periods when heating is off completely.

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9.4.1 Fresh air / recirculation valve

Fresh air/recirculation valve, description

The valve is located in the external unit for fresh air inlet to the cab. An electrically controlled recirculation valve is only available in combination with air conditioning and automatic climate control. Fully open for fresh air, alternatively recirculation air from the cab.

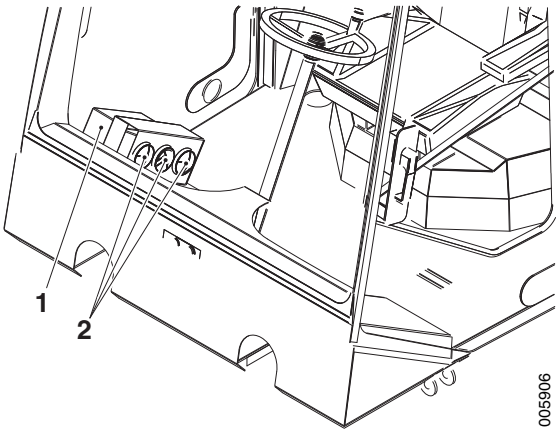


Fresh air intake to cab, Spirit Delta

9.4.2 Air vents

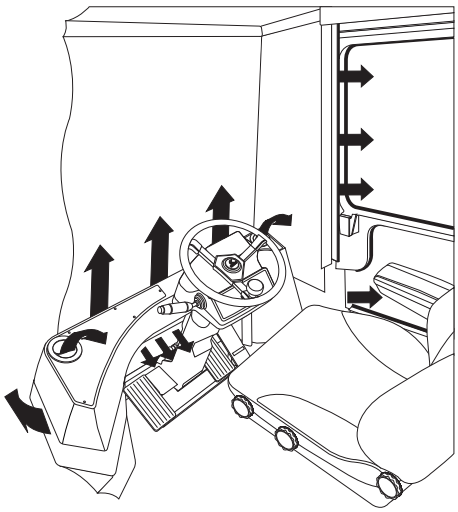
Air vents, FlexCab, description

There are three adjustable air vents on the heater unit. These make it is easy to choose the direction of the heated air.



1. Cab fan
2. Air vents

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Air vents to cab

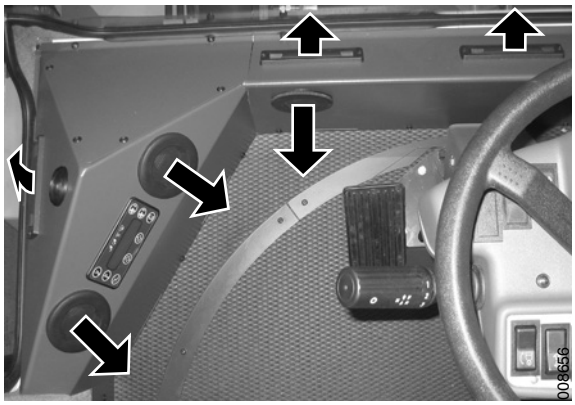
Air vents, Spirit Delta, description

The cab interior has a number of fixed air vents, such as at the front edge of the doors and the defroster vents for the windscreen. There are also two

adjustable nozzles in the outer corners of the instrument panel to adjust flow and direction (flow is proportional to fan speed).

A large air vent is located low in the cab (floor). This allows the gradual adjustment of the air flow from the lower part of the cab to defroster.

An optional, adjustable air vent located central in the instrument panel is available. ⊕

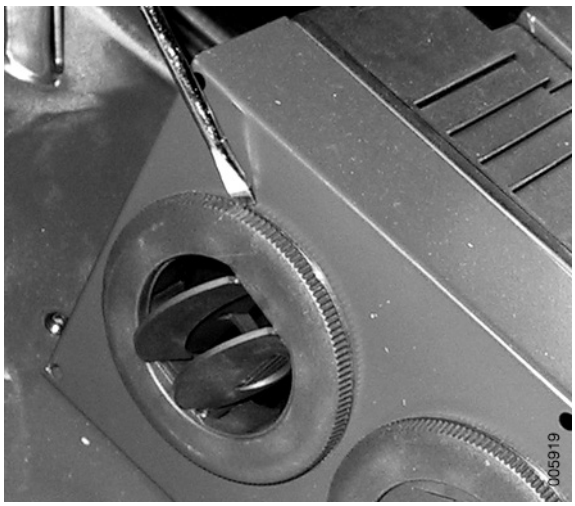


Air vents to cab Spirit Delta Space

Air vents, Spirit Delta Space, description

There are a number of adjustable air vents in the cab's interior, such as six at the windscreen for defroster and six adjustable air vents in the instrument panel. Adjustable flow and direction (flow is proportional to fan speed).

A large air vent is located low in the cab (floor). This allows the gradual adjustment of the air flow from the lower part of the cab to defroster.

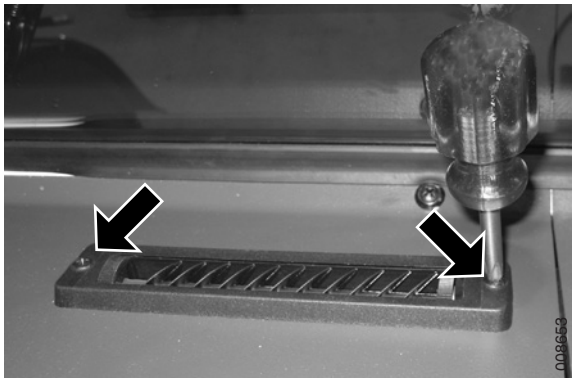


Air vents, FlexCab, replacement

1 Machine in service position, see section *B Safety*.
2 Use a screwdriver or similar to remove the air vent.
3 Remove the air vent.
4 Install a new air vent.

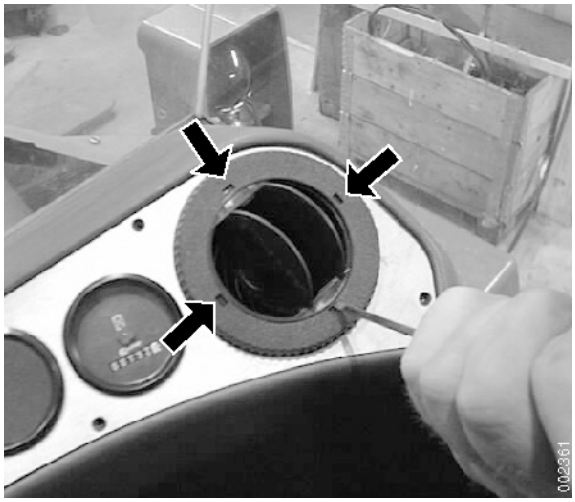
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Air vents, Spirit Delta Space, replacement



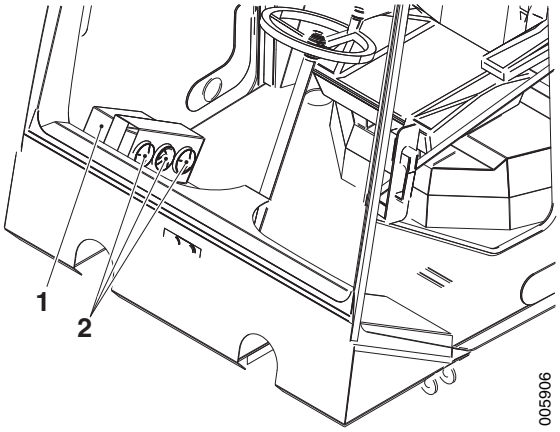
1 Machine in service position, see section *B Safety*.
2 Remove the two screws and the remove the vent.

Air vents, Spirit Delta and Spirit Delta Space, replacement



1 Machine in service position, see section *B Safety*.
2 Remove the instrument panel for warning lights and switches.
3 Squeeze the four catches towards the centre and remove the vent.
4 Remove the two screws and the rest of the vent.

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1. Cab fan
2. Air vents

9.4.3 Cab fan

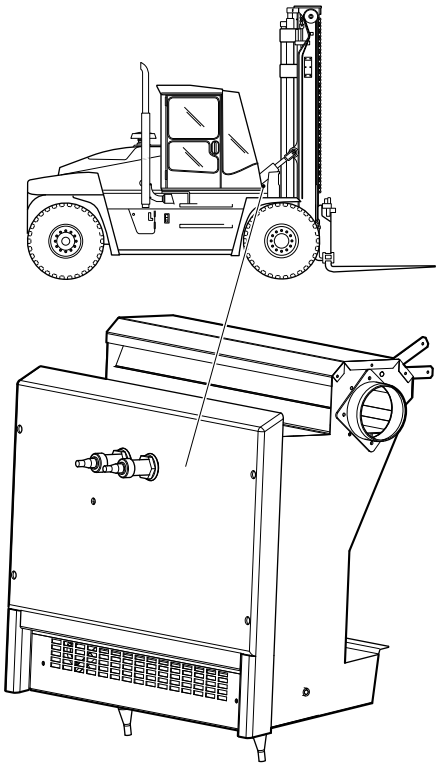
Cab fan, FlexCab, description

The heating unit is located on the floor in the right, front corner of the cab.

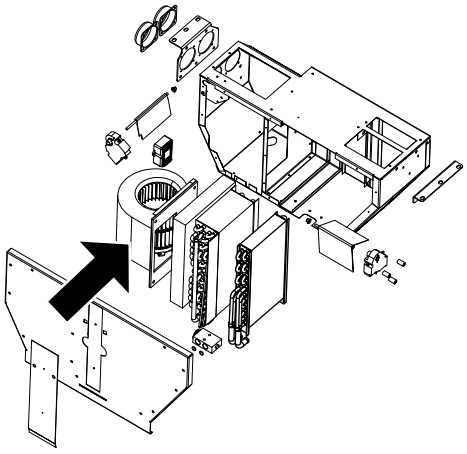
The heating unit (cabin/defroster) is connected to the engine cooling system and provides heat when the engine is warm. The heating unit consists of a fan and a heating element for heating the air. The air is distributed through three integrated air vents and can be directed towards the defroster, floor, etc.

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Cab fan, Spirit Delta and Spirit Delta Space, description



Fresh air intake to cab, Spirit Delta



Fresh air intake to cab, Spirit Delta Space

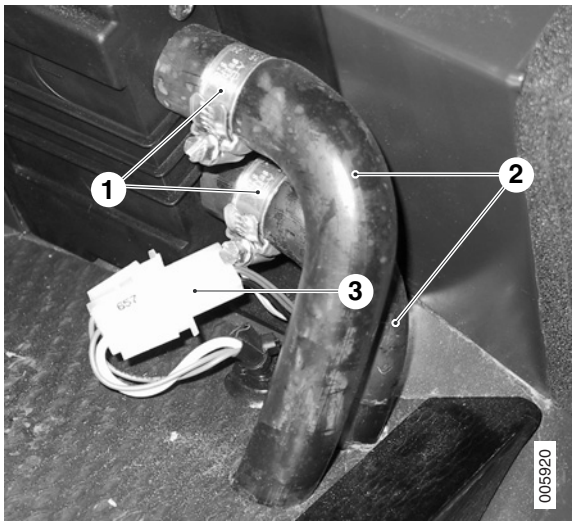
The cab fan for Spirit Delta cabs and Spirit Delta Space is located in the external unit for fresh air intake to the cab (between the tilt cylinders). The fan comprises two single fans on Spirit Delta and one on Spirit Delta Space.

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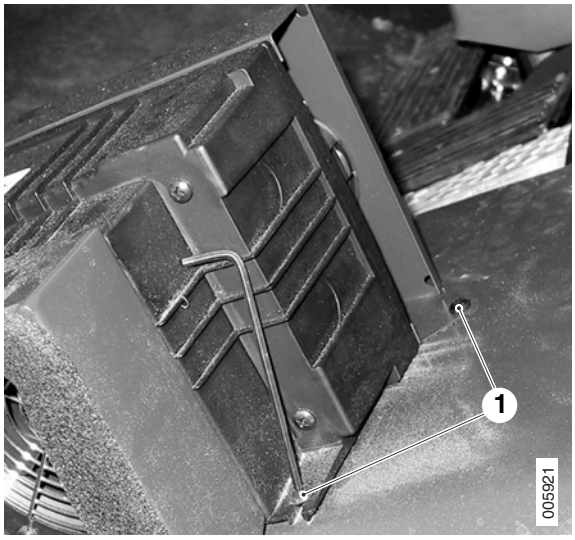
Cab fan, replacement

FlexCab

1. Machine in service position, see section *B Safety*.
2. Unplug the electric connections.
3. Install clamps on the hoses to prevent coolant from running out.
4. Undo the hose clamps and remove the hoses. Use a vessel to collect any coolant that runs out.



1. Hose clamps
2. Hoses
3. Connector



1. Screws

5. Remove the four screws that hold the cabin fan to the cab floor.
6. Remove the cab fan.
7. Fit in the reverse order.

NOTE

After replacement of cab fan, check coolant level and top up as necessary.

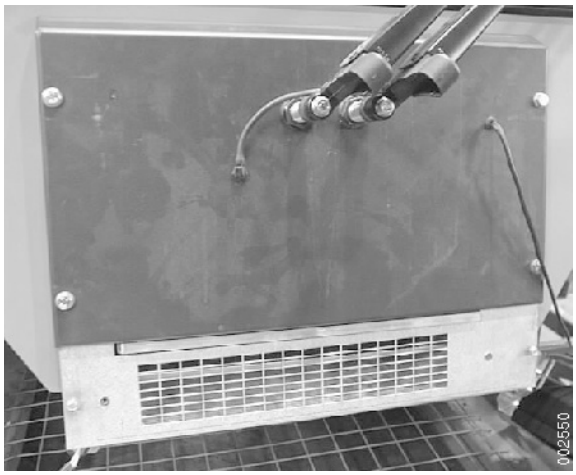
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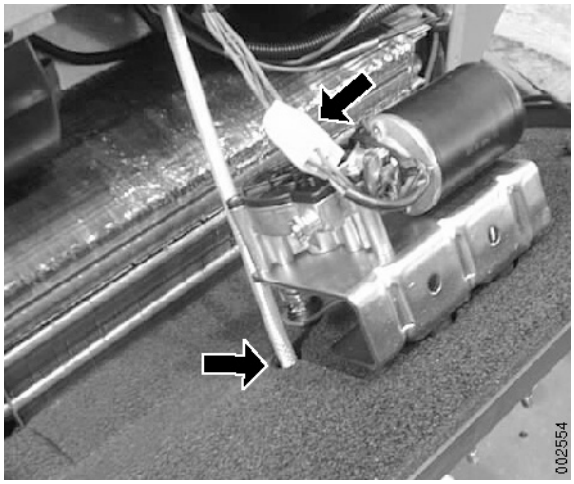
Cab fan, replacement

Cab Spirit Delta

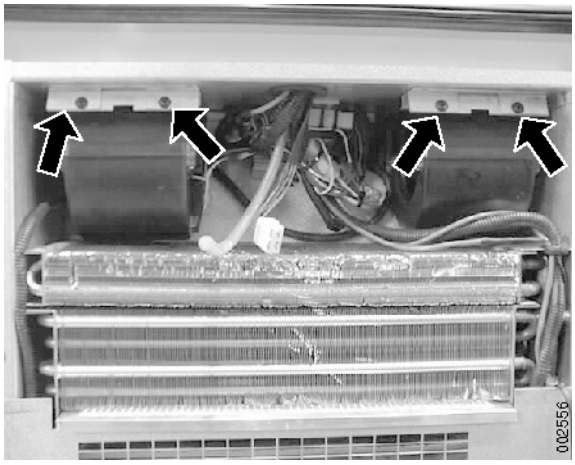
1 Machine in service position, see section *B Safety*.

2 Remove the cover plate holding the wiper motor.





3 Remove the washer fluid hose and unplug the connector from the wiper motor.



4 Remove the bolts securing the cab fan to be replaced.

5 Unplug the connector from the cab fan.

6 Replace the cab fan.

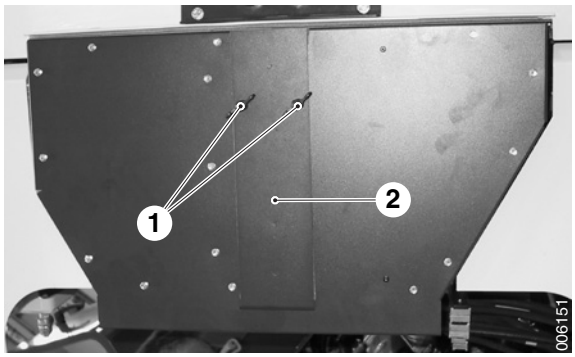
7 Fit in the reverse order.

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Cab fan, replacement

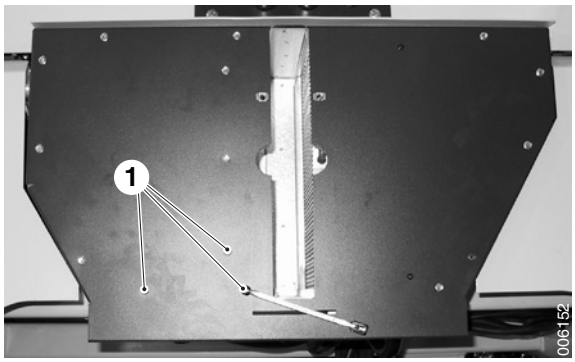
Cab Spirit Delta Space

1 Machine in service position, see section *B Safety*.



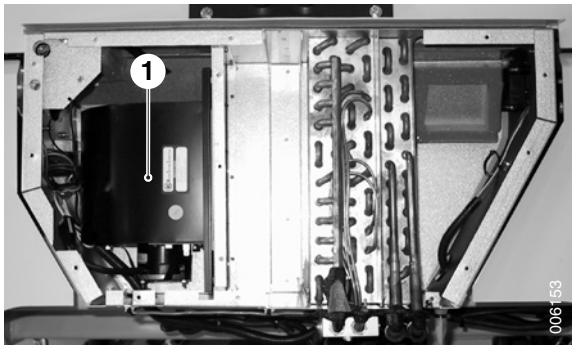
1. Wing nuts.
2. Cover plate.

2 Undo the wing nuts, remove the cover plates and secondary filter.



1. Screws

3 Remove the 15 screws securing the cover plate and remove the cover plate.



1. Cab fan.

4 Remove the two bolts securing the cab fan to be replaced.

5 Unplug the connector from the cab fan.

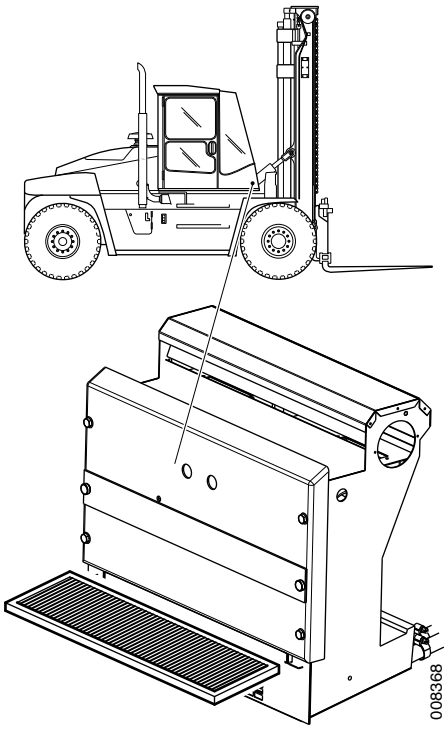
6 Replace the cab fan.

7 Fit in the reverse order.

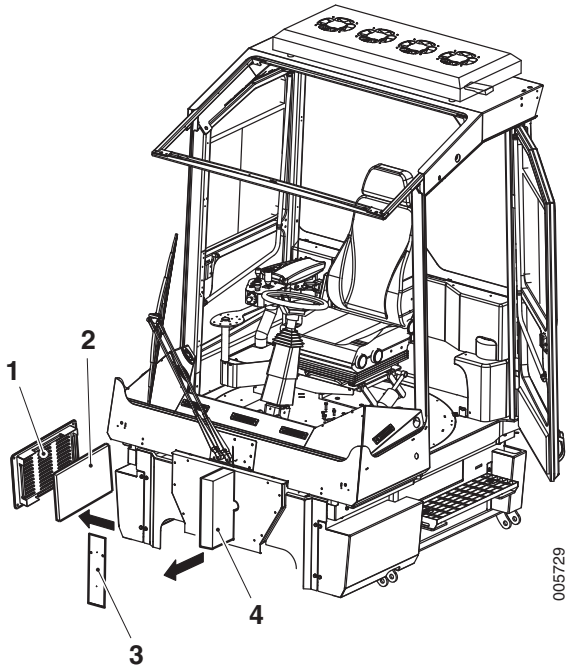
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9.4.4 Fresh air filter

Fresh air filter, description



Cab Spirit Delta:
Fresh air intake to cab with fine filter and filter holder.



Cab Spirit Delta Space:

Fresh air intake to cab with fine filter and filter holder.

1. Cover
2. Fresh air filter
3. Cover
4. Fine filter

The fresh air filter is standard equipment on machines with only heating, but can also be selected for machines with AC or ECC. It is located in the external unit for fresh air inlet to the cab, on Spirit Delta in front of the cab fan (between the tilt cylinders) and on Spirit Delta Space on the right-hand side of the cab.

A fine filter is standard equipment on machines with AC and ECC, but can also be selected for machines with only heating.

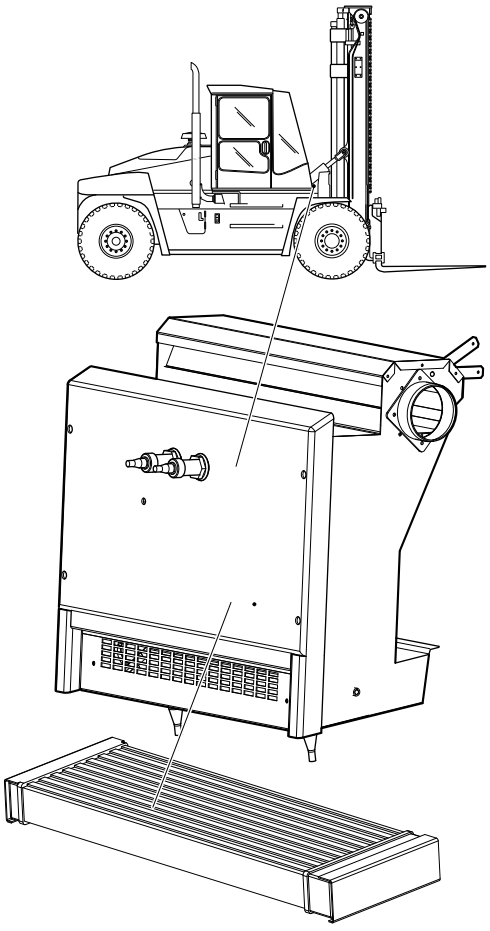
NOTE

Ensure that the filter cassettes are installed with the arrow markings pointing in the direction of air travel.

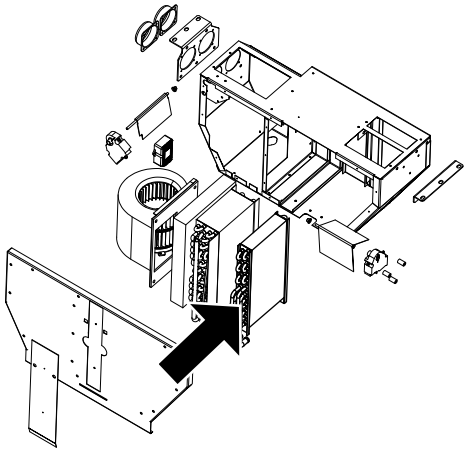
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9.4.5 Heat exchanger heat

Heat exchanger heat, description



Cab Spirit Delta:
The heat exchanger for heating at bottom (located in fresh air intake to cab)



Cab Spirit Delta Space:
The heat exchanger for heating to the left (located in fresh air intake to cab)

Pipes and fins in the heat exchanger transfer heat from the hot coolant in the engine to the ventilation air in the cab.

The heat exchanger for heating is located in the external unit for fresh air intake to the cab (between the tilt cylinders).

NOTE

Clamps should be installed on the hoses to prevent unnecessary loss of coolant when any work is done on the coolant circuit.

Wear protective gloves and use a collection vessel to collect the coolant that runs out.

NOTE

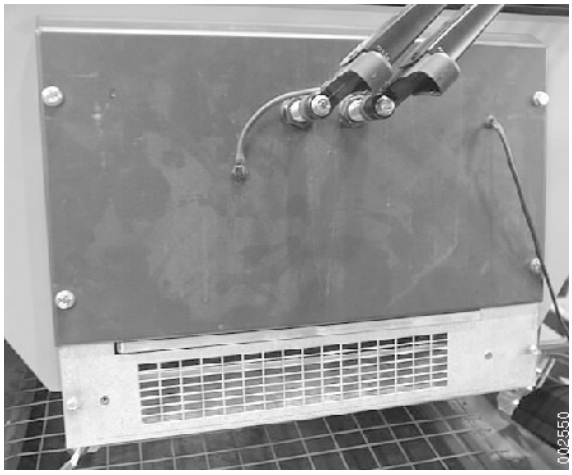
After work is performed, check the coolant circuit for leaks and check the coolant level. Top up coolant if necessary.

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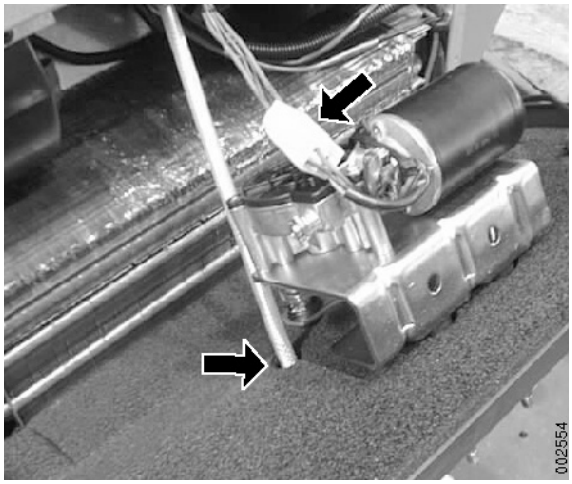
Heat exchanger heat, Spirit Delta, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the cover plate holding the wiper motor.



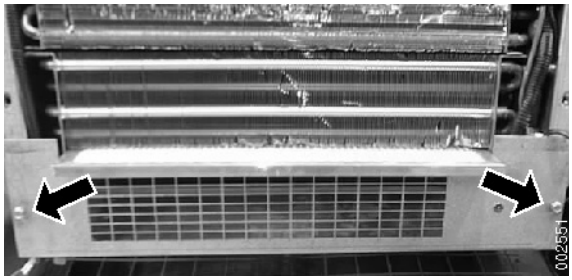
3 Remove the washer fluid hose and unplug the connector from the wiper motor.



4 Remove the fresh air filter and the two screws securing the grille for the fresh air intake.

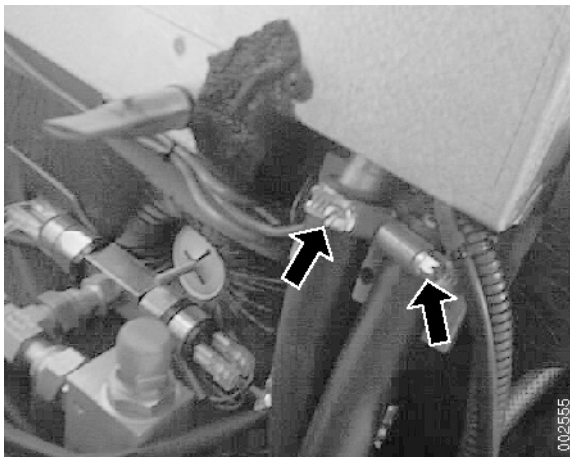
5 Empty the cooling system of coolant, see *Maintenance manual DCE 90-180*.

6 Clamp the hoses to and from the heat exchanger with pinch-off pliers to prevent coolant escaping.

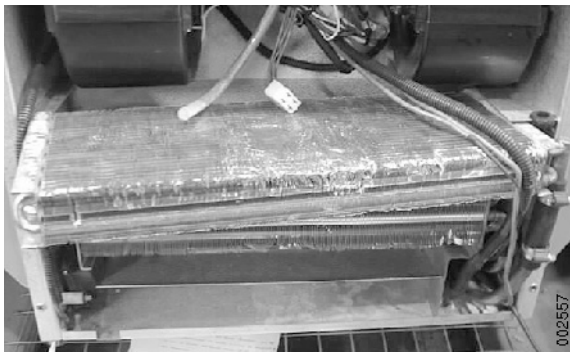


Picture shows heating with AC.

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7 Disconnect the coolant hoses from the heat exchanger under the cab.



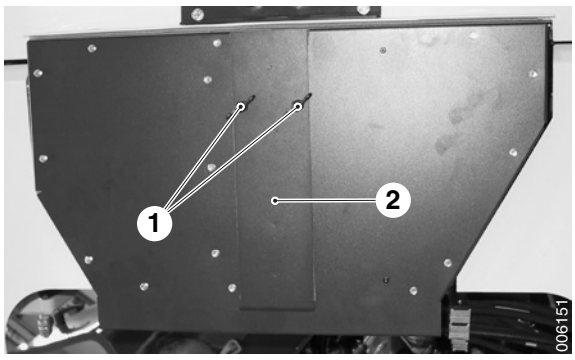
8 Withdraw the heat exchanger from its rest position.

9 Replace the heat exchanger.

10 Fit in the reverse order.

Heat exchanger heat, Spirit delta Space, replacement

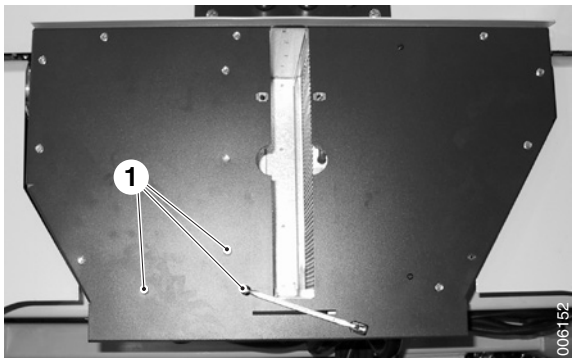
1 Machine in service position, see section *B Safety*.



1. Wing nuts.
2. Cover plate.

2 Undo the wing nuts, remove the cover plates and secondary filter.

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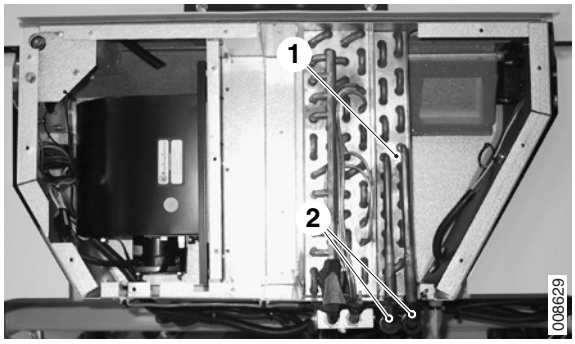


1. Screws

3 Remove the 15 screws securing the cover plate, remove the cover plate.

4 Empty the cooling system of coolant, see *Maintenance manual DCE 60-90*.

5 Clamp the hoses to and from the heat exchanger with pinch-off pliers to prevent coolant escaping.



1. Heat exchanger heat.
2. Connections.

6 Disconnect the coolant hoses from the heat exchanger under the cab.

7 Withdraw the heat exchanger from its rest position.

8 Replace the heat exchanger.

9 Fit in the reverse order.

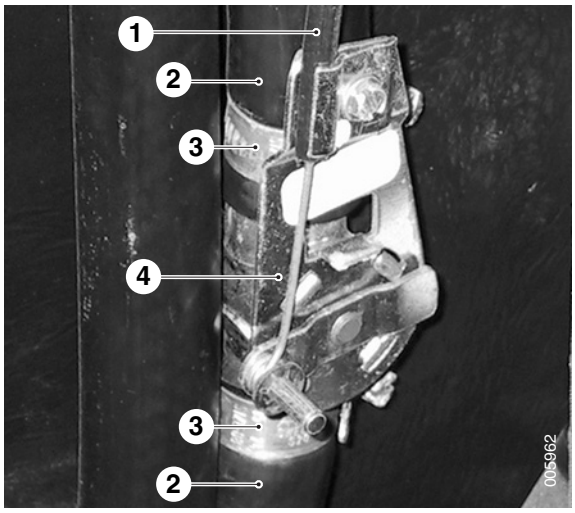
9.4.6 Water valve

Water valve, description

The water valve is located under the cab, on one of the hoses that leads coolant to the cabin fan. The valve has a shutter function that releases or shuts off the coolant flow to the cabin fan. On machines without ECC, it is controlled by a cable connected to the heater control.

On machines with ECC, the water valve is electrically operated.

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1. Wire
2. Hoses
3. Hose clamps
4. Water valve

Water valve machines without ECC, replacement

1 Machine in service position, see section *B Safety*.

2 Undo the screw and the lock washer that fixes the cable to the water valve.

3 Install clamps on the hoses to prevent coolant from running out.

4 Undo the hose clamps and remove the hoses. Use a vessel to collect any coolant that runs out.

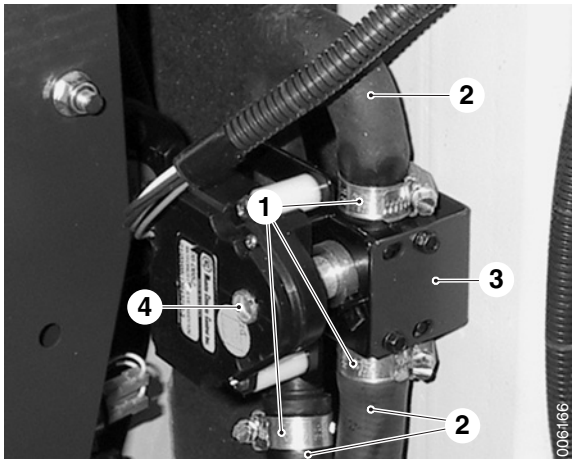
5 Unscrew the water valve from underneath the cab floor.

6 Fit in the reverse order

NOTE

Ensure that the water valve is installed with the arrow markings pointing in the direction of coolant travel.

After fitting the water valve, check the valve for leaks and check the coolant level. Top up coolant if necessary.



1. Hose clamps
2. Hoses
3. Water valve
4. Centre shaft with groove

Water valve machines with ECC, replacement

1 Machine in service position, see section *B Safety*.

2 Install clamps on the hoses to prevent coolant from running out.

3 Undo the hose clamps and remove the hoses. Use a vessel to collect any coolant that runs out.

4 Undo the water valve connector.

5 Unscrew the water valve from underneath the cab floor.

6 Fit in the reverse order

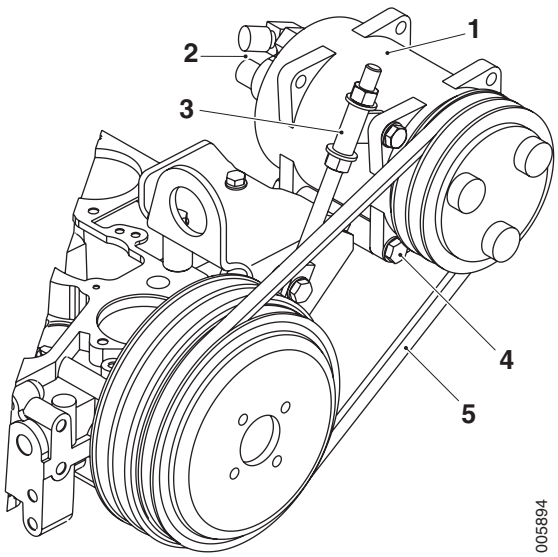
NOTE

After fitting the water valve, check the valve for leaks and check the coolant level. Top up coolant if necessary.

NOTE

The water valve centre shaft has a groove that can be used for fault tracing the heating system.

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1. AC compressor
2. Connections
3. Rigging screw
4. Screw and nut
5. Compressor belt

9.4.7 AC Compressor

AC compressor, description

The AC compressor drives the system by working as a pump. It sucks in cold, low-pressure gas from the evaporator and compresses the gas to the condenser.

The AC compressor is mounted on the machine's engine and is driven by a V-belt directly from the engine. The solenoid clutch, controlled by the thermostat inside the AC unit (in front of the steering column), and the control unit for ECC, activates the AC compressor

AC compressor, replacement

IMPORTANT

Working on the air conditioning requires special authorisation.

NOTE

It is extremely important to prevent contamination and foreign particles from ending up in the refrigerant circuit. For this reason, always replace the particle and moisture filter when any work is done on the refrigerant circuit.

NOTE

For tightening torque of refrigerant hoses and pressure switch, see section F Technical data.

1 Machine in service position, see section *B Safety*.

2 Open the hood on the right side.

3 Drain the AC system of R134a refrigerant.

4 Release the belt tensioner and remove the AC compressor belt.

5 Undo the hose fittings and disconnect the inlet and outlet hoses from the AC compressor, plug the fittings to prevent contamination.

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6 Remove the nut and bolt securing the AC compressor.

7 Empty the oil from the old AC compressor (through inlet/outlet) and measure the quantity.

8 Empty the oil from the new AC compressor.

9 Refill the new AC compressor with the same amount of oil as was emptied from the old AC compressor.

10 Fit in the reverse order.

11 Turn the AC compressor over several turns by hand.

12 Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.

13 Check the function of the system.

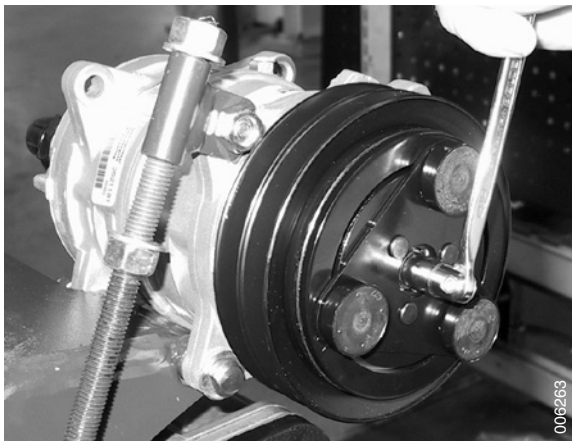
Groove and clutch coil, replacement

This replacement may be carried out without opening the refrigerant circuit.

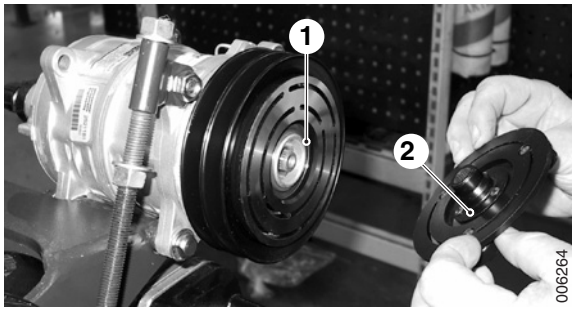
1 Machine in service position, see section *B Safety*.

2 Release the belt tensioner and remove the AC compressor belt.

3 Remove the screw in the centre of the pulley.

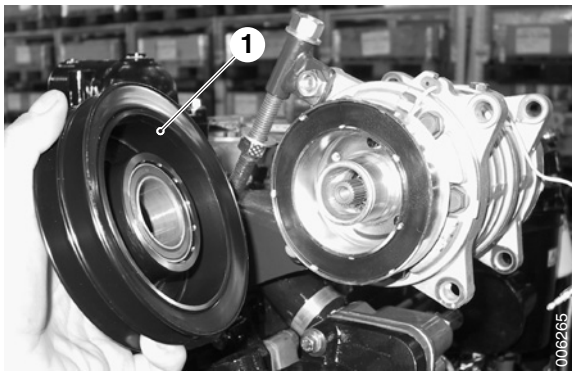


4 Remove the armature plate and the outer circlip.



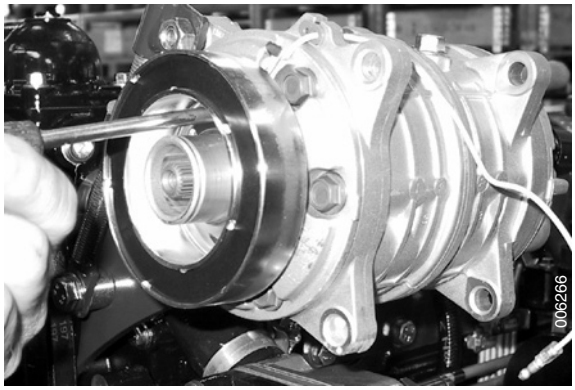
1. Circlip
2. Armature plate

https://truckmanualshub.com/

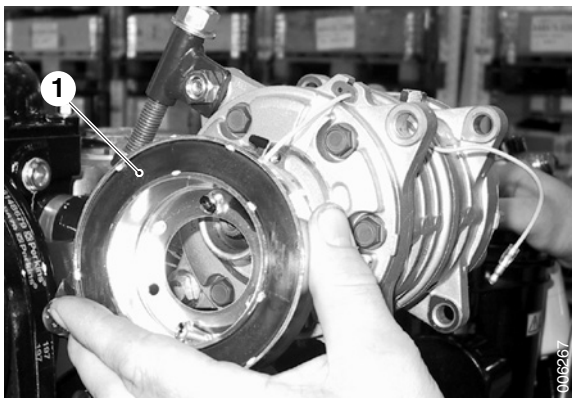


1. Groove

5 Remove the groove.



6 Remove the three screws that secure the clutch coil.



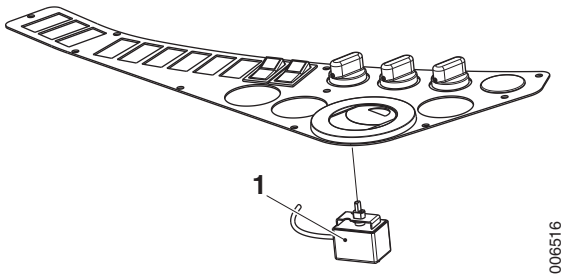
1. Electromagnetic clutch

7 Remove the clutch coil

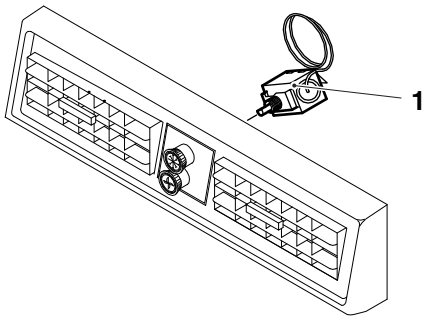
8 Fit in the reverse order.

9 Check the function of the system.

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1. Thermostat, Spirit Delta/Spirit Delta Space



1. Thermostat FlexCab

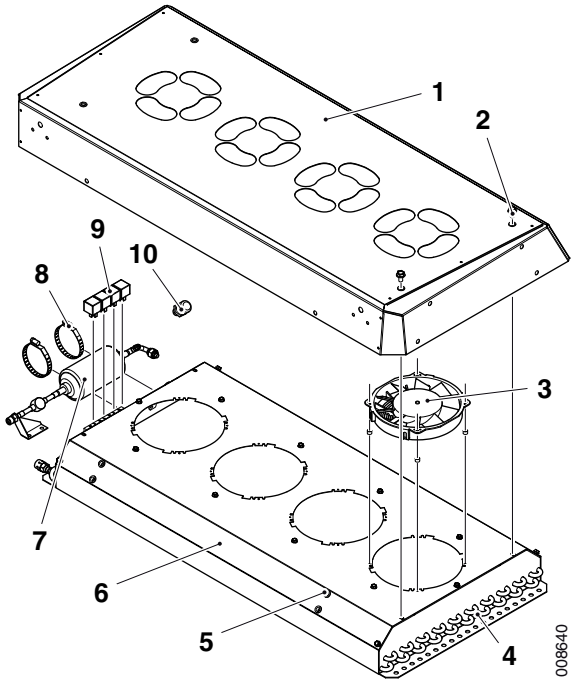
9.4.8 Thermostat

Thermostat, description

The thermostat regulates cooling capacity from 0 to 100 percent. On Spirit Delta, the thermostat sits beneath the instrument panel's cooling controls while on FlexCab is is found in the control panel of the cooling unit. The thermostat's sensor is found between the evaporator's flanges. In addition to controlling cooling capacity, the thermostat deactivates the compressor when ice has formed on the evaporator (defrosting).

ECC has an electronically monitored de-icing system. The sensor is located on the evaporator output pipe and is connected directly to the ECC control unit.

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Condenser unit Spirit Delta/Spirit Delta Space

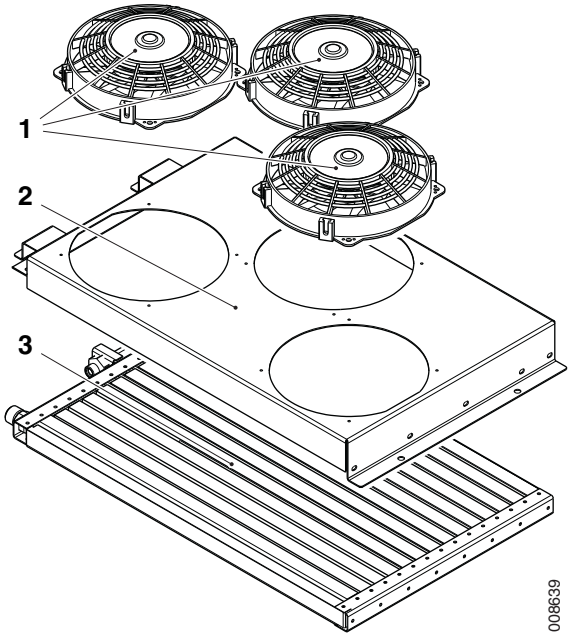
1.	Outer Casing	6.	Fan casing
2.	Screw	7.	Particle and moisture filter
3.	Fan	8.	Clamp
4.	Condenser	9.	Relay
5.	Screw	10.	Pressure switch

9.4.9 Condenser unit

Condenser unit, description

The condenser is located on the cab roof. The function of the condenser is to convert the hot, high-pressure gas from the compressor to liquid form. Pipes and cooling fins in the condenser battery absorb the heat, which is dissipated with a fan.

The refrigerant temperature in the condenser varies, depending on the ambient temperature and air flow through the condenser. When the refrigerant has condensed to liquid, it is forced on to the particle and moisture filter.



Condenser unit, FlexCab

1. Fan
2. Casing
3. Condenser

Condenser unit, replacement

IMPORTANT

Working on the air conditioning requires special authorisation.

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NOTE

It is extremely important to prevent contamination and foreign particles from ending up in the refrigerant circuit. For this reason, always replace the particle and moisture filter when any work is done on the refrigerant circuit.

1 Machine in service position, see section *B Safety*.

2 Drain the AC system of R134a refrigerant.

3 Remove the outer protective cover from the condenser, four M6 screws.

4 Cut off the tie wraps and unplug any lighting cables.



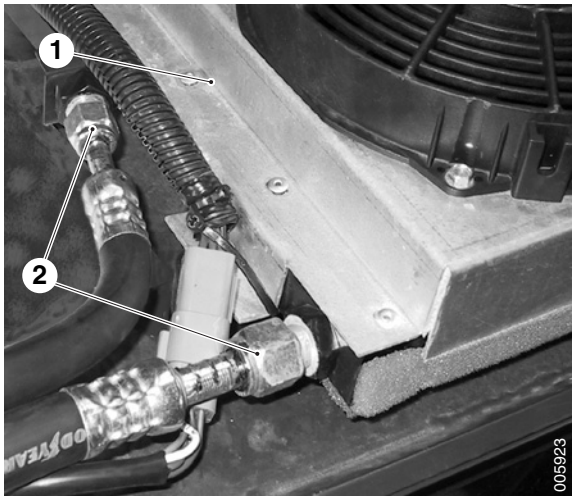
Picture shows Spirit Delta / Spirit Delta Space

NOTE

Make certain the AC system is drained of R134a refrigerant.

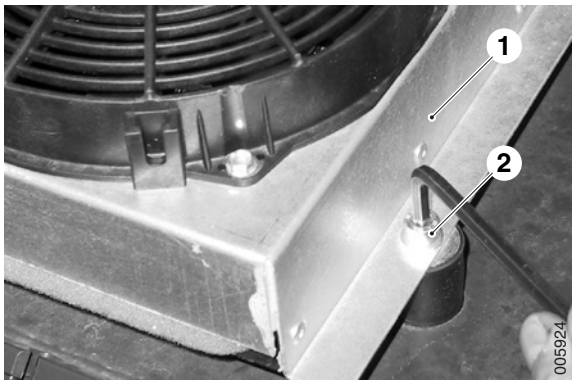
5 Remove the refrigerant hoses from the condenser unit.

6 Plug the hoses to avoid contamination of the refrigerant circuits.



1. Condenser unit
2. Connections

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Picture shows FlexCab
1. Condenser unit
2. Screw

7 Remove the four screws for the rubber buffers on the condenser.

8 Separate the condenser from the cover by drilling out the pop rivets.

9 Pop rivet the cover to the new condenser.

10 Fit in reverse order.

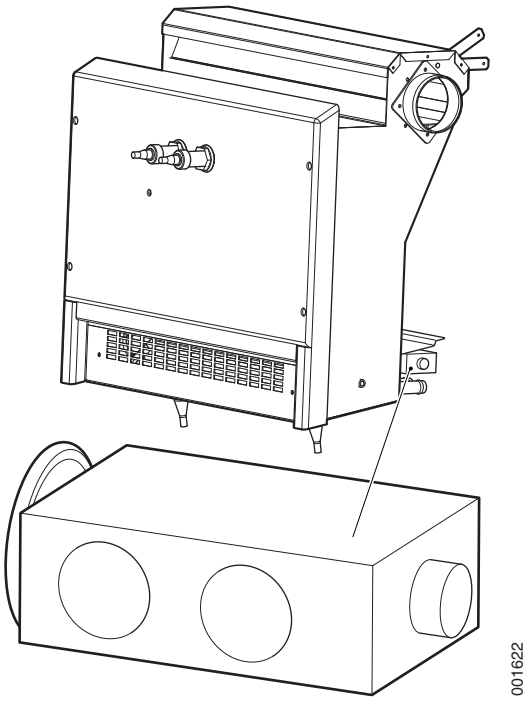
11 Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.

12 Check the function of the system.

9.4.10 Expansion valve

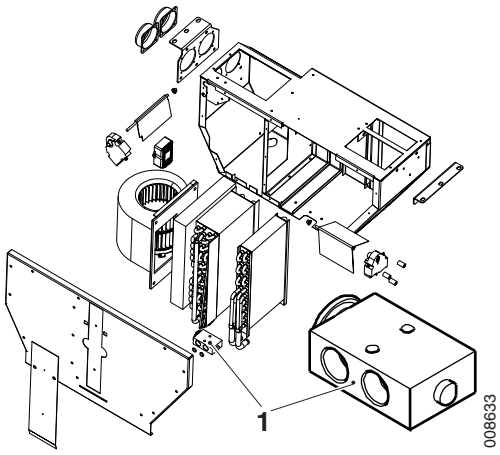
Expansion valve, description

The expansion valve (evaporator) is the part in the circuit that separates the high-pressure side from the low-pressure side. The refrigerant arrives at the expansion valve under high pressure and leaves it under low pressure. After the expansion valve, the refrigerant converts to a gaseous state and is transported to the compressor once again.



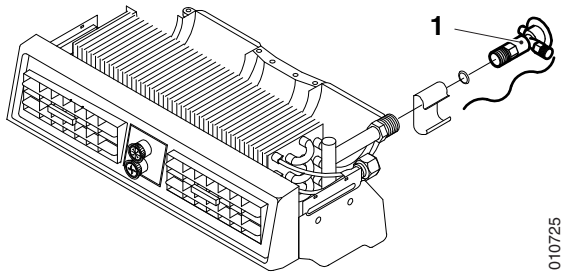
Cab Spirit Delta:
Expansion valve

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Cab Spirit Delta Space:
1. Expansion valve

The amount of refrigerant that passes the expansion valve varies depending on the heat load. The valve works from fully open to fully closed and searches between these for an optimal evaporation point.



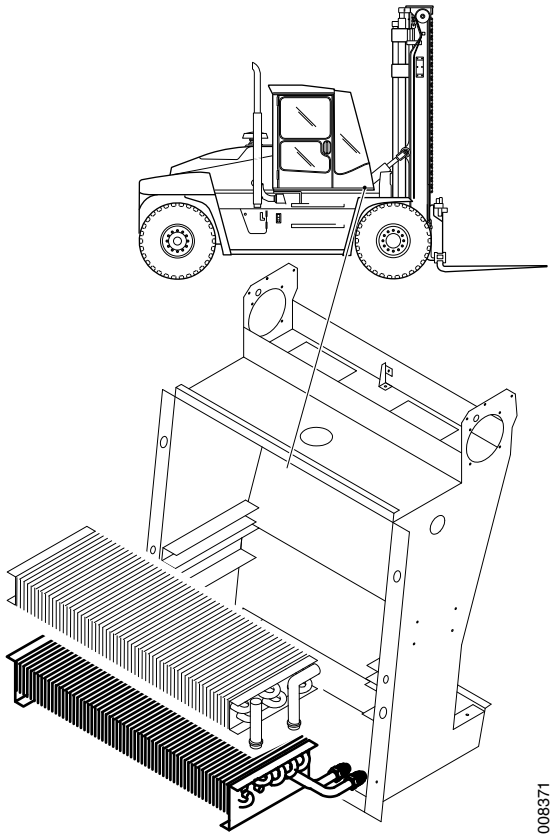
FlexCab:

1. Expansion valve

9.4.11 Evaporator

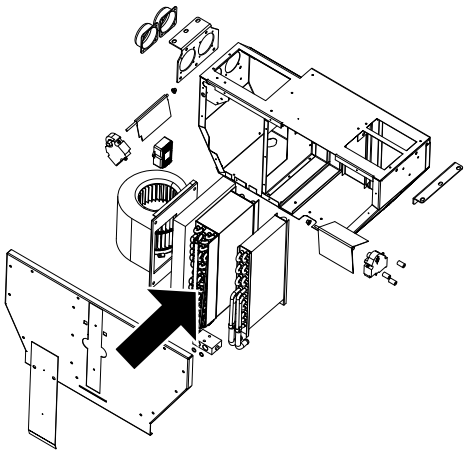
Evaporator, description

The evaporator consists of pipes that lead the refrigerant through cooling fins. Heat from the cab's air is transmitted through the fins to the refrigerant in the pipes.



Cab Spirit Delta:
Evaporator at bottom (located in fresh air intake to cab)

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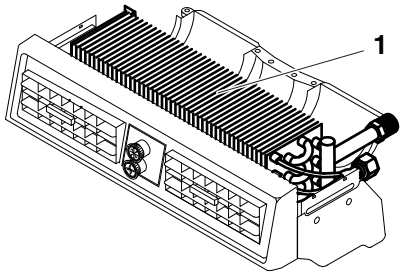


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Cab Spirit Delta Space:
Evaporator to the left (located in fresh air intake to cab)

The refrigerant circulates and returns to a gaseous state, becoming cold, and is drawn from the evaporator back to the compressor. The cycle has come full circle.

The evaporator sits under the heat exchanger for heat in the exterior unit for fresh air intake into the cab (between the tilt cylinders) on the Spirit Delta and Spirit Delta Space. On the FlexCab, it is in the cooling unit.



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FlexCab:

1. Evaporator

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Cooling evaporator, FlexCab, replacement

IMPORTANT

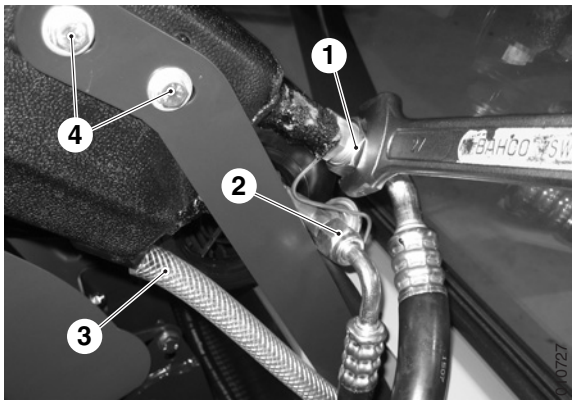
Working on the air conditioning requires special authorisation.

NOTE

It is extremely important to prevent contamination and foreign particles from ending up in the refrigerant circuit. For this reason, always replace the particle and moisture filter when any work is done on the refrigerant circuit.

1 Machine in service position.

2 Drain the AC system of R134a refrigerant.



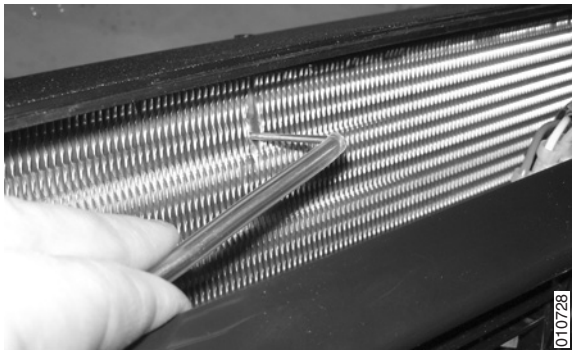
3 Detach the hoses from the expansion valve (2), the evaporator outlet connection (1) and the two drain hoses (3).

NOTE

Use a suitable tool to hold the pipe when removing the nut or tightening so as not to damage the evaporator.

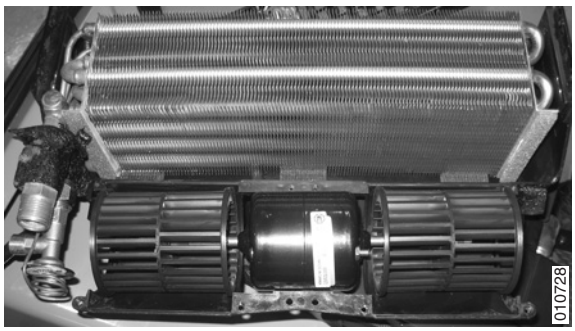
4 Detach the cooling unit from the mounting (4).

5 Remove the front of the cooling area (two screws).



6 Carefully pull out the thermostat's capillary tube and bend aside.

7 Remove the twelve screws holding the covers together and lift off the upper cover.



8 Remove the evaporator together with the expansion valve.

9 Remove the connection nut of the expansion valve from the inlet line of the evaporator. Remove the insulation from the evaporator outlet line, undo the clip that secures the capillary tube to the outlet line and remove the expansion valve from the evaporator.

10 Replace the evaporator.

11 Fit in the reverse order.

12 Use new O-rings when installing and replace the old particle and moisture filter before refilling the cooling system.

13 Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.

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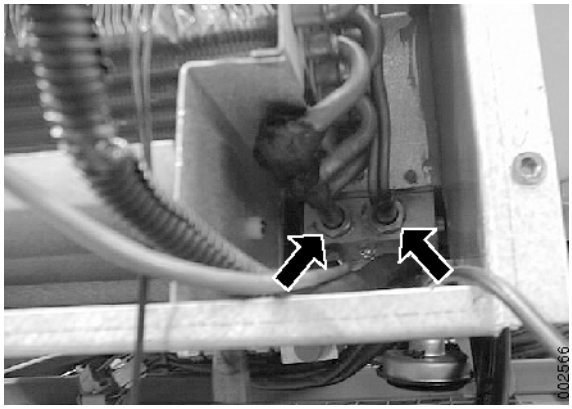
Cooling evaporator, Spirit Delta, replacement

IMPORTANT

Working on the air conditioning requires special authorisation.

NOTE

It is extremely important to prevent contamination and foreign particles from ending up in the refrigerant circuit. For this reason, always replace the particle and moisture filter when any work is done on the refrigerant circuit.



1 Machine in service position.

2 Remove the heat exchanger for heating as described under *Heat exchanger heat, Spirit Delta, replacement page 56*.

3 Drain the AC system of R134a refrigerant.

4 Remove the hoses from the expansion valve.

5 Detach the screw, that secure the expansion valve to the hosing

6 Carefully pull out the thermostat's capillary tube and bend aside.

7 Remove the evaporator together with the expansion valve.

8 Remove the two fitting nuts of the evaporator from the expansion valve.

9 De-icing sensor for ECC, see *Sensor for ECC, description page 72*, is located on the pipe under the insulation.

   a) Undo the insulation.

   b) Cut off the tie wrap that holds the de-icing sensor to the pipe.

   c) Remove the de-icing sensor from the pipe.

10 Replace the evaporator.

11 Fit in the reverse order.

12 Use new O-rings when installing and replace the old dryer and moisture filter before refilling the cooling system.

13 Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.

Evaporator, spirit Delta Space, replacement

IMPORTANT

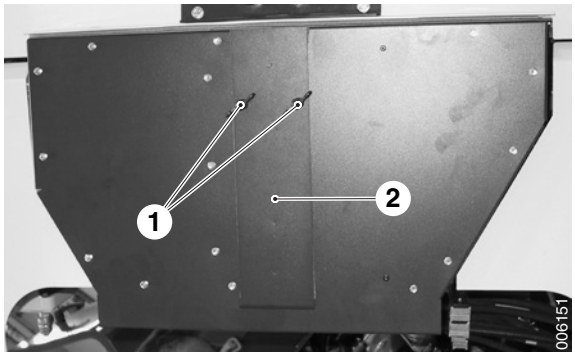
Working on the air conditioning requires special authorisation.

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NOTE

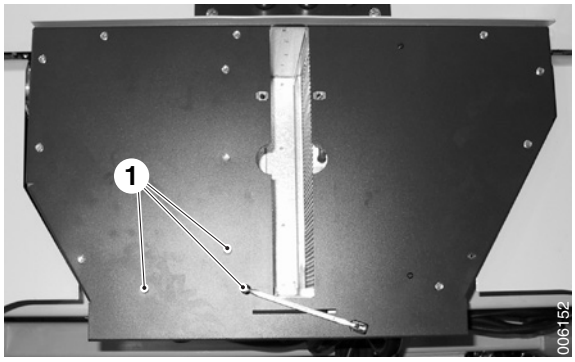
It is extremely important to prevent contamination and foreign particles from ending up in the refrigerant circuit. For this reason, always replace the particle and moisture filter when any work is done on the refrigerant circuit.

1 Machine in service position, see section *B Safety*.



1. Wing nuts.
2. Cover plate.

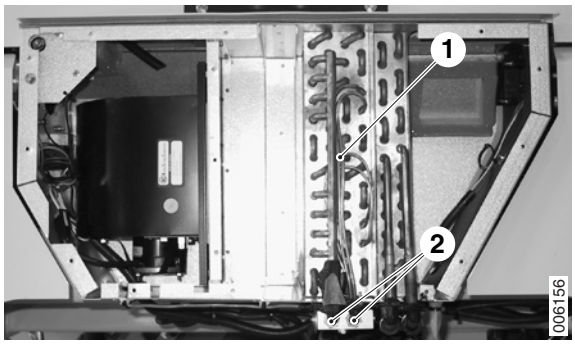
2 Undo the wing nuts, remove the cover plates and secondary filter.



1. Screws.

3 Remove the 15 screws securing the cover plate, remove the cover plate.

4 Drain the AC system of R134a refrigerant.



1. Heat exchanger cooling.
2. Connections.

5 Disconnect the fitting nuts to the expansion valve (position 2).

6 De-icing sensor for ECC is located on the pipe under the insulation.

a) Undo the insulation.

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b) Cut off the tie wrap that holds the de-icing sensor to the pipe.

c) Remove the de-icing sensor from the pipe.

7 Withdraw the evaporator from its rest position.

8 Replace the evaporator.

9 Fit in the reverse order.

10 Use new O-rings when installing and replace the old dryer and moisture filter before refilling the cooling system.

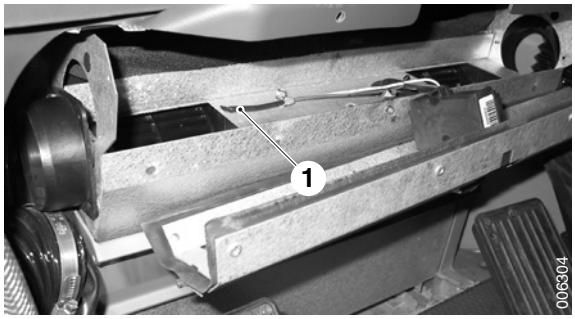
11 Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.

9.4.12 Sensor for ECC

Sensor for ECC, description

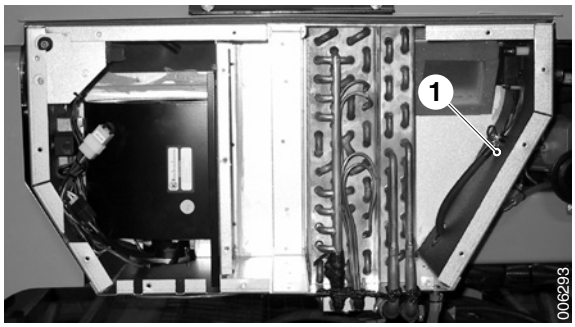
There are four sensors when the ECC climate unit is installed. The following sensors are installed:

1. Temperature in cab sensor, on a Spirit Delta, the interior sensor is installed on the left-hand edge of the instrument panel. On the Spirit Delta Space, it is in the airstream by the recirculation inlet to the climate unit.
2. The ambient temperature sensor is located on the left or right hand side of the rear edge of the roof so that it always senses the current outdoor temperature, without being affected by heat from the vehicle.



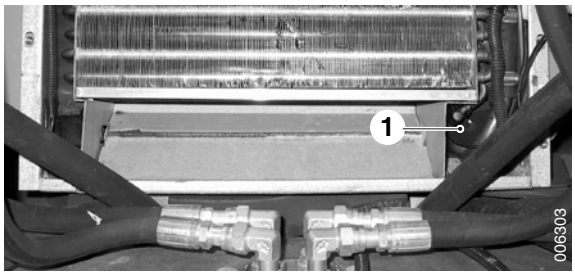
Spirit Delta
1) After coil sensor

3. The after coil sensor is integrated into the climate unit cables and is located in the air distribution outlet. The after coil sensor on the Spirit Delta is accessible from inside the cab, please refer to *Actuator motor, air distribution, Spirit Delta, replacement page 81*, and on the Spirit Delta Space it is accessible from outside the cab.

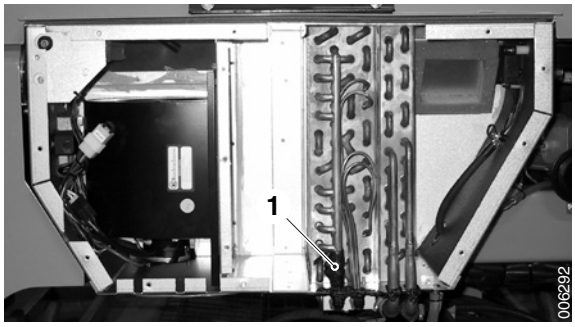


Spirit Delta Space
1) After coil sensor

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Spirit Delta
1) De-icing sensor



Spirit Delta Space
1) De-icing sensor

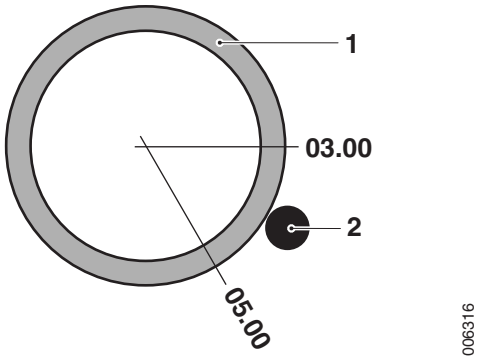


Figure 1
1) Pipe
2) De-icing sensor

4. The de-icing sensor is integrated into the climate unit cables and is located on the evaporator manifold, fixed with tie wraps to the pipe and insulated, accessible from outside the cab.

NOTE

When the de-icing sensor is replaced on a horizontal pipe, it is important that the de-icing sensor should be positioned between 03.00 and 05.00 o'clock (please refer to figure 1).

It is also very important for climate unit function that the de-icing sensor has full contact with the pipe, it is fixed to the pipe with a tie wrap and that insulation material is applied over the de-icing sensor and pipe.

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9.4.13 Control unit ECC

Control unit ECC, description

The ECC (Electronic Climate Control) control unit is located in the left-hand instrument panel. It controls the heating and cooling of the climate control system. The cab temperature is kept within a set range irrespective of the ambient temperature.

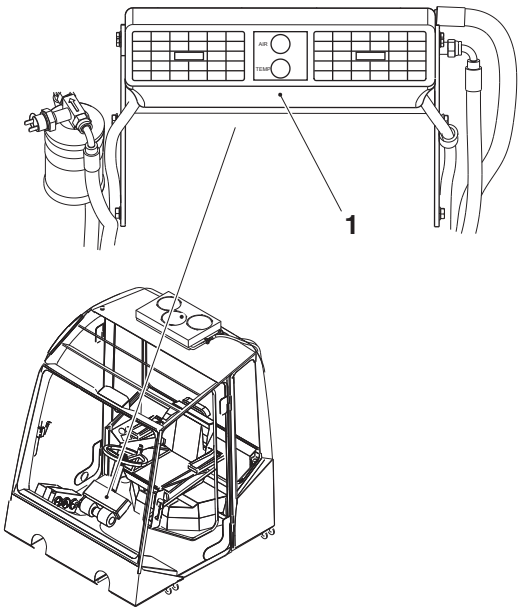
NOTE

Due to different applications, the control units are designed in different versions, dedicated for Spirit Delta respective for Spirit Delta SpaceCab

9.4.14 Air distributor

Air distributor, FlexCab, description

The air distributor distributes the air between the defroster and floor vents. The air distributor of the cooling unit is located in front of the steering panel and the air distributor of the heating unit is located in the front right corner of the cab.



1. Air distributor for cooling unit

Air distributor, Spirit Delta and Spirit Delta Space, description

The air distributor distributes air between the defroster and floor vents. It is installed on top of the climate unit, under the instrument panel.

9.4.15 Fine filter

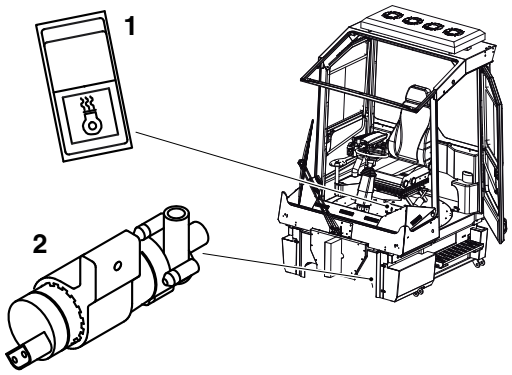
Fine filter, description

Only applies to Spirit Delta and Spirit Delta Space cabs.

The climate unit can be equipped with a fine filter, which delimits smaller particles, pollen etc. to contaminate the cabin air.

Machines with AC or ECC have a fine filter as standard equipment.

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1. Switch pause heater (S1019)
2. Circulation pump pause heater (M663)

9.4.16 Pause heater

Pause heater, description

Only applies to Spirit Delta and Spirit Delta Space cabs.

Pause heating is an option for the heating unit, which uses residual heat in the engine's cooling system to keep the cab warm.

An extra electrically operated water pump pumps the coolant through the heater unit when the engine is stopped. The cabin fan forces air into the cab. The pause heater is automatically switched off by a thermostat in coolant circuit when the coolant temperature is below a set temperature value. The pause heater is activated with the Pause Heater switch.

9.4.18 Cabin heater

Cabin heater, description

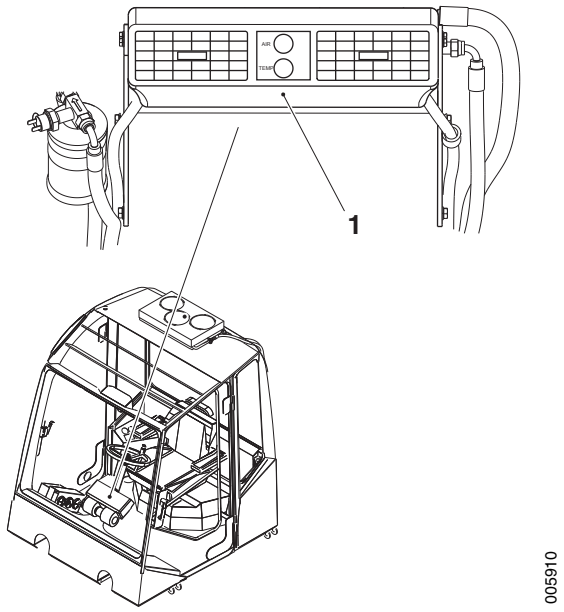
The machine can be equipped with an electric cabin heater. The cabin heater is connected to an electric socket installed in the cab.

When using an electric cabin heater, the machine must be parked and attached to a external electric socket.

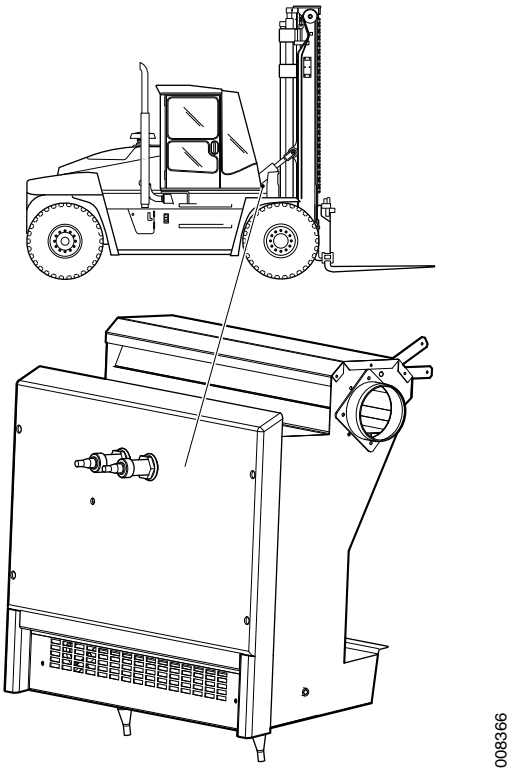
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9.4.20 Cooling unit

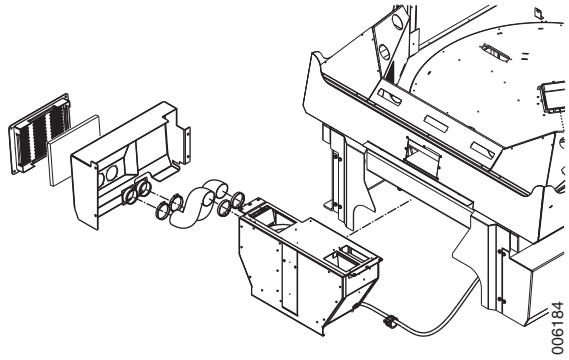
Cooling unit, description



1. Air conditioner, FlexCab



Air conditioner, Spirit Delta



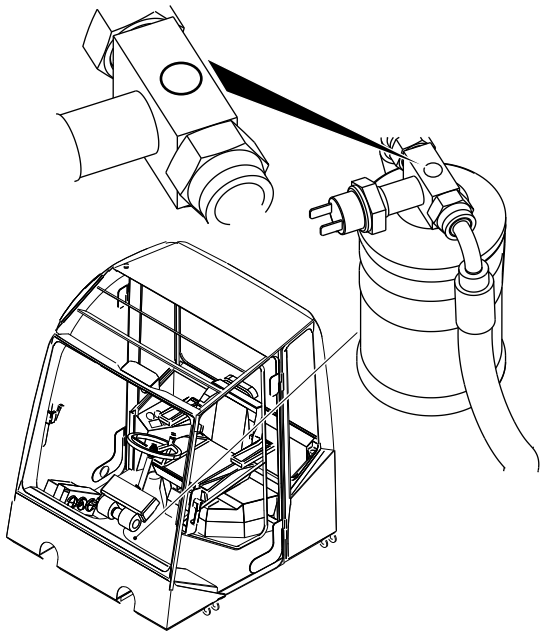
Air conditioner, Spirit Delta Space

The air conditioner is installed in the front of the cab and consists of an expansion valve, evaporator, fan, adjustable nozzles and controls. The refrigerant is evaporated in the cooling unit inside the cab. When the refrigerant is evaporated in the evaporator, the air which the cabin fan forces through the climate unit is cooled.

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9.4.21 Particle and moisture filter

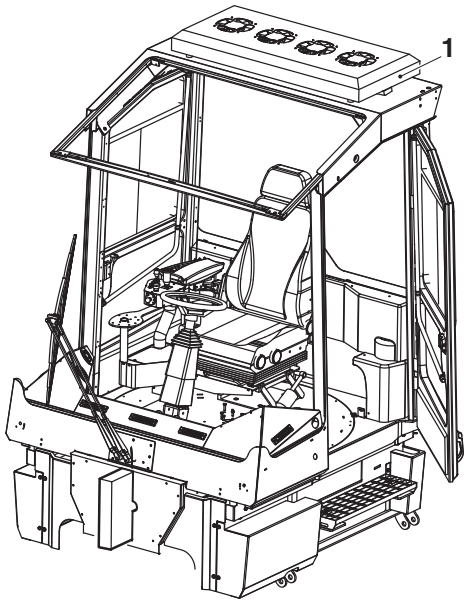
Particle and moisture filter, description



005384

FlexCab

The filter, which contains a particle trap and a hygroscopic medium, collects liquid refrigerant, binds moisture and filters contamination out. The housing functions as an expansion vessel in the cooling circuit.



006158

Spirit Delta and Spirit Delta Space.

When refrigerant passes through the absorption and filter material, it collects in the bottom of the fluid reservoir, from which it is pumped through an immersion tube. You can look through a viewing glass to check that there are no bubbles in the flow, and that the system is sufficiently filled with refrigerant.

The particle and moisture filter is a component not normal subject to wear and not normally requiring replacement. Only replaced when working in the coolant circuit, e.g. when replacing other components requiring that the coolant circuit be open for awhile or there is a risk that the opened coolant circuit has been contaminated with foreign particles.

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Particle and moisture filter, FlexCab, replacement

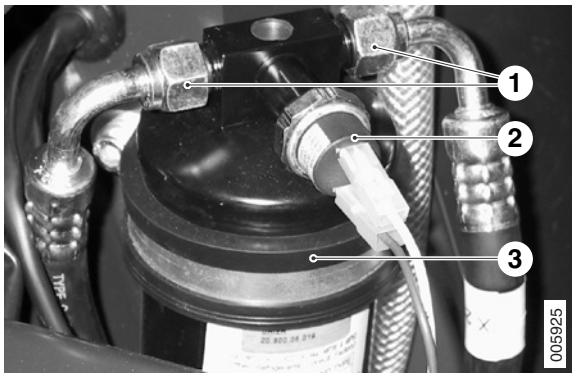
IMPORTANT

Working on the air conditioning requires special authorisation.

NOTE

It is extremely important to prevent contamination and foreign particles from getting into the refrigerant circuit.

The filter is filled with nitrogen under pressure on delivery and is plugged to ensure that no moisture is absorbed. For this reason, never remove the plugs until you are just about to connect it to the coolant circuit (open connections can allow the absorbent material to become saturated with moisture after only a few hours).



1. Connections
2. High/low pressure sensor
3. Clamp

1. Machine in service position, see section *B Safety*.
2. Drain the R134a refrigerant out of the AC system.
3. Undo the connections for the coolant hoses.
4. Plug the hoses to avoid contamination of the refrigerant circuits.
5. Undo the connections for the high/low pressure sensor
6. Undo the clamps which hold the particle and moisture filter.
7. Remove the filter.
8. Unscrew and remove the high/low pressure sensor

NOTE

The high/low pressure sensor is installed on the drying filter pipe, via a valve built into the pipe, which allows it to be replaced without having to empty the refrigerant. So, to just replace the high/low pressure monitor:

A. Undo the cable connectors.

B. Unscrew the high/low pressure sensor.

C. Screw in a new high/low pressure sensor and refit the cable terminals.

9. Install the sensor in the new particle and moisture filter.
10. Fit in reverse order.
11. Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.
12. Check the function of the system.

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Particle and moisture filter, Spirit Delta and Spirit Delta Space, replacement

IMPORTANT

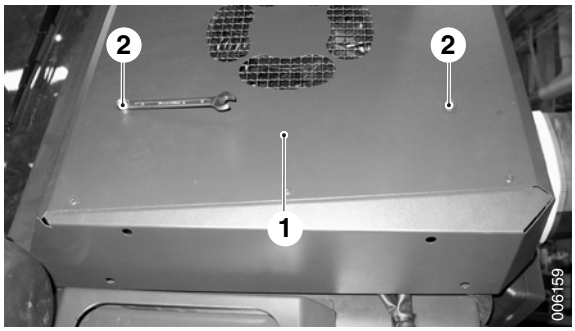
Working on the air conditioning requires special authorisation.

NOTE

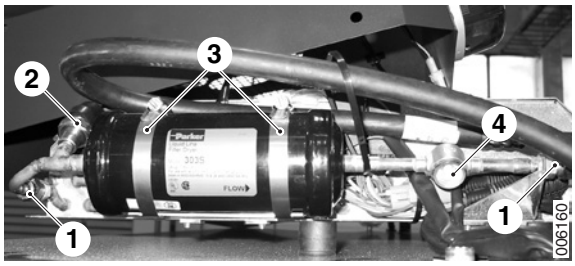
It is extremely important to prevent contamination and foreign particles from getting into the refrigerant circuit.

The filter is filled with nitrogen under pressure on delivery and is plugged to ensure that no moisture is absorbed. For this reason, never remove the plugs until you are just about to connect it to the coolant circuit (open connections can allow the absorbent material to become saturated with moisture after only a few hours).

1. Machine in service position, see section *B Safety*.
2. Drain the R134a refrigerant out of the AC system.
3. Remove the four screws holding the housing over the condenser.



1. Screws
2. Condenser housing



1. Connections
2. Pressure switch
3. Clamp
4. Sight glass

4. Undo the connections for the coolant hoses.
5. Plug the hoses to avoid contamination of the refrigerant circuits.
6. Undo the connections for the high/low pressure sensor
7. Undo the clamps which hold the particle and moisture filter.
8. Remove the filter.
9. Unscrew and remove the high/low pressure sensor

NOTE

The high/low pressure sensor is mounted in the receiver dryer pipe via a valve integrated in the pipe. This means that it can be replaced without having to drain the refrigerant. Do as follows to replace the high/low pressure sensor only:

A. Undo the cable connectors

B. Unscrew the high/low pressure sensor

C. Screw in a new high/low pressure sensor and refit the cable terminals.

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10. Install the sensor in the new particle and moisture filter.
11. Fit in reverse order.
12. Using vacuum equipment, refill the system with R134a refrigerant and test for leaks.
13. Check the function of the system.

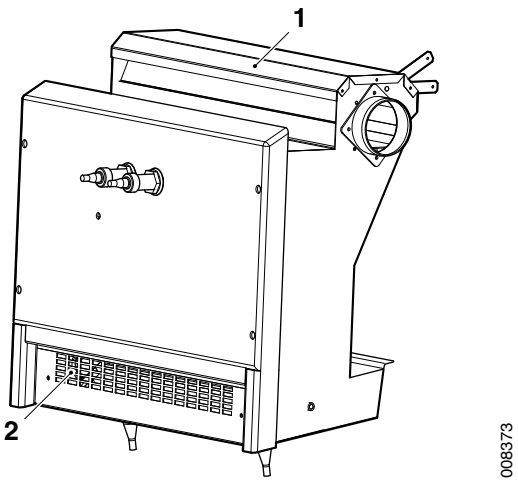
9.4.22 Actuator motor

Actuator motor, description

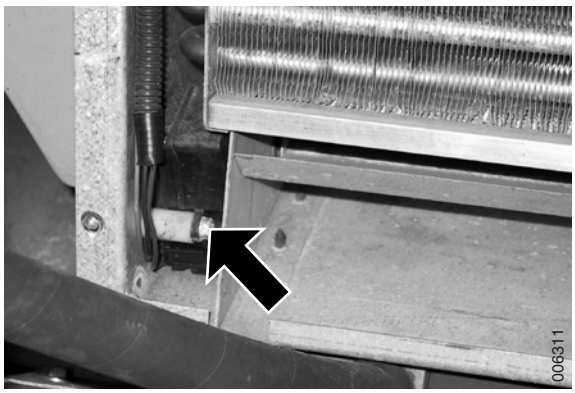
The climate unit with ECC or AC is equipped with actuators which controls distribution of fresh air/recirculation respectively air distribution inside the cab.

Actuator motor, Fresh Air, Spirit Delta, replacement

1. Machine in service position, see section *B Safety*.
2. Remove the cover plate holding the wiper motor, washer fluid hose and the grille for the fresh air intake., See *Heat exchanger heat, Spirit Delta, replacement page 56*.



1. Actuator motor, air distribution
2. Actuator motor, fresh air

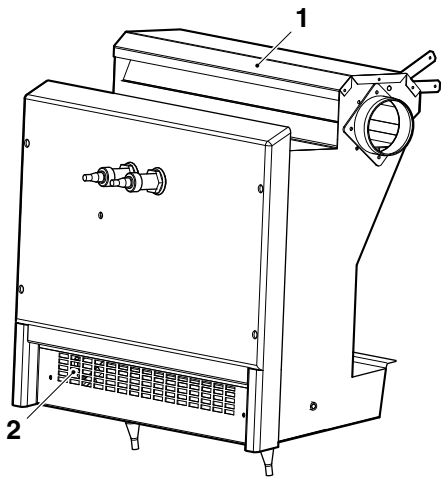


3. Undo the connector and remove the two screws which hold the fresh air actuator motor (position 2), remove and replace the fresh air actuator motor.
4. Fit in the reverse order.

NOTE

Be careful when installing the front of the climate unit, to ensure that no electric cables are pinched or damaged.

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1. Actuator motor, air distribution
2. Actuator motor, fresh air

Actuator motor, air distribution, Spirit Delta, replacement

1. Allows access to the climate unit from inside the cab, please refer to *Interior plastic components, replacement page 131*, by:

   a) Undoing the steering column and folding it backwards.

   b) Undoing and lifting up the top front instrument panel.

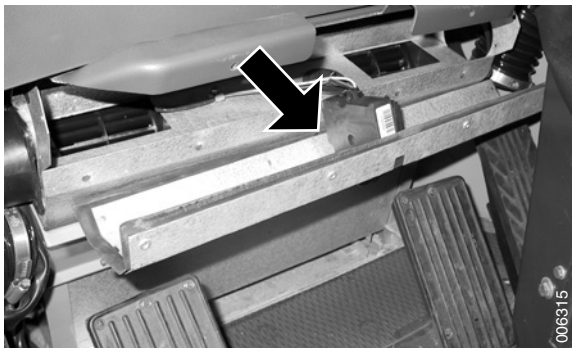
   c) Undoing and removing the plastic cover in front of the pedal arrangement, please refer to *Interior plastic components, replacement page 131*.





2. Cut off the four pop rivets which fix the top section on each side of the climate unit, using a cold chisel etc.

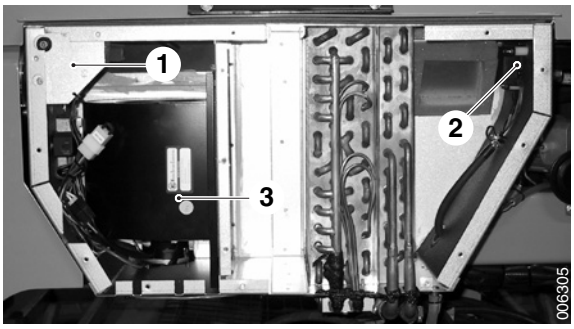
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3. Lift out and fold forwards the top part of the climate unit, on which the air distribution actuator (position 1) is located.
4. Undo the screw which holds the air distribution actuator motor (1) on the top part of the climate unit and replace the air distribution actuator motor.
5. Fit in the reverse order.

Actuator motor, fresh air Spirit Delta Space, replacement

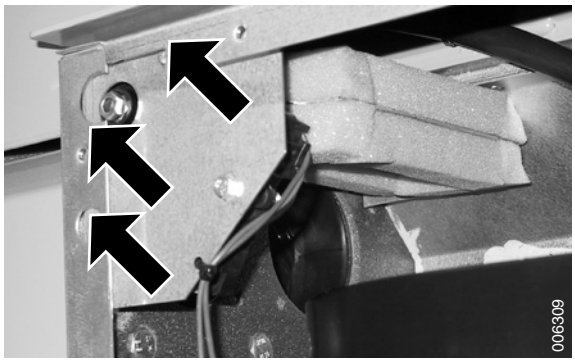
1. Machine in service position, see section *B Safety*.
2. Undo the wing nuts, remove the cover plates and secondary filter.
3. Remove the 15 screws securing the cover plate, remove the cover plate.



1. Actuator motor, fresh air
2. Actuator motor, air distribution
3. Cab fan



4. Undo the connector and remove the two screws which fix the cab fan (position 3). Remove the cab fan.

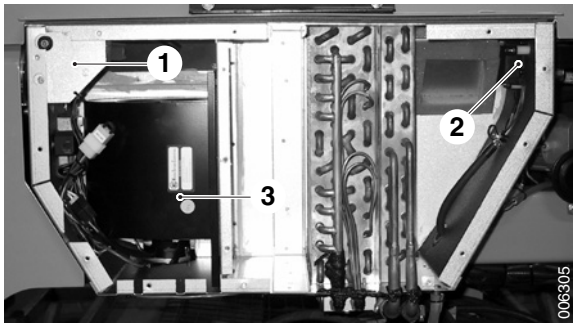


5. Undo the connector and undo the three anchorages for the adapter plate that the fresh air actuator motor (position 1) is fixed to.
6. Remove the adapter plate and the fresh air actuator motor (position 1).
7. Unscrew the fresh air actuator motor (position 1) from the adapter plate and screw a new fresh air actuator motor onto the adapter plate.
8. Fit in the reverse order.

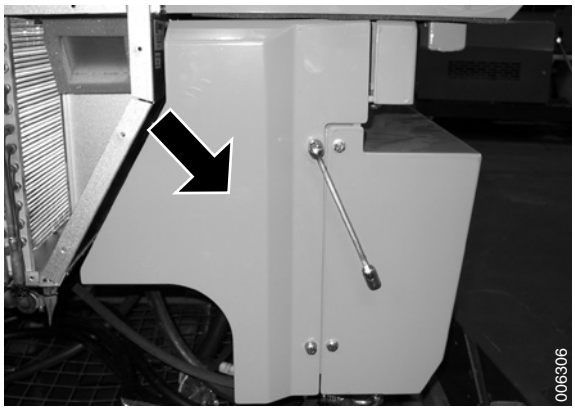
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Actuator motor, air distribution, Spirit Delta Space, replacement

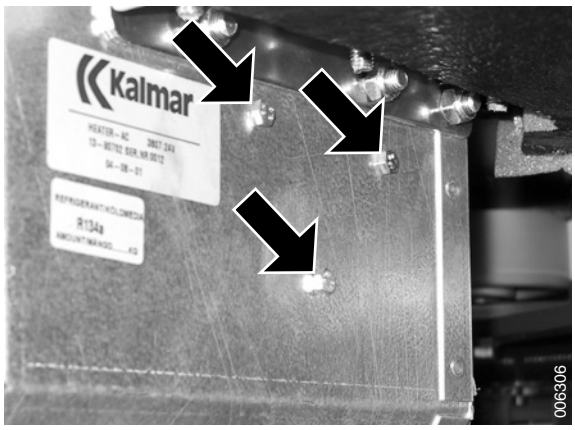
1. Machine in service position, see section *B Safety*.
2. Undo the wing nuts, remove the cover plates and secondary filter.
3. Remove the 15 screws securing the cover plate, remove the cover plate.



1. Actuator motor, fresh air
2. Actuator motor, air distribution
3. Cab fan

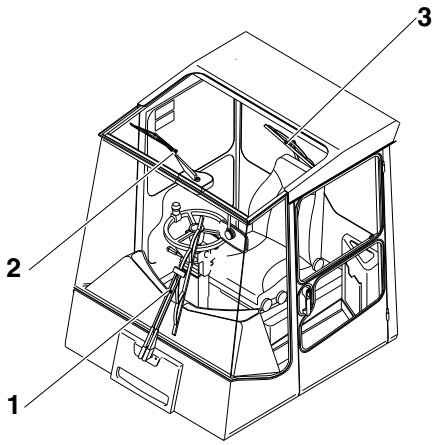


4. Remove the two screws which fix the cover plate on the front of the cab, on the left of the climate unit.



5. Undo the connector and remove the three screws which hold the air distribution actuator motor (position 2), replace the air distribution actuator motor.
6. Fit in the reverse order.

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1. Wiper, front
2. Wiper, roof
3. Wiper, rear

9.5 Wiper/washer system

Wiper/washer system, description

Spirit Delta and Spirit Delta Space cab have wipers for front, rear and roof windows.

On open cab with weather protecting windows as well as on cab there are wipers for front, rear and roof windows.

The wiper arm is secured at the wiper arm motor shaft over a grooved cone. The shaft is produced from hardened steel and the wiper arm bracket of soft compression mouldings.

When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened so hard that the grooves are pressed into the bracket and work as drivers. When fitting, hold against the wiper arm so that the force is not transferred to the wiper motor which could be damaged.

9.5.1 Wiper front

Wiper, front, description

These wipers are of the parallel wiper type.

9.5.2 Wiper roof

Wiper, roof, description

(+) (Standard equipment for Spirit Delta Space). Sector wiper with approx. 180 degree wiping angle. An optional wiper unit of the parallel wiper type is available for Spirit Delta and Spirit Delta Space (see *Wiper, front, description page 84*.

(+) On the Spirit Delta, there is also a side-mounted roof wiper. (Standard equipment for Spirit Delta Space).

9.5.3 Wiper rear

Wiper, rear, description

The wipers for Spirit Delta are of the same model as the wiper for the roof (sector wipers).

The wipers for Spirit Delta Space are of the same type as the wiper for the roof but a different model (sector wipers).

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9.5.4 Washer motor and reservoir

Washer motor and reservoir, description

The washer motor is located in the washer fluid reservoir. The reservoir is located at the centre of the fire wall in front of the engine compartment (accessible when the engine hood is open). There are non-return valves on the lines from the reservoir to the wiper arms. The nozzles are mounted on the wiper arms.

Washer motor and reservoir, replacement

1 Machine in service position, see section *B Safety*.

2 Unscrew the reservoir and empty out the washer fluid.

3 Remove the hoses from the pumps.

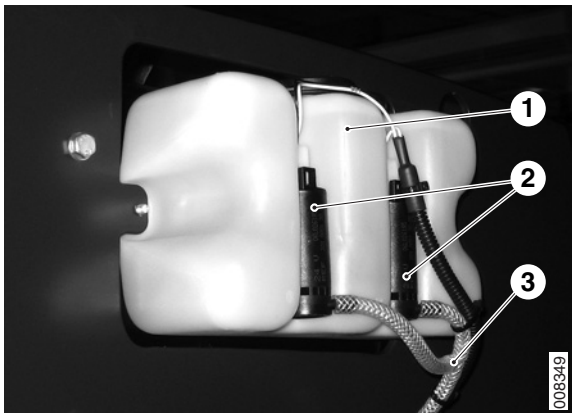
4 Undo the connector on the electric cable for the pumps.

5 Remove the pumps from the reservoir. A rubber bushing seals between the pumps and the reservoir.

6 Replace the pump.

7 Fit in reverse order.

8 Fill the reservoir up with screenwasher fluid.



1. Reservoir
2. Pumps
3. Hoses

9.5.5 Wiper motor, front

Wiper motor, front, description

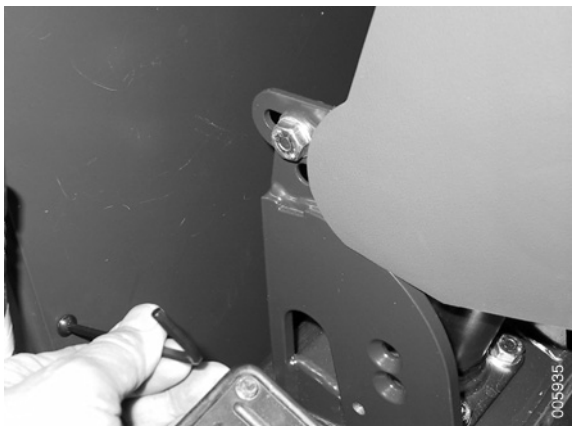
The wiper motor drives the windscreen wipers. The wiper arm is mounted directly on the motor. The motor produces the movement of the wiper.

Wiper motor, front, FlexCab, replacement

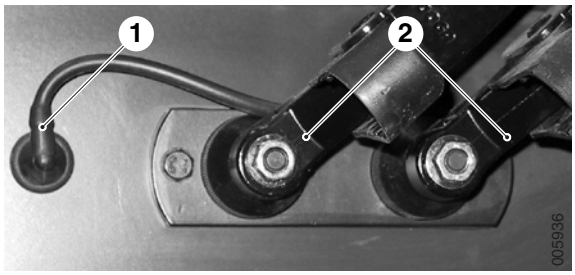
1 Machine in service position, see section *B Safety*.

2 Remove the screws securing the cover plate in front of the steering column. Remove the cover plate.

3 Unplug the wiper motor connectors.



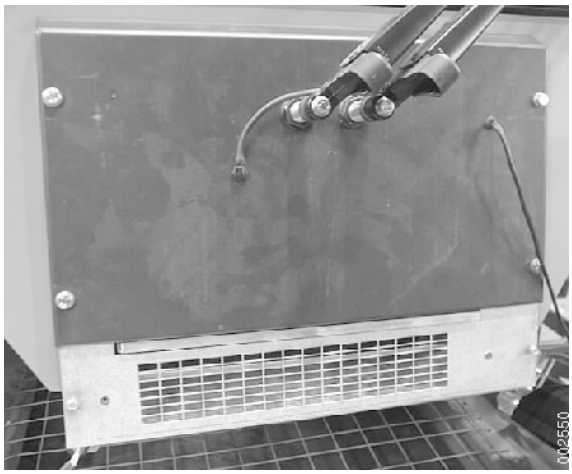
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1. Washer hose
2. Wiper arm



1. Screw
2. Locknut



4 Disconnect the washer hose.

5 Remove the wiper arms.

6 Remove the screw and lock nut.

7 Remove the wiper motor from the inside.

8 Fit in the reverse order.

NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

Wiper motor, front, Spirit Delta, replacement

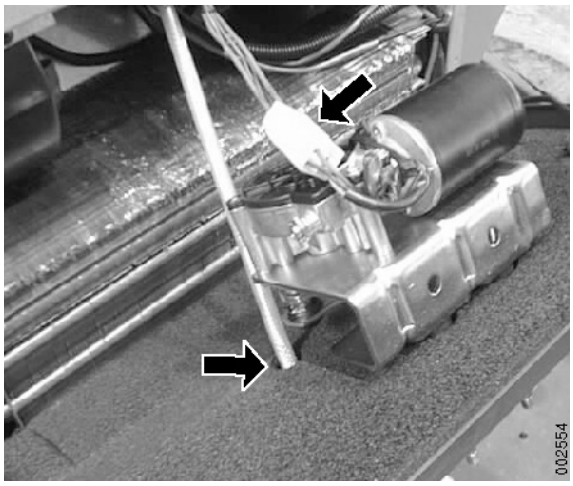
1 Machine in service position, see section *B Safety*.

2 Raise the nut protector and remove the nut securing the wiper arm (two nuts).

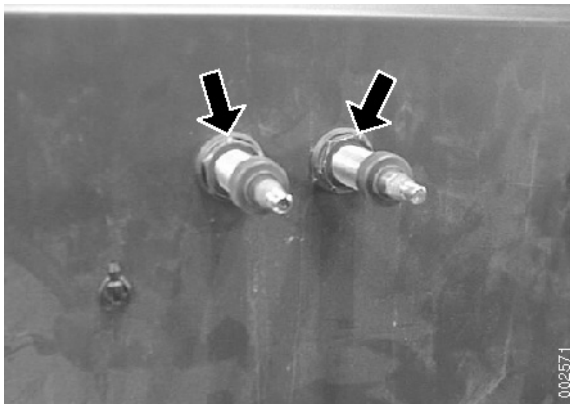
3 Remove the four screws securing the cover plate.

4 Disconnect the washer hose.

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5 Remove the washer fluid hose and unplug the connector from the wiper motor.



6 Remove the two nuts securing the motor to the cover plate.

7 Replace the wiper motor.

8 Fit in the reverse order. Tighten the wiper arms to 16-20 Nm.

NOTE

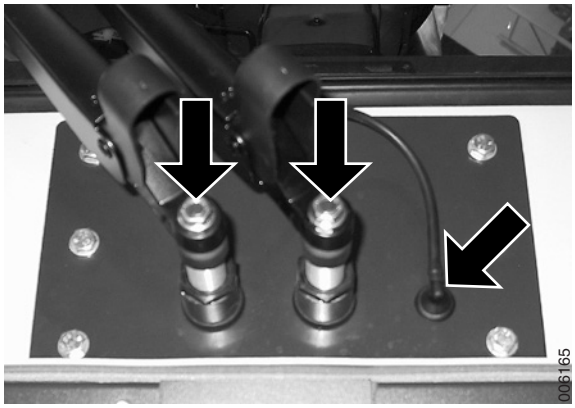
*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

Wiper motor, front, Spirit Delta Space, replacement

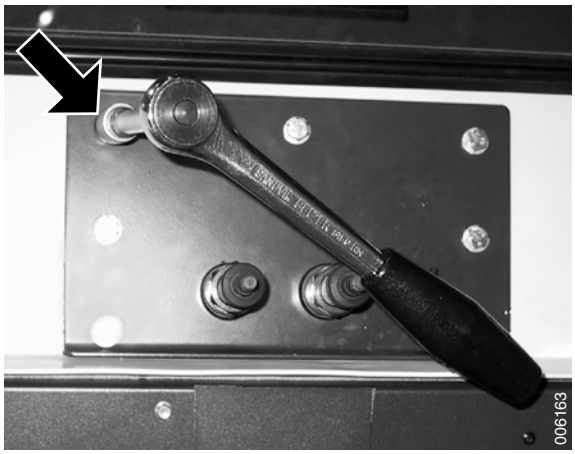
1 Machine in service position, see section *B Safety*.

2 Raise the nut protector and remove the nut securing the wiper arm (two nuts).

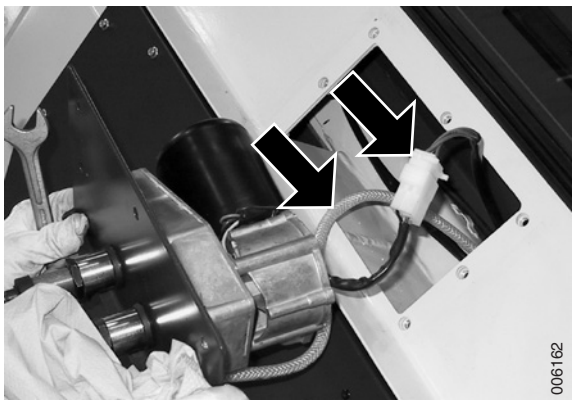
3 Disconnect the washer hose.



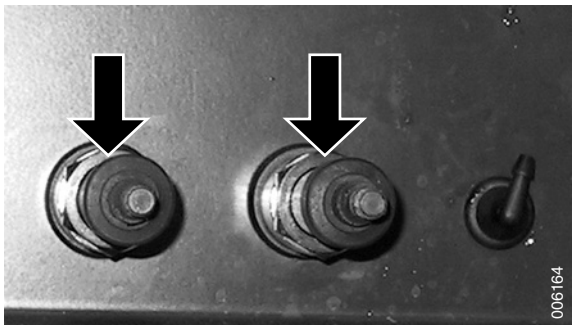
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4 Remove the seven screws securing the cover plate.



5 Remove the washer fluid hose and unplug the connector from the wiper motor.



6 Remove the two nuts securing the motor to the cover plate.

7 Replace the wiper motor.

8 Fit in the reverse order. Tighten the wiper arms to 16-20 Nm.

NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

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9.5.6 Wiper motor, roof

Wiper motor, roof, description

(Standard equipment for Spirit Delta Space). The wiper motor drives the roof wiper. The wiper arm is mounted directly on the motor. The motor produces the movement of the wiper.

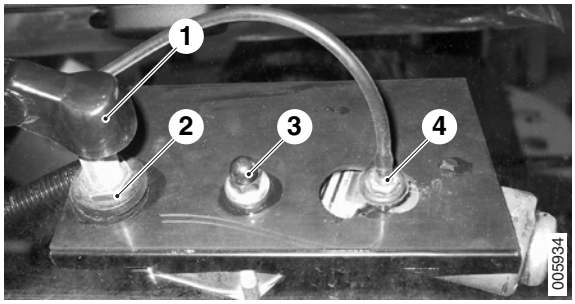
Wiper motor, roof, FlexCab, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the plastic cover over the wiper motor, inside the cab.

3 Unplug the wiper motor connectors.





1. Wiper arm
2. Locknut
3. Domed nut
4. Washer hose

4 Remove the wiper arm.

5 Remove the washer fluid hose.

6 Remove the locknut and domed nut.

7 Remove the wiper motor from the inside.

8 Fit in the reverse order.

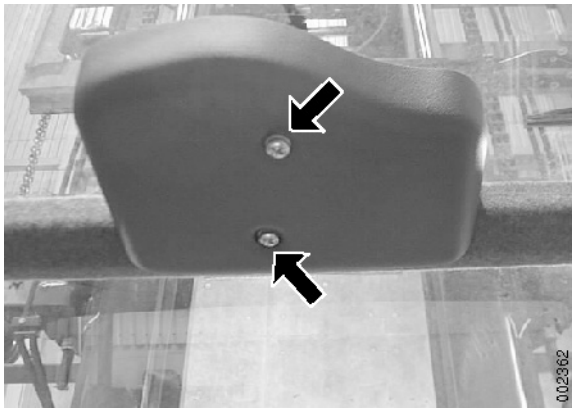
NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

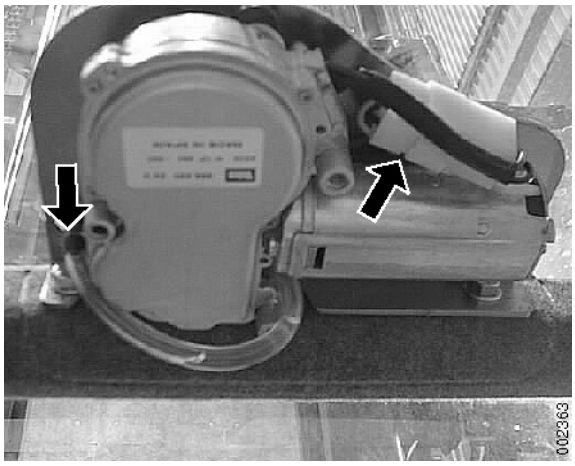
Wiper motor, roof, Spirit Delta, replacement

1 Machine in service position, see section *B Safety*.

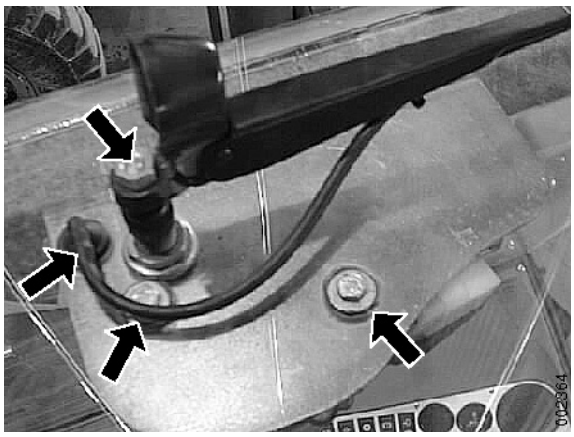
2 Remove the two screws securing the plastic cover to the wiper motor.



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3 Disconnect the washer hose and the wiper motor connector.



4 Undo the lock nut securing the wiper arm and disconnect the washer fluid hose.

5 Remove the two screws securing the wiper motor.

6 Replace the wiper motor.

7 Fit in the reverse order. Tighten the wiper arm to 16-20 Nm.

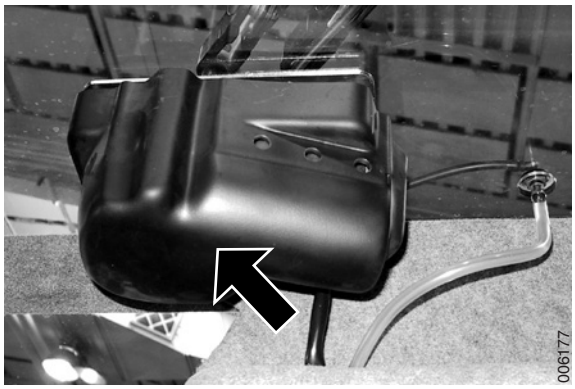
NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

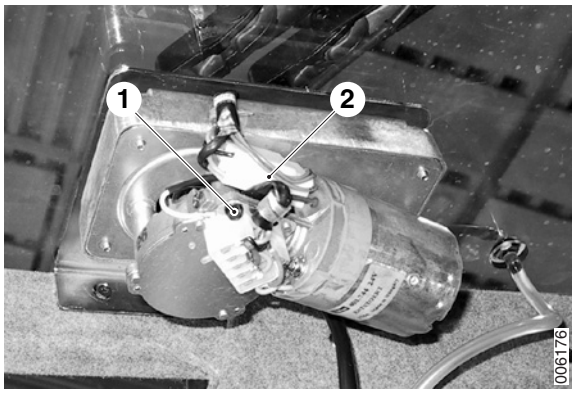
Wiper motor, roof, Spirit Delta Space and side mounted roof wiper for Spirit Delta, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the plastic cover from the wiper motor.

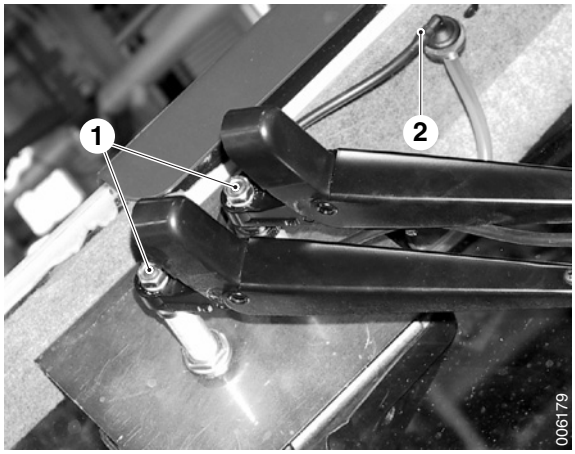


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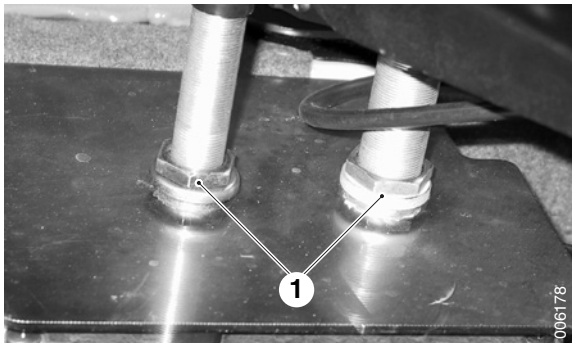
1. earth cable
2. Wiper motor connector

3 Unplug the wiper motor connector and earth cable.



1. Lock nut
2. Washer fluid hose

4 Undo the lock nut securing the wiper arm and disconnect the washer fluid hose.



1. Nuts

5 Remove the two nuts securing the wiper motor.

6 Replace the wiper motor.

7 Fit in the reverse order. Tighten the wiper arm to 16-20 Nm.

NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

9.5.7 Wiper motor, rear

Wiper motor, rear, description

The wiper motor drives the rear window wiper. The wiper arm is mounted directly on the motor. The motor produces the movement of the wiper.

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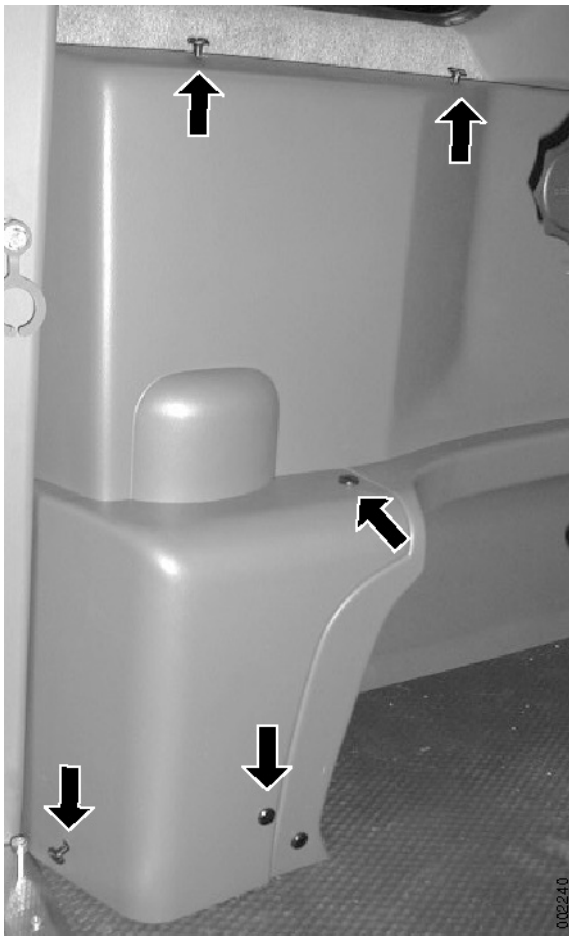
Wiper motor, rear, FlexCab, replacement

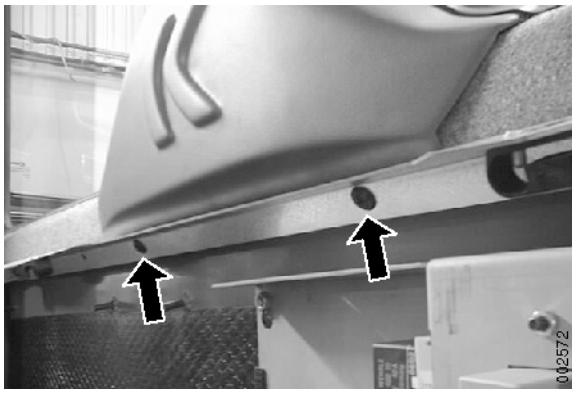
See *Wiper motor, roof, FlexCab, replacement page 89*.

Wiper motor, rear, Spirit Delta, replacement

1 Machine in service position, see section *B Safety*.

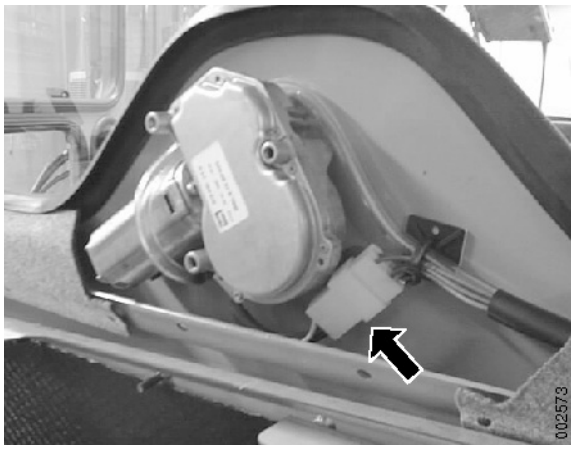
2 Remove the upper panels behind the operator's seat.





3 Remove the two screws securing the plastic cover over the wiper motor.

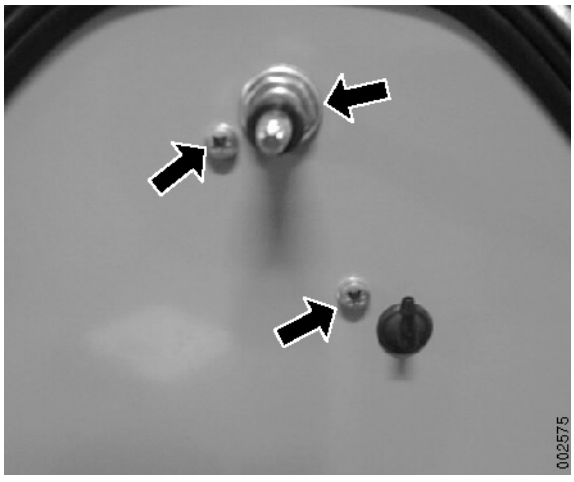
https://truckmanualshub.com/



4 Unplug the connector from the motor.



5 Raise the plastic cover and remove the nut securing the wiper arm. Disconnect the washer hose.



6 Remove the two screws securing the motor and the lock nut on the motor.

7 Replace the wiper motor.

8 Fit in the reverse order. Tighten the wiper arm to 16-20 Nm.

NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

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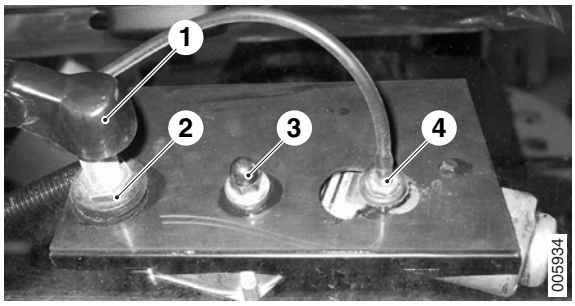
Wiper motor, rear, Spirit Delta Space, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the plastic cover over the wiper motor, inside the cab.

3 Undo the cable connector.





1. Wiper arm/protective cap
2. Locknut
3. Domed nut
4. Screenwasher fluid hose

4 Fold away the plastic protective cap and undo the nut, remove the wiper arm.

5 Remove the screenwasher fluid hose.

6 Remove the locknut and domed nut.

7 Remove the wiper motor from the inside.

8 Fit in the reverse order.

NOTE

*When fitting it is important to ensure that the grooves are free from metal filings or similar. In addition, the nuts must be tightened with **16-20 Nm**, that makes the grooves pressed into the bracket and work as drivers.*

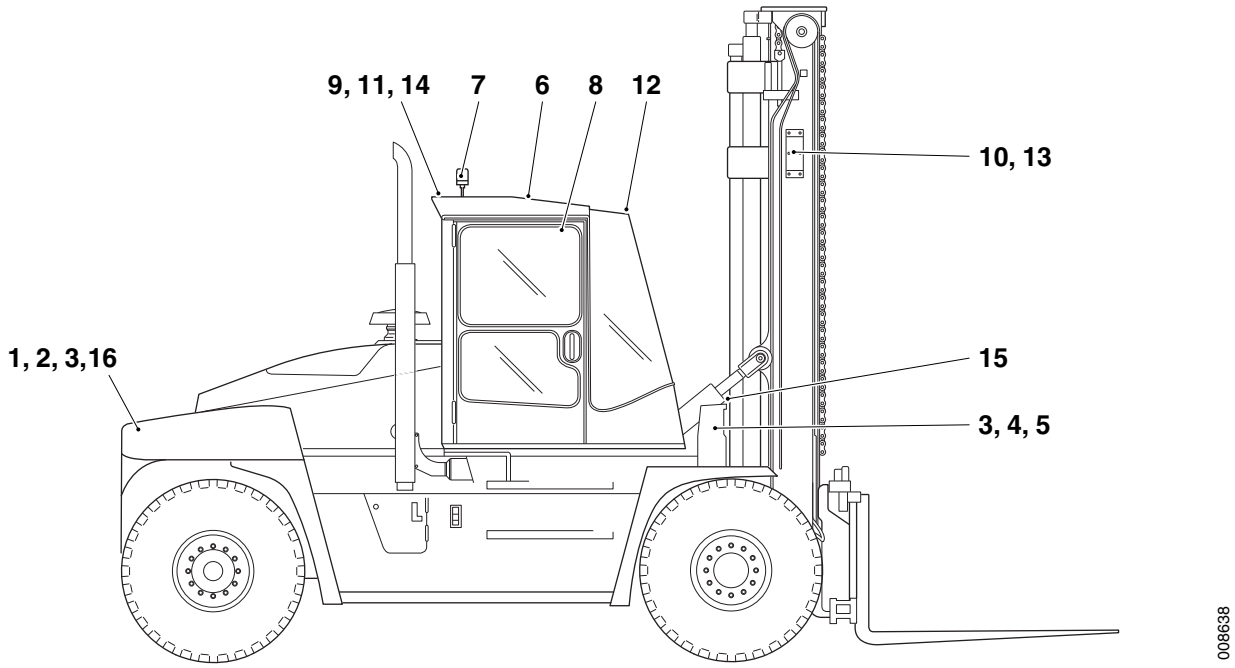
https://truckmanualshub.com/

9.6 Lighting system

Lighting system, description

The function of the lighting is to increase safety during operation and load handling.

The following lighting is fitted to the machine:



1. Rear lights, red
2. Brake light
3. Driving direction indicator
4. Headlight
5. Rear lights, red and Brake light ⊕
6. Manoeuvrable spot lamp ⊕
7. Rotating warning light
8. Interior lightning
9. Working lamps (reversing light), cab roof, rear edge, 2 lamps
10. Working lamps (reversing light ⊕), mast, 2 lamps
11. Extra working lamps cab roof rear edge, 2, 4 or 6 lamps ⊕ back
12. Extra working lamps for cab roof front edge, 2 lamps ⊕
13. Extra working lamps, mast, 2 lamps ⊕
14. Extra working lamps for container handling, 4 lamps, ⊕
15. Extra working lamps between tilt cylinders, 1 lamp ⊕
16. Headlight ⊕

NOTE

It is important that the right type of lamp is used for each area. See section F Technical data.

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9.6.1 Headlights

Headlights, description

There are headlights at the front end of the machine to give operators added visibility when operating in the dark, as well as to give others in traffic and the surroundings an indication of the machine's position. Headlights have a high beam and a dipped beam (to prevent glaring other road-users).

The headlights are turned on with a switch on the instrument panel.

The headlights switch between high and dipped beam using the multi-function lever.

NOTE

The reversible driver's station option includes headlights at both ends of the machine. The headlights are activated in the relevant direction so that the headlights are always lit in front of the operator.

9.6.2 Position light

Position light, description

There are position lights on the right and left side of the machine to give others in traffic and the surroundings an indication of the machine's position.

The position lights are activated with the same switch as the headlights.

9.6.3 Tail light

Tail light, description

There are tail lights at the back of the machine to give others in traffic and the surroundings an indication of the machine's position in the dark.

NOTE

The reversible driver's station option includes tail lights at both ends of the machine. The tail lights are activated in the relevant direction so that the tail lights are always lit behind the operator.

9.6.4 Brake light

Brake light, description

There are brake lights at the back of the machine to give others in traffic and the surroundings an indication that the machine is braking and is thus reducing speed.

NOTE

The reversible driver's station option includes brake lights at both ends of the machine. The brake lights are activated in the relevant direction so that the brake lights are always lit behind the operator.

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9.6.5 Reversing light

Reversing light, description

There are reversing lights at the back of the machine to give others in traffic and the surroundings an indication that the machine is reversing. Reversing lights also provide the operator improved visibility when operating in the dark.

Reversing lights are activated when reverse is engaged.

NOTE

The reversible driver's station option includes reversing lights at both ends of the machine. The reversing lights are activated in the relevant direction so that the reversing lights are always lit behind the operator.

9.6.6 Driving direction indicator

Driving direction indicator, description

There are indicators on both the front and the rear of the machine, to give other road users and the environment an indication that the machine is about to change direction of travel, i.e. turn.

The indicators are controlled by using the indicator switch (lever), and is indicated with a green indicator lamp on the steering panel.

9.6.7 Warning lamp, Hazard

Warning lamp, Hazard, description

The machine is equipped with hazard warning flashers, which means that by pressing a switch, all the indicator lamps can be made to flash at the same time, to show others that there is danger, such as a mechanical failure.

9.6.8 Rotating beacon

Rotating beacon, description

⊕

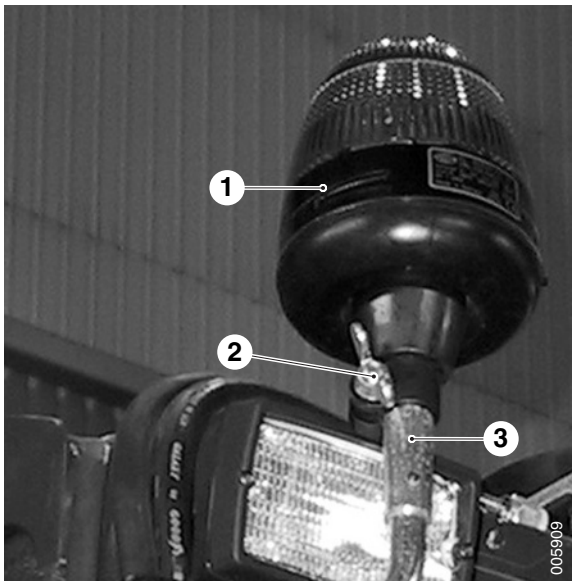
The rotating beacon is located up high on the cab roof and there are two versions, roof mounted and pole mounted. Used to give others in traffic and the surroundings an indication that the machine is moving and working. Indication to bystanders to take caution.

Available as an option is a rotating beacon in combination with flashing direction indicators front and rear. ⊕

The function is activated with a switch on the instrument panel, where the symbol flashes at the same rate as the direction indicators. A relay generates the direction indicator and hazard light function.

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Rotating beacon, pole mounted, replacement



1. Rotating beacon
2. Wing nut
3. Pole

1. Machine in service position, see section *B Safety*.
2. Undo the wing nut which fixes the rotating beacon to the pole.
3. Lift the rotating warning beacon off.
4. Install the new rotating beacon.
5. Tighten the wing nut.

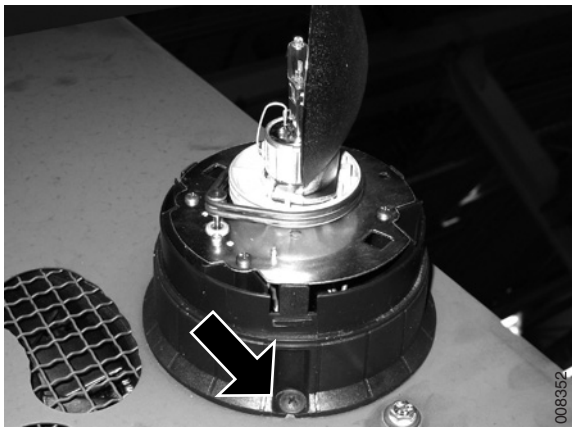
Rotating beacon, roof mounted, replacement



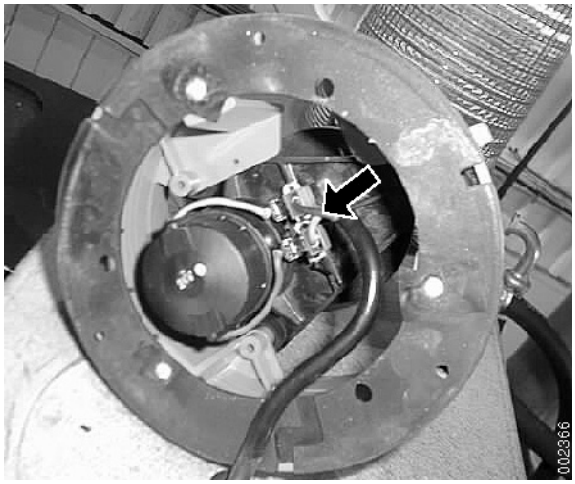
1 Machine in service position, see section *B Safety*.

2 Turn the lamp dome counter-clockwise.

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3 Remove the screws securing the lamp base.



4 Unplug the connector.

5 Replace the beacon.

6 Fit in the reverse order.

9.6.9 Working lights, mast

Mast working lights, description

These working lights are located on the mast and provide better vision for load handling in the dark.

The working lights are turned on with a switch on the instrument panel.

On machines with reversible operator's seat or reversible driver's station the working lights will become reversing lights, when the driver shifts working direction and has the back against the mast.

Additional work lights can be installed for increased illumination.

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9.6.10 Working lights, cab

Working lights, cab, description

These working lights are located on the cab and provide better vision for load handling in the dark.

The working lights are turned on with a switch on the instrument panel.

On machines with reversible operator's seat or reversible driver's station the working lights will become reversing lights, when the driver shifts working direction and has the back against the mast.

Additional work lights can be installed for increased illumination. Various numbers and designs are available as options, which can be located on the front or rear of the cab roof and/or the front panel of the cab. ⊕

9.6.11 Interior lighting

Interior lighting, description

Interior lighting lights the cab up, and is selected by the interior lighting switch.

There is background illumination in all switches, function keys and rotary controls. This is so that the driver will be able to read their functions and settings in darkness.

⊕ A reading lamp is mostly installed together with a writing plate. The reading lamp is mounted on a front door pillar, on a bracket with an adjustable, flexible arm on which the lamp housing is mounted. The lamp is activated by a switch on the lamp housing when the ignition is switched on.

9.6.12 Working lights, fenders

Working lights, fenders, description

⊕

The machine can be equipped with additional working lights located on the fenders to provide better vision for work in the dark.

The working lights are turned on with a switch on the instrument panel.

9.6.13 Engine room lighting

Engine room lighting, description

⊕

The machine can be equipped with lighting in the engine room, to facilitate service and maintenance.

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9.7 Signalling system

Signalling system, description

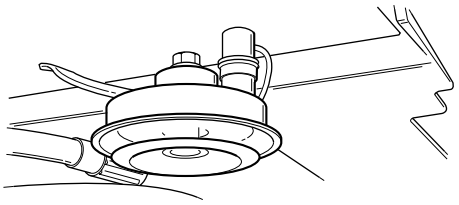
Signal system for alerting the driver or surroundings.

The signal system is regarded as being the following:

- Horn
- Warning lights
- Rotating beacon
- Warning lamp, parking brake
- Buzzer, parking brake not applied. The buzzer sounds if the seat is vacated when the parking brake is not applied (circuit closed by empty seat switch and sensor at hydraulic line forparking brake calliper).
- Buzzer, low pressure hydraulic accumulator (brake system). Buzzer sounds when pressure is below a set value (circuit closed by a sensor at the hydraulic line to the accumulator system).
- Reversing alarm

9.7.1 Horn

Horn, description


001247

Electromagnetic horn, operated from the multi-function lever.

The horn is located under the front of the cab.

A compressed air activated strong tone horn is available as an option.

⊞

The strong tone has an electric compressor and is operated with a switch on the instrument panel.

9.7.2 Warning lamp, Hazard

Warning lamp, Hazard, description

See, *Warning lamp, Hazard, description page 97*.

9.7.3 Rotating beacon

Rotating beacon, description

⊞

See, *Rotating beacon, description page 97*.

9.7.4 Warning parking brake

Warning parking brake, description

A buzzing sound is activated when the operator leave the seat without activating the parking brake.

A sensor in the seat indicates whether the seat is occupied.

The buzzer is located in the seat.

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9.7.5 Reversing alarm

Reversing alarm, description



When reverse is selected, a warning sound and the back-up lights are activated. This is to give others in traffic and the surroundings an indication that the machine is reversing. Indication to bystanders to take caution.

The reversing alarm receives an input signal from the transmission and the output signal goes to the reversing alarm and back-up lights.

The reversing alarm is located on the rear-end counterweight. The volume of the alarm is determined by the ambient noise level.

Reversing alarm, replacement

1 Machine in service position, see section *B Safety*.

2 Unplug the connector from the reversing alarm.

3 Remove the two Allen screws securing the reversing alarm.

4 Replace the reversing alarm.

9.7.6 Flashing brake light for reversing

Flashing brake light for reversing, description

When reverse is selected, the brake lamps flash as a warning to others nearby.

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9.8 Entertainment and communication

Entertainment and communication, description

This section describes items for supporting the driver or facilitating communication for the driver.

Entertainment and communication consist of the following:

- Radio with CD ⊕
- Communication radio, ⊕ Kalmar Industries can prepare the installation but does not provide the equipment.
- Telephone, ⊕ Kalmar Industries can prepare the installation but does not provide the equipment.
- Terminal, ⊕ Kalmar Industries can prepare the installation but does not provide the equipment.
- Screen, ⊕ Kalmar Industries can prepare the installation but does not provide the equipment.
- Computer, ⊕ Kalmar Industries can prepare the installation but does not provide the equipment.
- Voltage converter ⊕
- Reversing camera with monitor in the cab, ⊕ Kalmar Industries can prepare the installation and provide the equipment if required.
- Load camera with monitor in the cab, ⊕ Kalmar Industries can prepare the installation and provide the equipment if required.
- Barcode reader camera on mast or bale clamp. ⊕ Kalmar Industries can prepare the installation but does not provide the equipment.

9.8.1 Radio with CD

Radio with CD, description

⊕

The cab can be equipped with a radio. This is powered by the battery via a converter (24 V to 12 V).

The converter is located beside the electrical distribution box, see *Voltage converter, description page 105.* ⊕

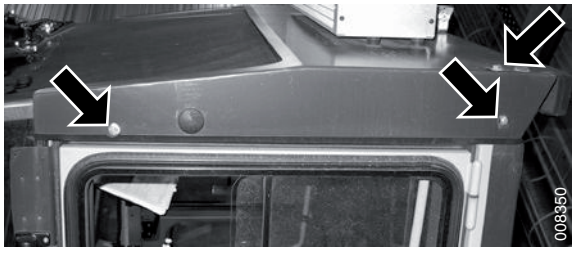
https://truckmanualshub.com/

Radio antenna, description

The cab roof provides provisions for the installation of a radio and/or communication radio.

The radio antenna is permanently mounted on the cab roof. The antenna is made of a flexible material.

Radio antenna, replacement



1 Machine in service position.

2 Undo the screws which fix the roof panel and remove the roof panel.

3 Undo the antenna cable connector.



4 Undo the locknut which fixes the antenna to the roof panel and remove the antenna.

5 Replace the antenna.

9.8.2 Communication radio

Communication radio, description

⊞

If desired, the machine can be prepared for a communication radio.

9.8.3 Telephone

Phone, description

⊞

If desired, the machine can be prepared for a telephone.

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9.8.4 Terminal

Terminal, description

If desired, the machine can be prepared for a terminal.

9.8.5 Screen

Screen, description

If desired, the machine can be prepared for a screen.

9.8.6 Computer

Computer, description

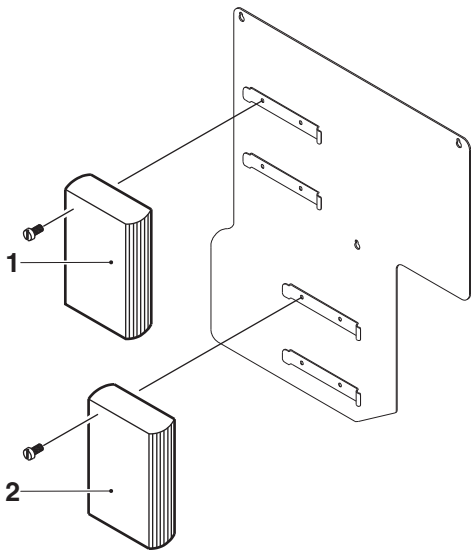
If desired, the machine can be prepared for a computer.

9.8.7 Voltage converter

Voltage converter, description

The voltage converter is located under a protective cover to the right behind the operator's seat.

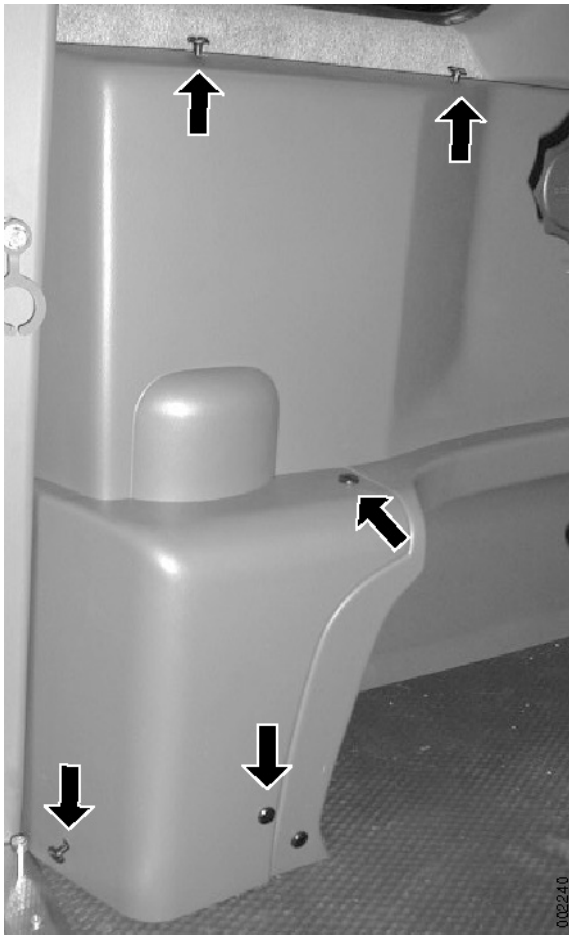
Its function is to convert the voltage (from 24 V to 12 V) so that it can be used for radio, communication radio, computer, etc.



Overview, location of voltage converter
1. Positioning of voltage converter on machines with AC.
2. Positioning of voltage converter on machines without AC.

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Voltage converter 12/24V, replacement



1 Machine in service position, see section *B Safety*.

2 Remove the cover from behind the operator's seat (five clips).

3 Detach the electrical cables to the converter.

NOTE

The voltage converter is available in two versions, one of which is a small variant with plastic brackets. The plastic brackets are fragile. Be careful when changing.



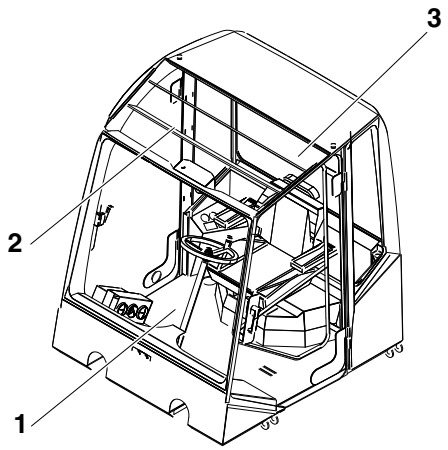
4 Remove the converter from its bracket.

5 Replace the converter.

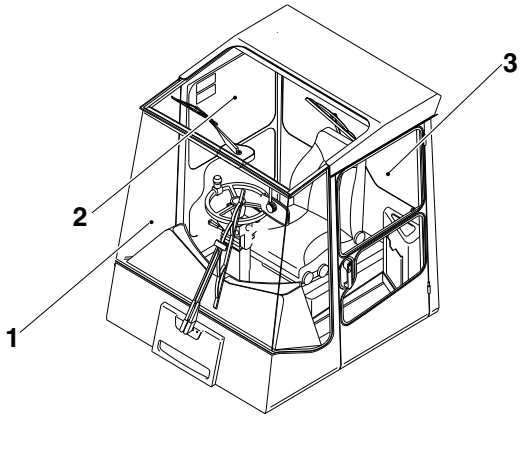
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9.9 Glass/windows/mirrors

Glass/windows/mirrors, description



Overview, cab windows, on FlexGuard and FlexCab.
1. Windscreen
2. Roof window
3. Rear window



Overview, cab windows, Spirit Delta and Spirit Delta Space.
1. Front window
2. Roof window
3. Rear window

Toughened (tempered, strengthened) glass is standard on all FlexGuard cabs with weather protection windows as well as with FlexCab. Spirit Delta windows are made of toughened (tempered, strengthened) glass, except for the roof window, which is made of a scratch-resistant polycarbonate glazing material. As an option the Spirit Delta cabs may be equipped with laminated (except sliding windows) and/or tinted windows.

The mirrors are all convex type. The inner rear-view mirror is fitted in all trucks.

⊞ Mirrors with extra convexity are available as an option, both as external and inner rear-view mirror. External rear-view mirrors are also available in other sizes, as electric heated and/or electric adjustable from the driver's seat.

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Silicone adhesive, handling advice

The window panes are secured with locking strip in glazing rubber and silicone adhesive.

NOTE

The purpose of this instruction is to describe how silicone adhesive 923854.0001 should be handled in connection with replacement of the windscreen and roof window on the Spirit Delta cab.

- *Silicone adhesive 923854.0001 is a quick-curing, two-component silicone adhesive that can withstand temperatures between -50 °C and +200 °C. The curing properties of the adhesive are extremely dependent on the ambient temperature. An increase of 10 °C cuts curing time in half.*

  Silicone adhesive 923854.0001 is mixed at a ratio of 1:10 in a static mixer. Change mixer after every interruption that lasts more than 5 minutes. The short setting time means that work has to be planned carefully to avoid undesired curing.

Fixing time:

10-20 minutes at 20 °C

approx. 5 minutes at 60 °C

Curing time:

approx. 24 hours at 20 °C

approx. 1 hour at 60 °C

Full strength is obtained after 7 days.

- *In warm climates, it is advantageous to cool the container to increase curing time. The silicone adhesive should not be used at temperatures above +75 °C.*
- *In cold climates, the curing time can be shortened by covering the joints so that cooling is prevented. The window pane can be warmed with defroster or cab heater.*
- *The recommended storage temperature is between -30 °C and +20 °C. Storage in a refrigerator or a colder environment is recommended.*

9.9.1 Windscreen

Windscreen, description

The windshield consists of the front window and side windows. The windshield is attached to the cab with a key strip and is glued to the roof window with silicone adhesive. Front and side windows are joined with silicone adhesive to give good all-round visibility from the operator's station.

For location, see *Glass/windows/mirrors, description page 80*.

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Figure 1: Removing key strip

Windscreen, replacement

NOTE

Read the handling advice for silicone adhesive before starting work. See Silicone adhesive, handling advice page 108.

1 Machine in service position, see section *B Safety*.

2 Remove the locking strip.

3 Remove the broken window pane and check that no glass or other particles remain in the window pane's groove on the glazing gasket. Cut apart silicone joints with a sharp tool.

NOTE

Make sure that no silicone adhesive remains between the window pane and the strip by the window pane's lower front edge.

If the roof window is to be changed, then all bolts must be removed before the silicone adhesive is cut away.

⚠ CAUTION

Acetone may not come into contact with a roof window made of polycarbonate plastic. Acetone has a chemical effect on the polycarbonate plastic which reduces the roof window's strength.

4 Clean all surfaces thoroughly. Remove old remains of silicone with a razor blade or similar.

5 Fit masking tape on the inside and outside of the window panes by the surfaces that are to be glued.

6 When the windshield or a side window is to be replaced, the window panes must be adjusted so that the upper edge on the side window has the same height as the top edge of the roof (see figure 2) and so that the distance between windshield and side window is as shown in figure 3.

Use spacers against the roof member to ensure that the distances are obtained.

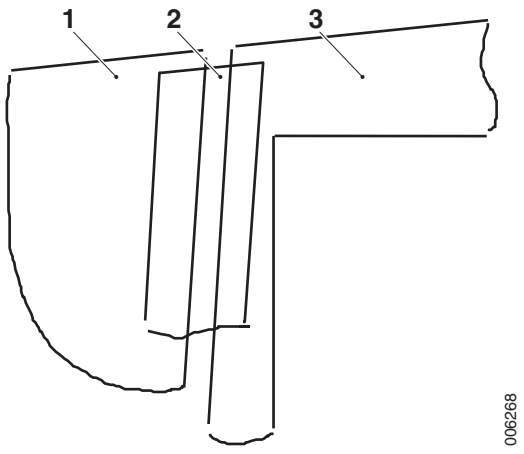


Figure 2: Adjusting side window - cab window
1. Side window
2. Glazing gasket
3. Cab frame / door opening

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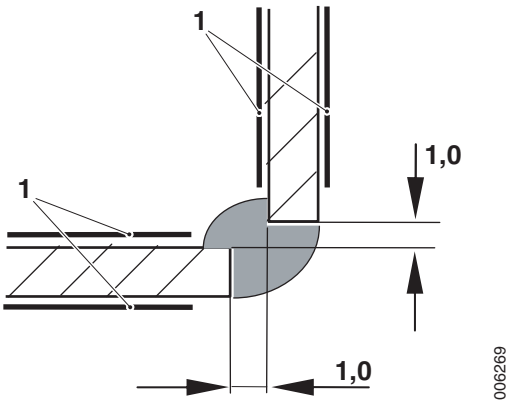


Figure 3: Adjusting side window - windshield

1. Masking tape

7 Install the locking strip around the whole window pane.

8 Apply silicone adhesive 923854.0001 around the window panes. Make the new joint wider than the old one to create a good seam.

The silicone should be applied from the outside of the joints, to give a full and smooth joint.

NOTE

There must be silicone between the window panes, to avoid contact between the window panes.

9 Remove excess silicone adhesive from the outer vertical corners with a tool made of cardboard as shown in figure 4. Smooth out the joints on the inside with a finger, wet with water or soapy water.

10 Apply silicone adhesive 923854.0001 between the strip and window pane at the bottom edge of the front corners, so-called top sealing.

11 If the roof window is to be replaced, apply silicone adhesive 923854.0001 by the cab frame (where it was glued earlier).

12 Put the roof window into place and check that there is a uniform distance of one or several millimetres along the window pane's edges and by the protection over the frame's sides. Then tighten the corner bolts for the window pane.

13 Apply silicone adhesive 923854.0001 by the edges and smooth out the joints with a finger, wet with water or soapy water.

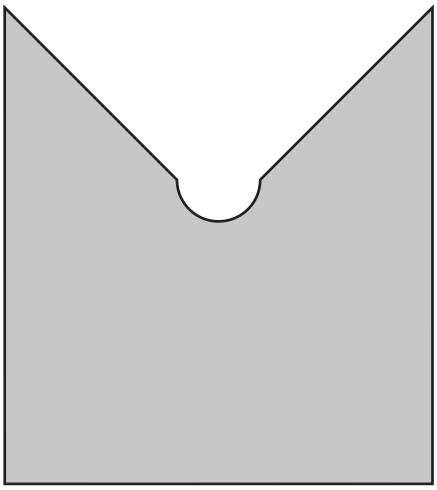


Figure 4: Tool template for silicone joint, scale 1:1

IMPORTANT

Mark the window panes with "New adhesive. Do not touch.".

14 Remove the masking tape immediately after applying adhesive to avoid edge formation. Curing time is dependent on ambient temperature, plan the change so that downtime is minimised.

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9.9.2 Side window

Side window, description

See *Glass/windows/mirrors, description page 80*.

Side window, replacement

NOTE

The method describes a general procedure.

1 Machine in service position, see section *B Safety*.

2 Use special tools to detach the locking strip.

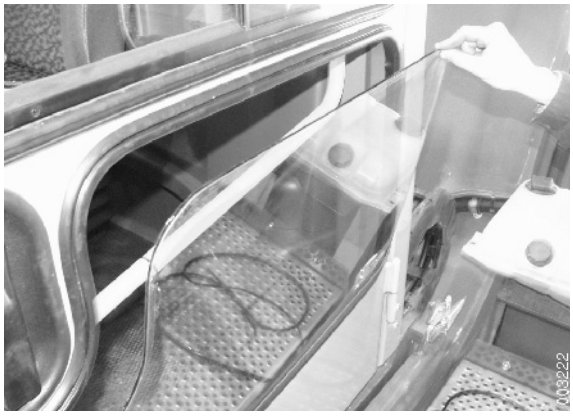


3 Remove the locking strip which runs around the whole window.

4 Carefully remove any remaining glass from the rubber strip.



5 Fit the new window, securing it at the bottom edge inside the rubber gasket.



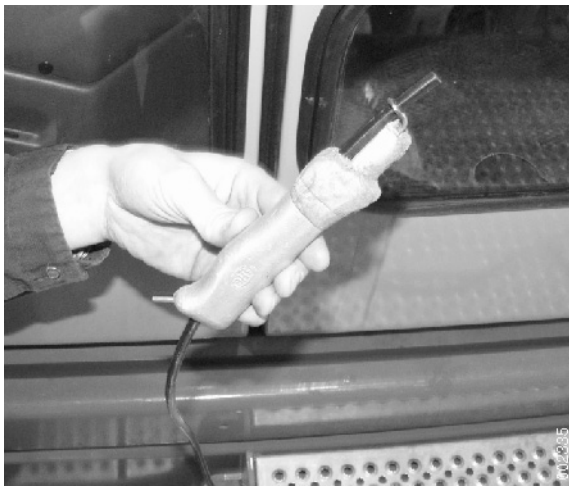
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6 Spray soap solution on the window and glazing rubber to facilitate fitting.



7 Thread the rubber gasket around the whole window; use special tools.



8 Secure the locking strip with a special tool. Use soap solution at the locking strip and the glazing rubber.

9 Pull the locking strip around the whole window and avoid to stretch the locking strip.

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10 Cut off the locking strip approx. 2 cm too long.

11 Push the remaining part of the locking strip into the glazing gasket and towards the opposite end of the locking strip.

12 Adjust the locking strip so that the correct fit is obtained.

9.9.3 Roof window

Roof window, description

The polycarbonate roof window is a safety detail, intended to protect the operator from falling objects. The polycarbonate plastic sheet is elastic and virtually unbreakable. Safety is maintained within a temperature range from +120 °C till -45 °C (becomes brittle first at -110 °C, glass transition temperature +145 °C). The roof window has a patented surface layer which increases its wear resistance as well as its resistance to UV-light and chemicals.

NOTE

The roof window on FlexGuard and FlexCab is made of toughened (tempered, strengthened) glass (not a safety component). FlexGuard has an integrated protective grating in the roof.

9.9.4 Rear window

Rear window, description

See *Windscreen, description page 114*.

9.9.5 Rear-view mirror

Rear-view mirror, description

The cab is equipped with a rear-view mirror. The function of the rear-view mirror is to give the operator rearward vision.

External rear-view mirrors are available as an option. ⊕ External rear-view mirrors are also available in other sizes, as electric heated and/or electric adjustable from the driver's seat.

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9.9.6 Protective panel in front of windscreen

Protective panel in front of windscreen, description

Machines with a Spirit Delta can be equipped with a protective panel, made by polycarbonate plastic, toughened glass, toughened and heat reflecting glass or laminated glass, in front of the windscreen. The protective panel can easily be replaced if it is damaged or scratched.

Machines with a Spirit Delta can also be equipped with a protective grating.

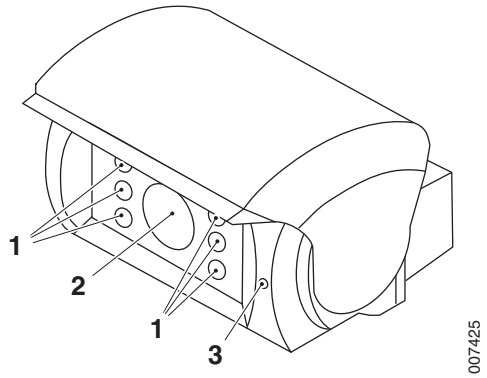
These options are not possible for Spirit Delta Space.

9.9.8 Reversing camera

Reversing camera, description

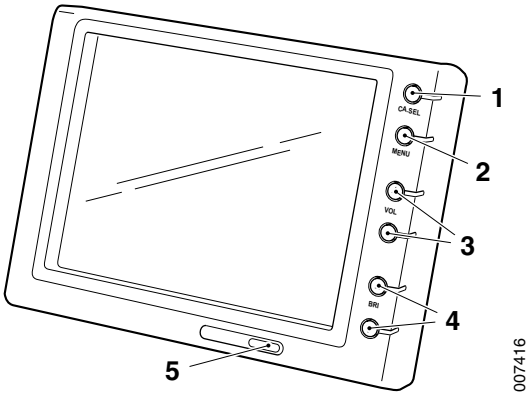
The reversing camera for improved vision when reversing is located at the rear of the horizontal counterbalance weight, furthest back on the machine. The reversing camera is watertight and has a microphone and infra-red lighting for night vision. In addition, the camera is equipped with automatic heating which is activated at ambient temperatures below +10 °C.

The reversing camera sends a colour image and sound to the monitor in the cab, please refer to *Monitor, reversing camera, description page 115*.



1. IR-diodes
2. Camera
3. Microphone

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1. Choice of camera
2. Menu
3. Illumination
4. Volume setting
5. Switching on and off

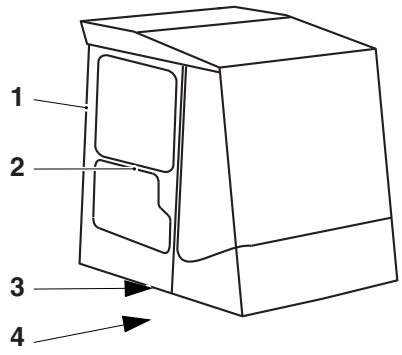
9.9.9 Monitor, reversing camera

Monitor, reversing camera, description

The monitor displays images and sound from the reversing cameral The image is displayed in colour and the illumination is automatically adjusted to suit the lighting conditions in the cab. The monitor can handle signals from two different cameras.

The monitor is on a hinged bracket on the left, in front of the cab door.

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Cab Spirit Delta
1. Cab frame
2. Door
3. Cab suspension
4. Cab undercarriage

9.10 Cab structure and suspension

Cab structure and suspension, description

The cab has a flat floor with a bracket for the driver's seat where the seat is attached. The cab is secured to the frame with strong rubber insulation and the protective roof is joined with four robust supporting pillars.

Consequently the cab frame constitutes a protective cage for the driver station. The protective cage is welded unit comprises floor, pillars and protective roof.

9.10.1 Cab frame

Cab frame, description

The cab structure is made of sheet metal profiles made of high-tensile steel. The cab is dimensioned to withstand blows and to some degree dropped loads.

9.10.2 Doors

Doors, description

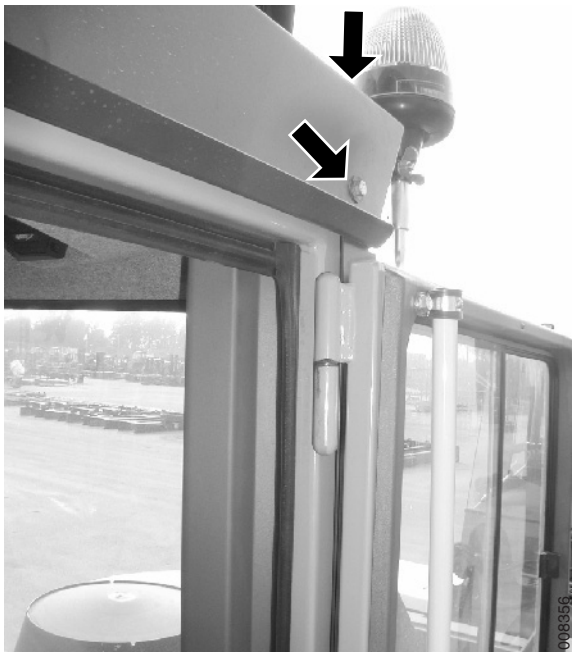
The cab has two doors. The left is the operator's door and the right is the emergency exit. Doors have:

- support rail (inside)
- opening handle (inside and outside)
- key lock
- opening window, (sliding window on left hand side is standard equipment). ✚

Doors, FlexCab, replacement

1 Machine in service position, see section *B Safety*.
2 Lift off the door in question by hand.
3 Replace the door.

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Doors, Spirit Delta and Spirit Delta Space, replacement

1 Machine in service position, see section *B Safety*.
2 Remove the screws securing the roof.
3 Lift the roof slightly (40-50 mm) using an overhead crane.
4 Lift off the door in question by hand.
5 Replace the door.
6 Fit in the reverse order.

9.10.3 Cab mounting

Cab substructure, description

The cab is mounted at four points, one in each corner. Each mounting has a rubber bushing and an attaching bolt.

⊞ The cab can be equipped with an optional raising sub-frame. The sub-frame is mounted on un-damped anchorages on the truck. The cab is mounted on the sub-frame as above.

Cab mounting, rubber bushings, replacement

1 Machine in service position.
2 Tilt the cab.
3 Remove the four bolts that secure the rubber bushings to the cab floor.
4 Remove the nut to split the locating pin and the rubber bushing.
5 Replace the rubber bushing.

Cab mounting raising frame, rubber bushings, replacement

1 Machine in service position.
2 Do not tip the cab. Only lift the cab just enough to remove the load from the rubber dampers and allow the rubber dampers to be replaced.

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9.10.4 Cab tipping

Cab tipping, description

The cab can be tipped to an angle, over its centre of gravity, pivoted around the left-hand side suspension or hinge at raising frame of cab, assisted by a hydraulic cylinder. The hydraulic oil pressure is generated by a hand-controlled pump with an integrated reset valve for tipping up or down.

On the right-hand side mounting are locking devices which secure the cab to the frame and can be easily released for tipping the cab.

Electric tipping of the cab is available as an option. ⊕

Hand-controlled cab tipping pump, replacement

1 Machine in service position, see section *B Safety*.

2 Place a receptacle under the pump.

3 Detach the hydraulic hoses from the pump.



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4 Remove the two bolts that secure the pump to the chassis.

5 Replace the pump.

6 Fit in the reverse order.

7 Fill up the system with hydraulic fluid.

NOTE

Vent the system by lifting and lowering the cab a few times. Check the fluid level and top up as necessary.

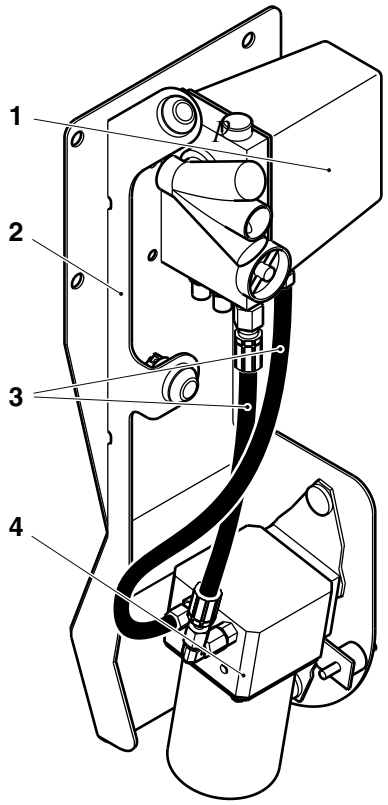
Electric cab tipping pump, replacement

1 Machine in service position, see section *B Safety*.

2 For replacing the hand-controlled cab tipping pump, please refer to *Hand-controlled cab tipping pump, replacement page 118*.

3 Place a receptacle under the pump.

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1. Hand-controlled cab tipping pump
2. Bracket
3. Hydraulic hoses
4. Electric pump

4 Detach the hydraulic hoses from the electric pump.

5 Release the electric connections from the electric pump.

6 Remove the bolts that secure the electric pump to the bracket.

7 Replace the electric pump.

8 Fit in the reverse order.

9 Fill up the system with hydraulic fluid.

NOTE

Vent the system by lifting and lowering the cab a few times. Check the fluid level and top up as necessary.

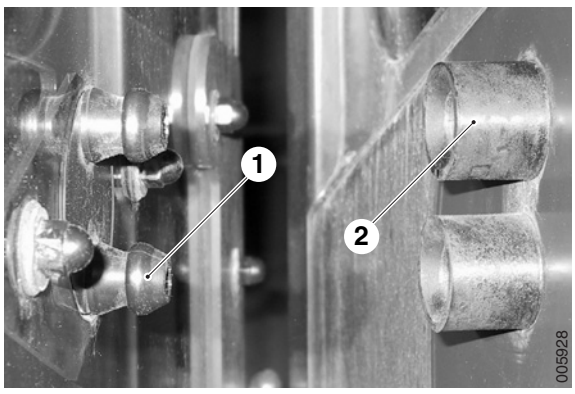
9.10.5 Door stop

Door stop, description

The door stop prevents the door from being damaged when it is opened.

A door stop with gas spring damping is available as an option ⊕.

Door stop Flex Cab, replacement



1. Components of door stop on the door.
2. Components of door stop on the cab side.

1 Machine in service position, see section *B Safety*.

2 Remove the domed nut which fixes door stop components on the inside of the door.

3 Remove the door stop components.

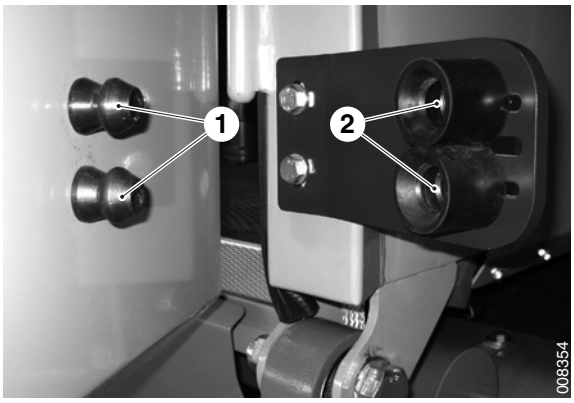
4 To gain access to the nuts for the door stop section on the cab side, remove the three screws that fix the interior trim to the inside of the cab wall.

5 Remove the screws and nuts that fix the door stop section to the cab side behind the door on the left side.

6 Remove the door stop components.

7 Fit in reverse order.

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1. Components of door stop on the door.
2. Components of door stop on the cab side.

Door stop Spirit Delta, replacement

1 Machine in service position, see section *B Safety*.

2 Remove the interior door panel.

3 Remove the nut which fixes components for the door stop on the inside of the door.

4 Remove the components for the door stop.

5 Remove the three screws that fix the interior trim to the inside of the cab wall, to gain access to the nuts for the door stop section on the cab side.

6 Remove the screws and nuts that fix the door stop section to the cab side behind the door on the left side.

7 Remove the components for the door stop.

8 Installation is in reverse order.

Door stop Spirit Delta and Spirit Delta Space, replacement



1 Machine in service position, see section *B Safety*.

2 Remove the screw which holds the catch strap in the cab.

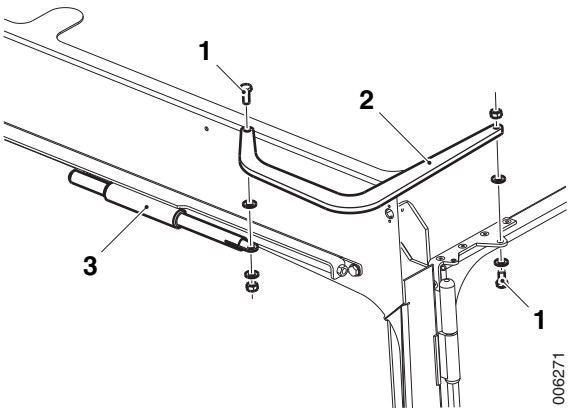
3 Remove the two screws that fix the catch strap anchorage to the door.

4 Remove the catch strap from the anchorage.

5 Fit in the reverse order

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Door stop with gas spring damping, replacement

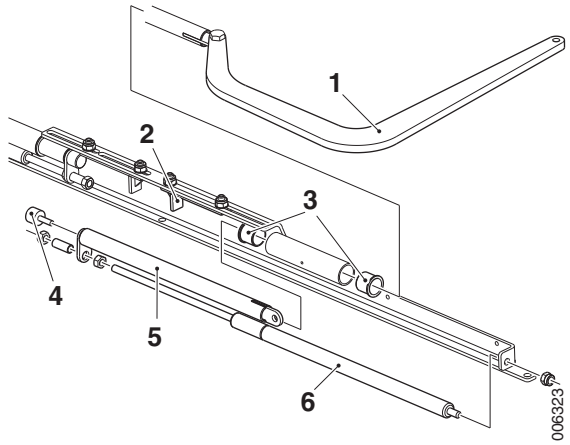


1. Screw, washers and nut
2. Lever
3. Gas damper device

1 Machine in service position, see section *B Safety*.

2 Place the door in fully open position.

3 Remove the screws (position 1) which fix the lever (position 2) to the door and the gas damper device (position 3).



Gas damper device

1. Lever
2. Door stop control
3. Bushes
4. Rubber buffer
5. Shaft
6. Gas damper

4 Remove and replace the lever or the necessary parts of the gas damping device.

5 Fit in the reverse order, lock the screws (position 1) with thread locking fluid before installation.

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9.10.6 Roof and door mouldings

Roof and door mouldings, description

The cab is equipped with roof and door mouldings.

The roof seal moulding for Spirit Delta and Spirit Delta Space has a rectangular cross-section, and is made of soft foam material with a self-adhesive long side. The roof seal moulding is not normally subject to any wear. The seal moulding can only be replaced if the roof panel is removed.

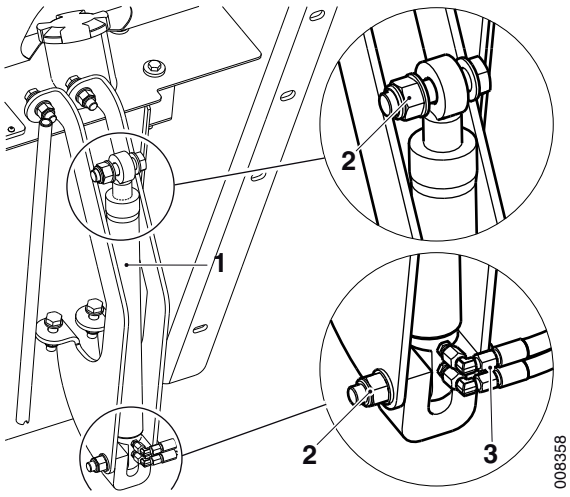
The door seals are "clip-on types", with a permanently vulcanised tubular moulding. The door seals for Spirit Delta and Spirit Delta Space are installed on the cab, by the door pillars and roof, and at the base of the plastic door trim. The door seals can only be replaced when the plastic components have been undone or removed. The door seals for FlexCab are installed directly on the edges of the door window.

9.10.7 Cab tipping cylinder

Cab tipping cylinder, description

The cab is tipped by means of a hydraulic cylinder which is located underneath the cab on the left side of the cab. The cylinder is fixed to the frame and the cab base, or raising sub-frame if found, and is powered by a hand or electric operated hydraulic pump.

Cab tipping cylinder, replacement



1. Hydraulic cylinder
2. Screws
3. Hydraulic hoses

1. Machine in service position, see section *B Safety*.
2. Tip the cab.
3. Secure the cab in the tipped position by opening both the cab doors and pulling a lifting strop through, which is fixed to a lifting device (travelling crane).

NOTE

Protect the cab in a suitable manner, to ensure that it is not damaged when fixed or lifted by the lifting device.

4. Place a receptacle under the hydraulic cylinder.
5. Detach the hydraulic hoses from the hydraulic cylinder.
6. Remove the two bolts that secure the hydraulic cylinder to the chassis and cab.
7. Replace the hydraulic cylinder.
8. Fit in reverse order.
9. Fill up the system with hydraulic fluid.

NOTE

Vent the system by lifting and lowering the cab a few times. Check the fluid level and top up as necessary.

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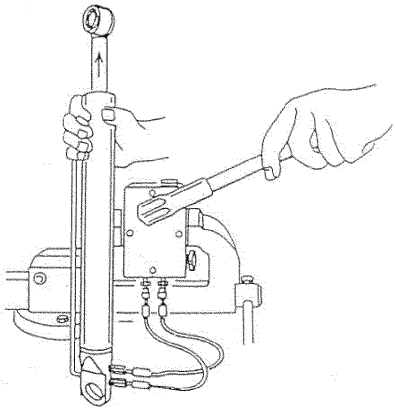
Cab tipping cylinder, repair

1. Machine in service position, see section *B Safety*.
2. Remove the cab tipping cylinder, see *Cab tipping cylinder, replacement page 123*.

NOTE

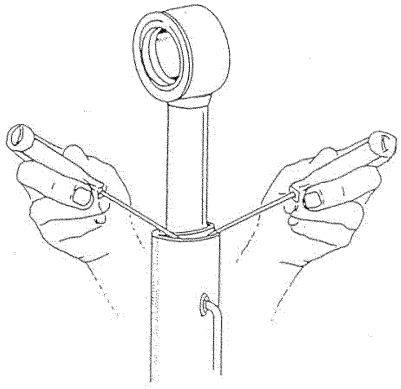
Prior to any repair or reconditioning procedures check cylinder assembly on excessive wear, damage and especially scars and dents on the chromed plunger rod. In any of these cases, replace the complete tilt cylinder, as repair efforts will not be justified.

3. Install the protection plug on the connection coupler and clean the cylinder assembly in a suitable cleaning solvent. Dry with compressed air.
4. Connect tilt cylinder to a suitable cab tilt hand pump. Make sure connections A and B correspond with same connections on tilt cylinder. Turn selector valve on hand pump to **UP** position and operate pump until plunger rod is fully extended. Thereafter shift the pump-selector valve to **DOWN** mode and retract cylinder rod approx. 10 mm.



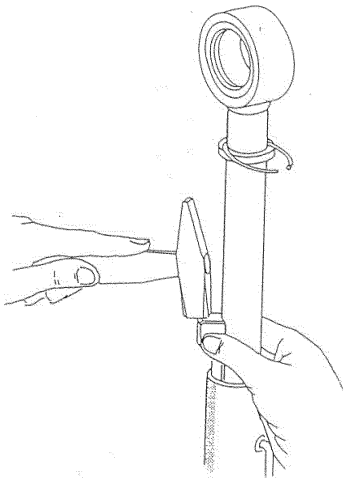
008641

5. Remove the dust wiper from the cylinder top end carefully with two small screw drivers.

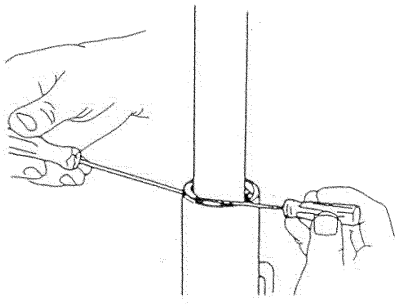


008642

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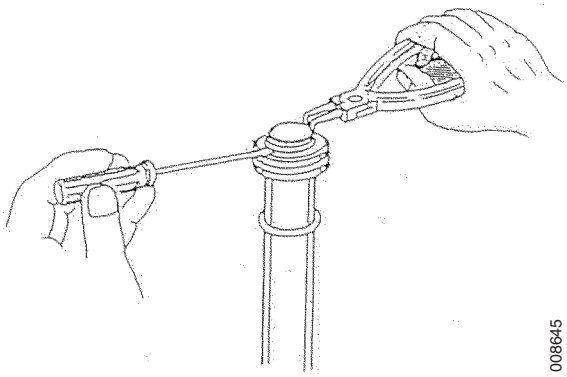
6. Use special tool to tap the gland 5 to 10 mm back on the plunger rod.


008644

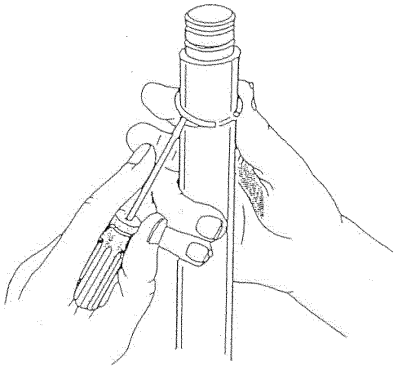
7. Remove the upper retaining ring from the cylinder and operate pump to remove the plunger rod.

DANGER

Never use compressed air to drive out the plunger rod assembly.

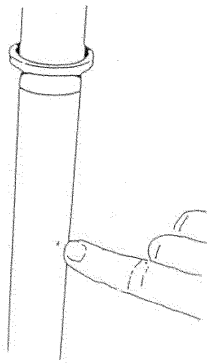

008645

8. Remove the retaining ring from the plunger rod, remove the piston and the O-ring below it.


008646

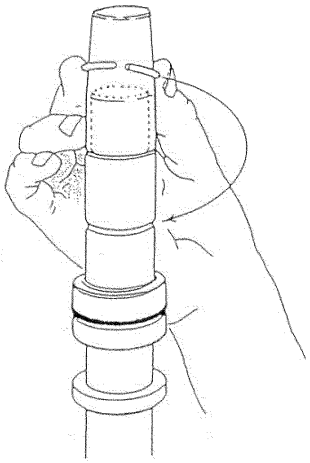
9. Remove the retainer stop-ring and the gland.

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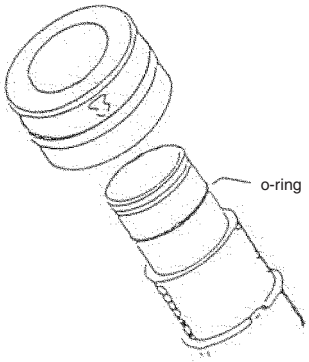
008647

10. Check once more the plunger rod and the top part of the cylinder for scores and damage. The same procedure applies for the inner cylinder tube. Renew the complete cylinder if scores or scratches are observed.



008648

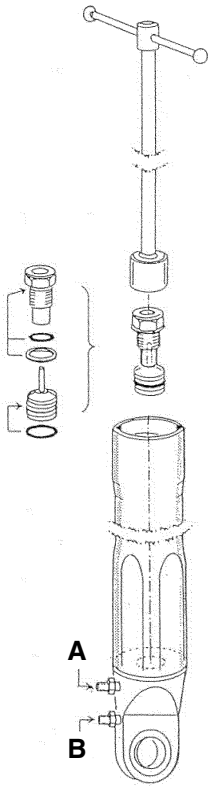
11. Slide carefully a new wiper on the plunger rod, to be followed by the gland.
12. Use a special cone to fit the retainer ring on the plunger rod.



008649

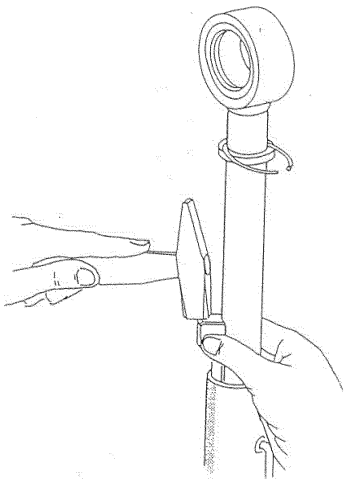
13. Fit a new O-ring in the groove at the plunger rod-end. Slide on the piston and make sure piston is fitted in the correct direction.

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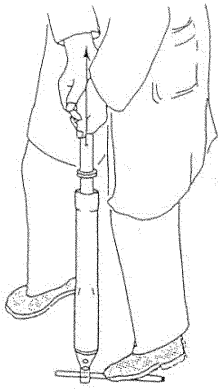
008650

14. After dismantling of plunger assembly from cylinder, unscrew valve (hexagon 17 mm) with an extended socket wrench.
15. Remove pilot piston by blowing with air nozzle in port B.
16. Check piston and O-ring on scratches and damage.
17. Mount piston together with a new valve assembly and new seal rings as illustrated while cylinder tube is clamped horizontally in the vice.
18. Tighten valve seat with a torque of **± 50 Nm.**



008643

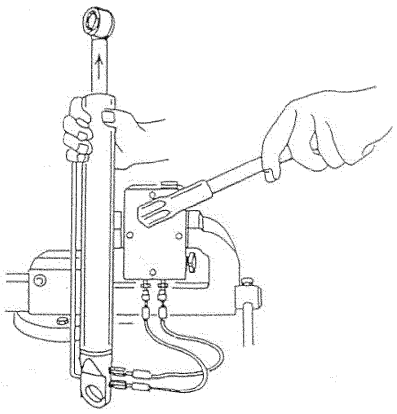
19. Use special tool to tap the upper bearing approx. 10 mm into the cylinder and install the retaining ring. Make sure the ring has snapped in its groove.



008651

20. Pull back cylinder rod with an instant jerk in order to place upper bearing in the correct position.

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008641

21. Reconnect cylinder to hand pump, watch correctness of connections. turn selector valve to **DOWN/DRIVE** position, start pumping and retract plunger rod completely. Refill pump reservoir with the appropriate fluid as necessary.
22. Replace pump selector valve to **UP** position, pump plunger rod to fully extended position and pressurize system.

    Check for leaks.
23. Replace pump selector valve to **DOWN/DRIVE** position again while pressure will immediately drop. At this stage the plunger rod must remain solid as the safety valve will block off the internal pressure.

    Immediately after a following pump stroke this valve will open and release the internal pressure. In case this procedure fails, repeat this check, or else the non-return valve is suspected to leak.
24. After completing the tests, fit the dust wiper.

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9.11 Cab interior

Cab interior equipment, description

The cab is designed for optimum driver comfort. Switches, controls, warning and indicator lamps are grouped on the instrument panels to provide the driver with a good driving environment.

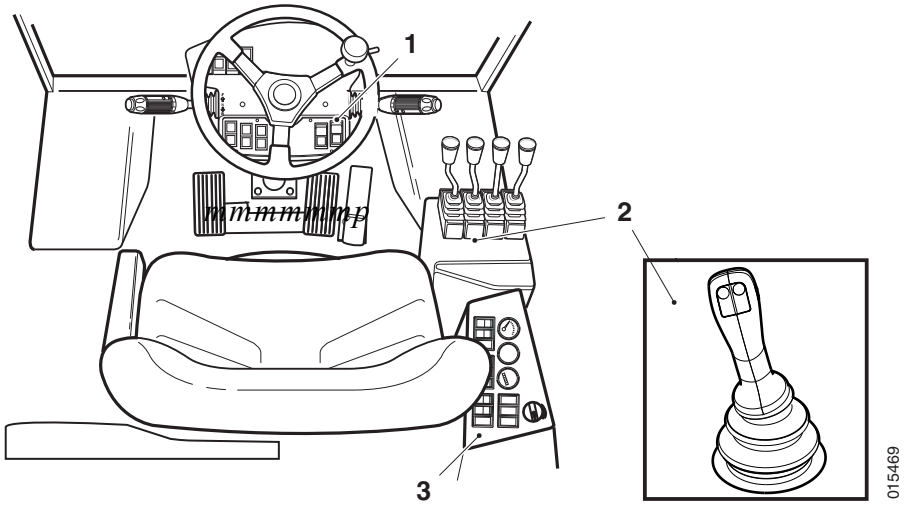
Recyclable materials have been used for all parts.

- Instrument panels
- Interior parts, plastic
- Interior parts, textile
- Insulation

9.11.1 Instrument and control panels

Instrument and control panels, description

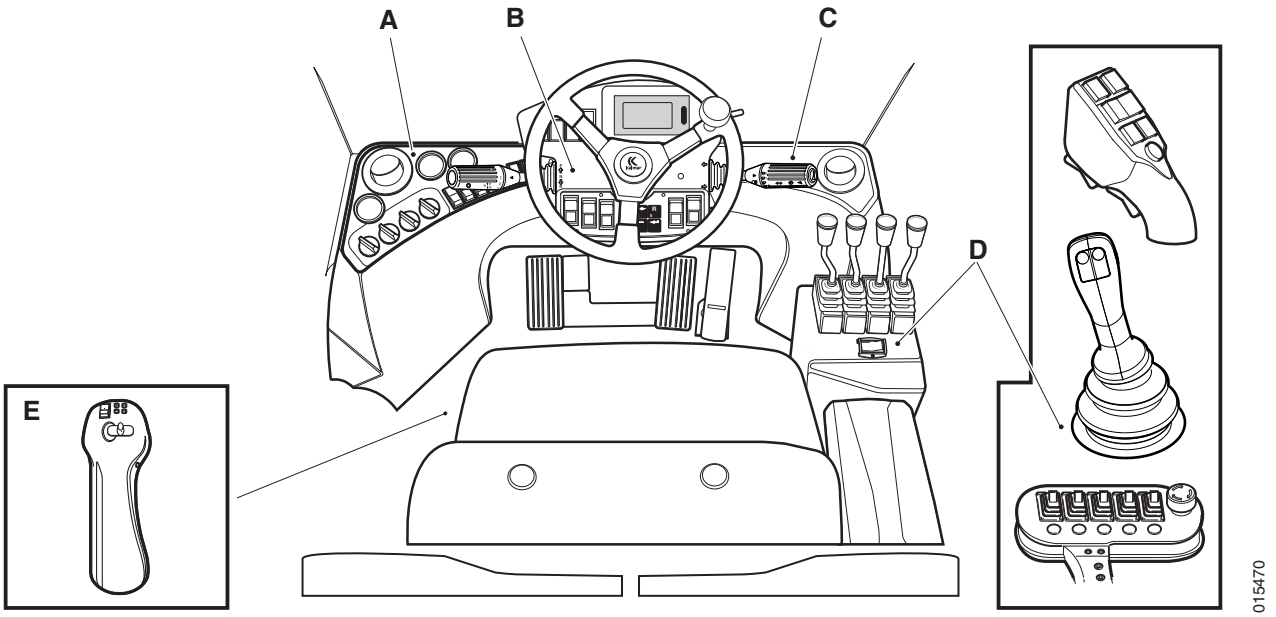
The FlexGuard and FlexCab contains the following instrument and control panels.



1. Steering wheel panel
2. Hydraulic controls with levers (4-lever, 5-lever, electrical servo or joystick)
3. Right-hand rear instrument panel

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The Spirit Delta cab contains the following instrument and control panels.



A. Left-hand instrument panel
B. Steering wheel panel
C. Right-hand instrument panel
D. Hydraulic controls with levers (4- or 5-lever, electrical servo or joystick)
E. Lever steering/mini-wheel ⊕

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9.11.2 Interior plastic components

Interior plastic components, description

The interior plastic components of the cab are made of recyclable material.

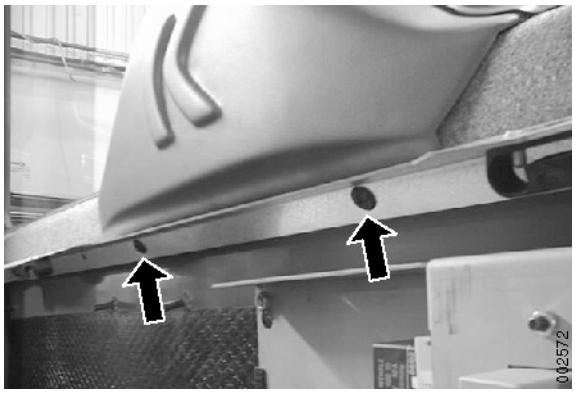
Interior plastic components, replacement

Steering wheel panel and steering column cover

1 Machine in service position, see section *B Safety*.

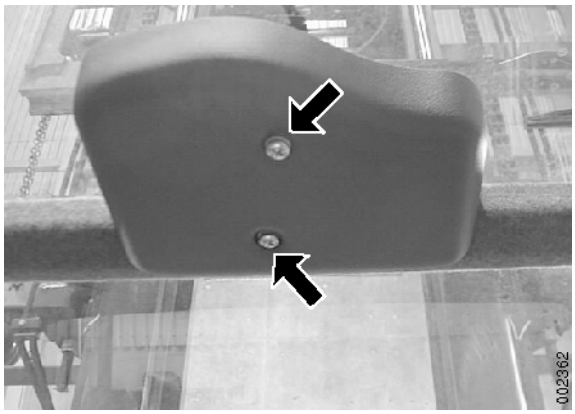
2 For Removing steering wheel panel and steering column cover, please refer to *Multi-function lever, replacement page 23*

Plastic cover over wiper motor



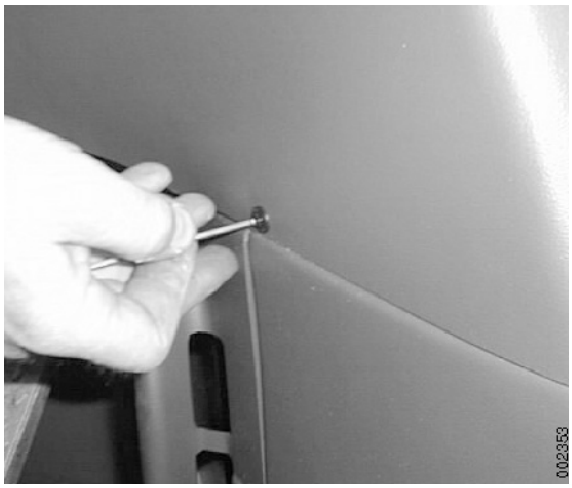
1 Machine in service position, see section *B Safety*.

2 For removing the plastic cover over the rear wiper motor, please refer to *Wiper motor, rear, Spirit Delta, replacement page 92* and *Wiper motor, rear, Spirit Delta Space, replacement page 94*.



3 For removing the plastic cover over the roof wiper motor, please refer to *Wiper motor, roof, Spirit Delta, replacement page 89* and *Wiper motor, roof, Spirit Delta Space and side mounted roof wiper for Spirit Delta, replacement page 90*.

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Instrument panel

Instrument panel

1 Machine in service position, see section *B Safety*.

2 To remove the instrument panel, remove the nine clips holding the instrument panel. Pressing in the centre pin on the clip (about 3 mm) unlocks the clip.

NOTE

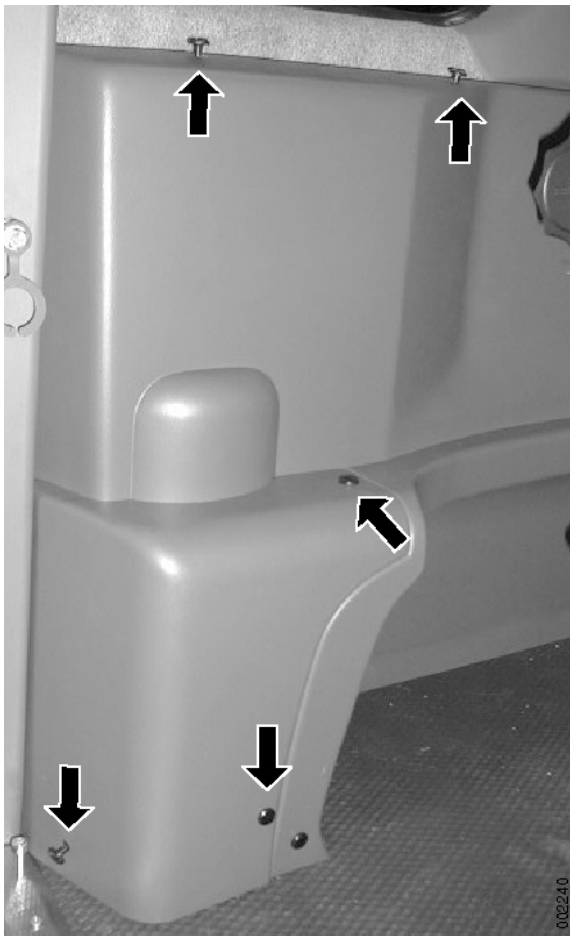
Reuse the clips by re-inserting the centre pin and pressing this flush with the head on fitting.

3 Raise the instrument panel slightly and unplug all electric connectors, remove the instrument panel.

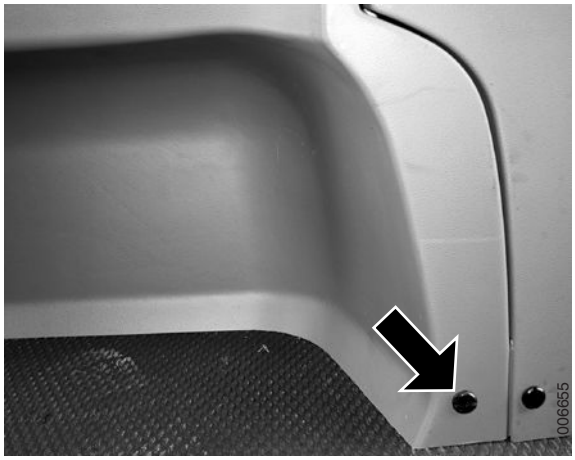
4 When the instrument panel is replaced all equipment, for example switches and gauges, which are mounted on the instrument panel must be removed and transferred to the new instrument panel.

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Rear covers



Rear side panels, two + three screws.



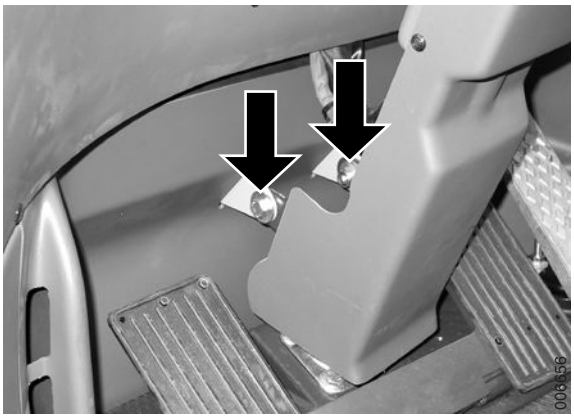
Rear panel (middle section) two screws.

1 Machine in service position, see section *B Safety*.

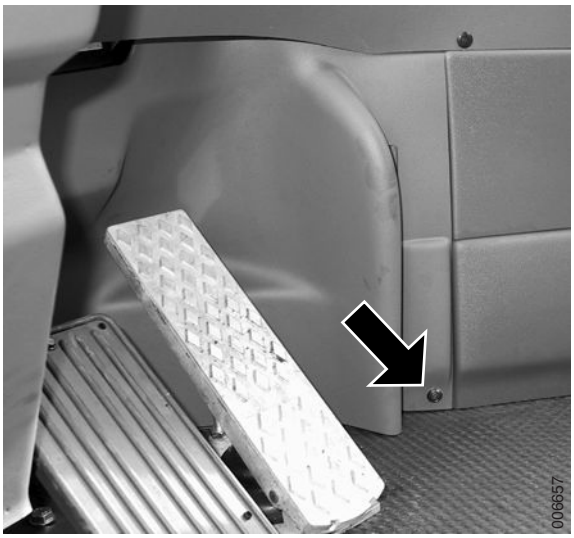
2 For removing the rear covers in the cab, loosen the screws holding the covers. Remove the covers.

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Front middle lower cover



Loosen the steering column.



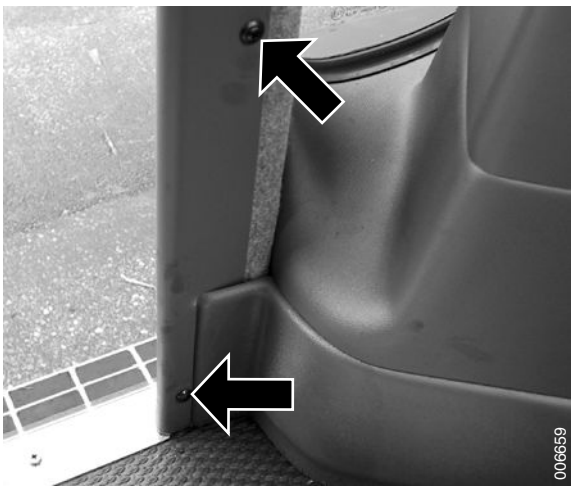
Loosen the two screws.

1 Machine in service position, see section *B Safety*.

2 For removing the front middle lower cover in the cab, loosen the steering column and fold it backwards.

3 Loosen the screws holding the cover. Remove the front middle lower cover.

Door opening covers



1 Machine in service position, see section *B Safety*.

2 For removing the plastic cover in the door front and top opening, loosen the screws holding the panels and remove the panels.

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9.11.3 Interior textile components

Interior textile components, description

The interior textile components of the cab are made of recyclable material.

Interior textile components, replacement

1 Machine in service position, see section *B Safety*.

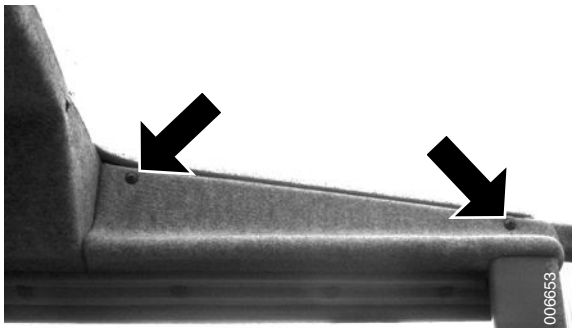


Figure 1

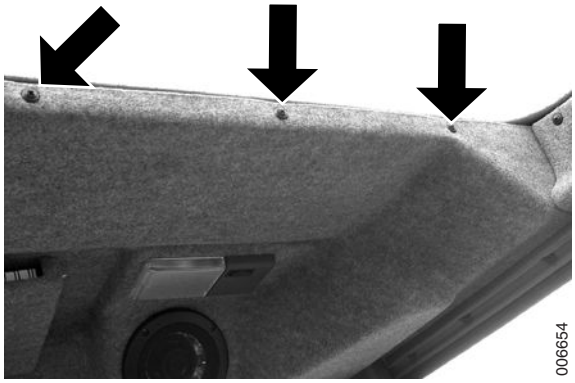


Figure 2

2 The interior textile components are replaced as depicted in figure 1-2.

3 When the roof panel is replaced, all equipment such as loudspeakers and lamps mounted on the roof must be removed and transferred to the new roof panel.

4 Fit in reverse order.

9.11.4 Floor covering

Floor covering, description

The floor covering is recyclable and is made of wear- and water resistant material.

Floor covering, replacement

1 Machine in service position, see section *B Safety*.

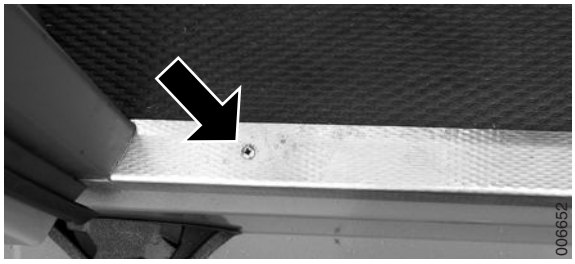
2 Open the doors on both sides.

3 Undo the screws which hold the sill moulding in the cab entry, and remove the sill moulding.

4 Undo and remove all equipment in the cab which is screwed through the floor matting, such as the seat and pedal base.

5 Replace the floor matting.

6 Fit in reverse order.



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9.11.5 Insulation

Insulation, description

The cab insulation consists of recyclable material.

The insulation material consists of both self-adhesive foam plastic material for noise and heat insulation and of self-adhesive matting (heavy material for good sound insulation at low noise frequencies).

9.11.6 Sunshield curtains

Sun blinds, description



Sun blinds can be specified for the front window (windscreen) and the roof window.

1. Sun blind, front and rear window: Can be raised and lowered using a cord on the right-hand side. Stops in selected position.
2. Sun blind, roof window: Extends forward to fasten in two hooks in the front edge of the window or is continously adjustable.

9.11.7 Terminal table

Terminal console, description



The function of terminal console is to provide a work area for computer/terminal aided operations. It is normally located to the right of the steering wheel, easily accessible for the operator.

9.11.8 Writing desk

Writing desk, description



The function of writing desk is to provide a work surface for a writing and notes. It is normally located to the right of the steering wheel, easily accessible for the operator.

9.11.9 Compartment for A4 papers

Compartment for A4 papers, description



The cab can be equipped with a compartment for A4 papers. It is located to the left of the steering wheel or at the side of the driver seat.

9.11.10 Holder for pump lever

Holder for pump lever, description

The cab is equipped with a holder for the pump lever at the hinge-side of the emergency exit door, (right side) for Spirit Delta, Spirit Delta Space and FlexCab and on the left side for FlexGuard.

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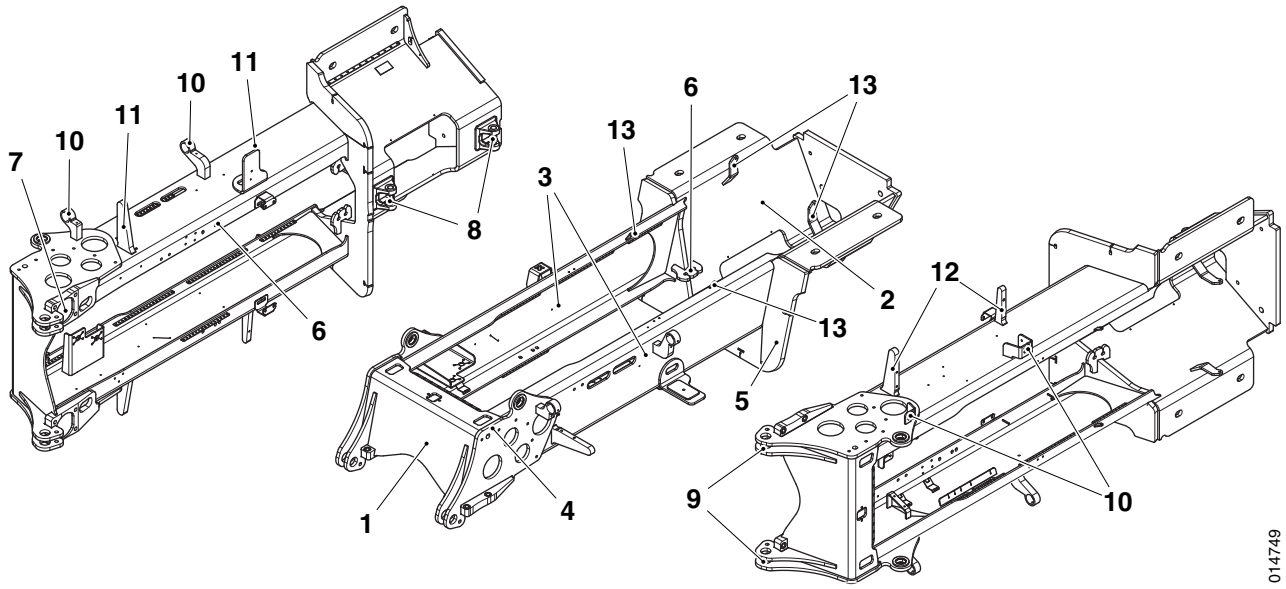
9.12 Frame

Frame, description

The chassis consists of two longitudinal beams bent from a solid steel plate. The fenders, footrests, tanks and counterweights are bolted to the frame.

The frame contains the anchorages for the steering axle, mast and cab. The anchorages for the engine, transmission, driving axle, fuel tank and hydraulic tank are bolted or welded to the frame, please refer to the appropriate sections. The fenders are bolted to the frame.

The space in the rear section, that is welded to the longitudinal frame, is used to contain the counterweights. The number and size of counterweights is adapted to the machine in question.



1. Frame front section
2. Frame rear section
3. Member pair
4. Mounting, front wings
5. Mounting, rear wings
6. Engine mounting
7. Drive axle mounting
8. Steering axle mounting
9. Mast mounting
10. Cab mounting
11. Fuel tank mountings
12. Hydraulic tank mountings
13. Engine cover mountings

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9.13 Body

Body, description

The body is regarded as being the following:

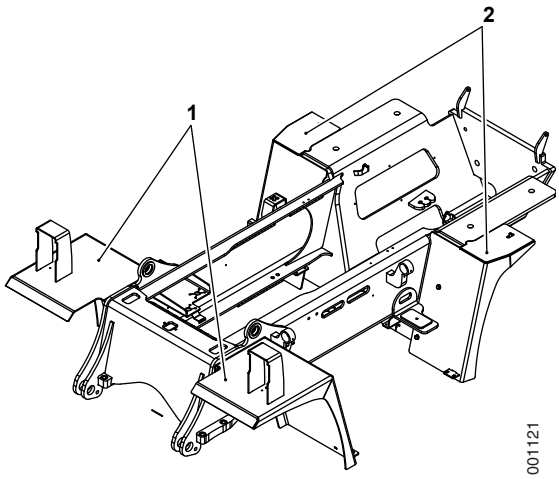
- Fenders
- Engine compartment cover
- Footstep
- Counterweights
- Battery compartment

9.13.1 Fenders

Fenders, description

There are fenders over the wheels to protect from dirt thrown up by the wheels during operation.

Fenders can also be equipped with rubber splash guards when demands on cleanliness are high. ✚

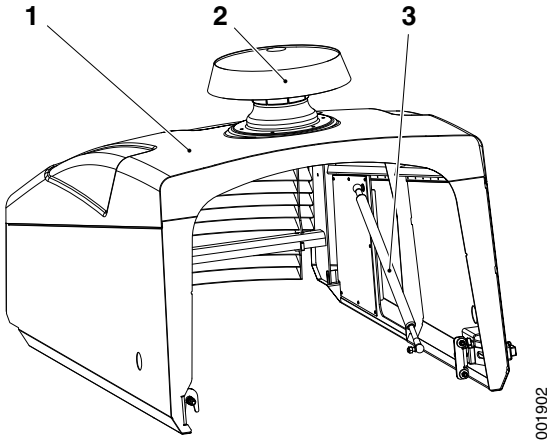


1. Front fenders
2. Rear fenders

9.13.2 Hood engine compartment

Hood engine compartment, description

An engine hood protects the machine's engine compartment. The hood is easy to raise, and gas struts hold it in place when raised.



1. Engine hood
2. Air inlet
3. Gas strut

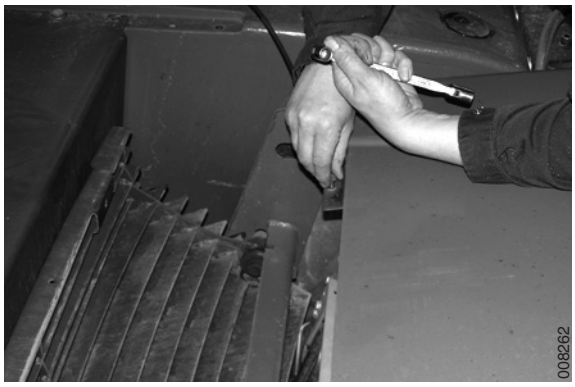
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Hood engine compartment, replacement



1 Machine in service position.

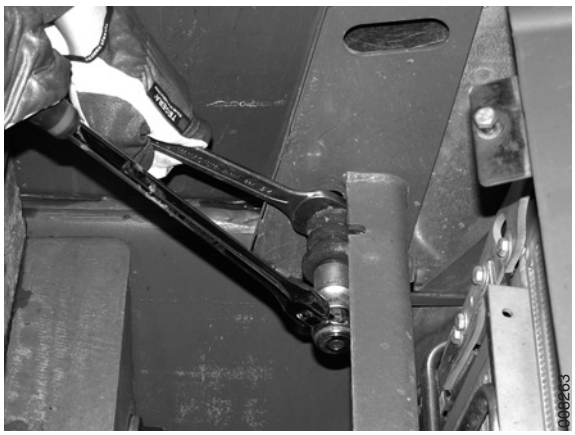
2 Open the engine hood remove the lock pin from the gas strut and pull the strut off the ball joint., close the engine hood and remove the hood over the air filter.



3 Remove the screws that hold the ventilation grating over the radiator, and remove the grating.



4 Attach the engine hood to an overhead crane.

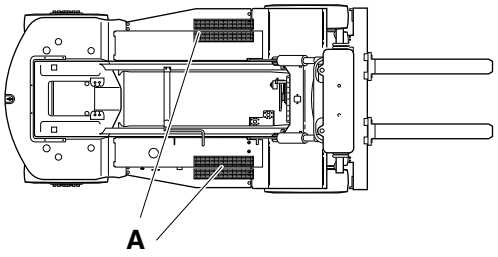


5 Remove the screws for the engine hood. Make sure the engine hood is unlocked and lift the engine hood off.

6 Replace the engine hood.

7 Fit in the reverse order.

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9.13.3 Footstep

Footstep, description

The cab entrances have slip protected steps on the sides of the truck.

⊕ If the optional raising sub-frame is installed, there are also slip protected steps on the sides of the sub-frame.

⊕ Fenders with slip-protected surfaces can optionally be used as steps.

9.13.4 Counterweight

Counterweight, description

The machine has counterweights to balance the machine's lift capacity and may therefore vary in quantity and weight.

The counterweights are located at the very back on the frame for maximal leverage.

There are two counterweights with fixed weight:

- vertical counterweight (rear weight)

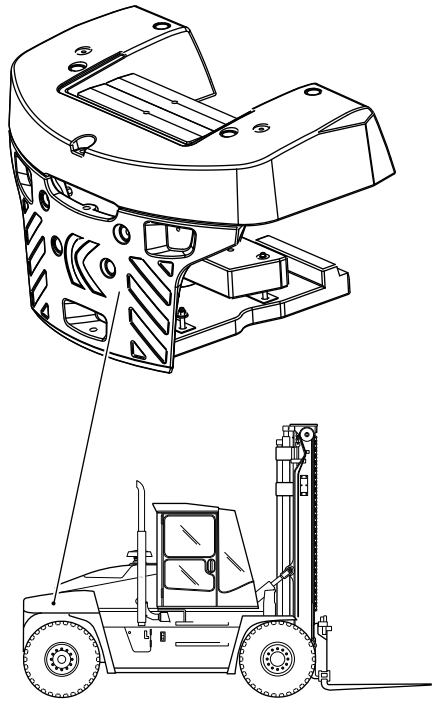
  There is a towing eye in the vertical counterweight at the back of the frame.

- horizontal counterweight (upper weight)

  The horizontal counterweight is located above the vertical counterweight. There are tapped holes on the counterweight for accessories. ⊕ The machine can optionally be fitted with lifting lugs (to lift the rear of the machine) in the counterweight.

There are a number of weight elements (in the counterweight box) under the horizontal counterweight that are adapted to balance the machine's lift capacity.

In addition to the weights named above, weights may in some cases also be located on the steering cradle.



001120

1. Horizontal counterweight (upper weight)
2. Vertical counterweight (rear weight)

⚠ DANGER

The counterweights are factory fitted and are adapted according to the machine's capacity.

The machine's operating characteristics are changed!

Never change the quantity of counterweights.

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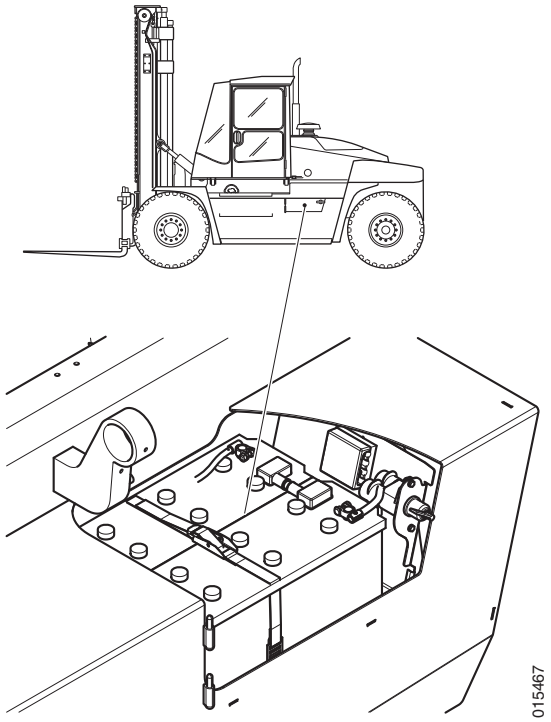
9.13.5 Battery compartment

Battery compartment, description

The machine has a battery compartment where two batteries connected in series, main fuses and battery disconnector are located.

NOTE

The battery compartment must not be used as a storage space.

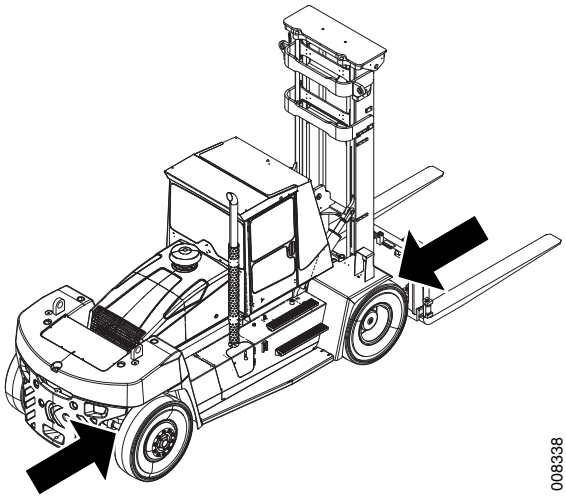


1. Hatch to battery compartment
2. Connections for fuel hoses to/from engine
3. Filling

9.13.7 Mud guards

Mud guards, description

(+) Fenders can also be equipped with elastic mud guards for reducing splash from the wheels when driving at wet surfaces.



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9.13.8 Tool kit

Tool kit, description

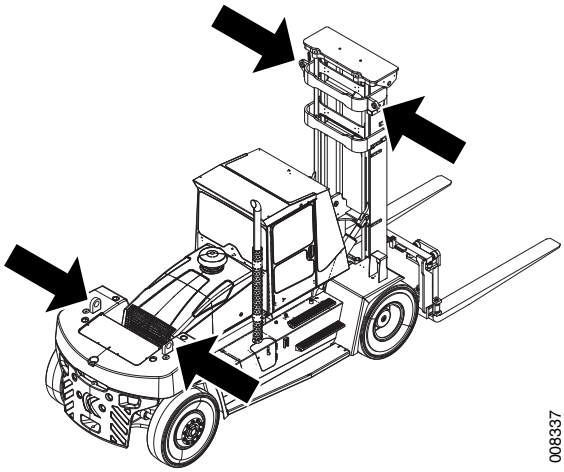
The machine can be equipped with a tool kit.

9.13.9 Lifting lugs

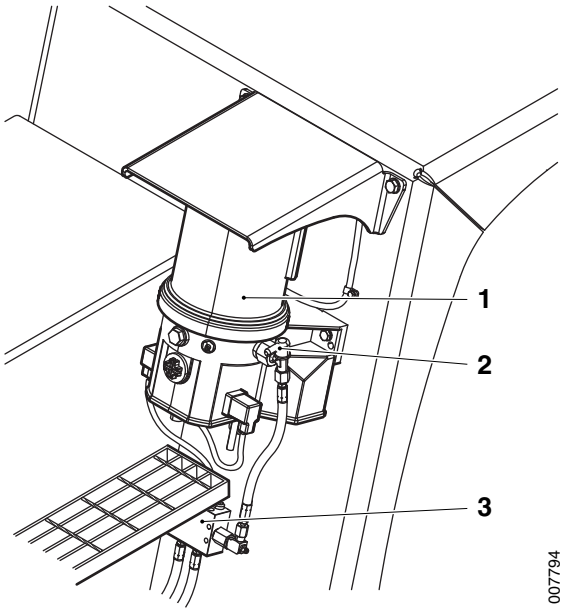
Lifting lugs, description

The machine can be equipped with lifting lugs.

The front lifting lugs are welded to the mast and the rear lifting lugs are screwed through the counterweight.



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1. Pump unit
2. Safety valve
3. Distribution block

9.14 Central lubrication

Central lubrication, description

Central lubrication (replaces manual lubrication) is available in different variants. The alternatives are:

- Manual, hand pumping lubricant at a lubrication point which via lines are distributed to all selected lubrication points.
- Automatic, pre-programmed lubrication unit lubricates all selected lubrication points at pre-set time interval.

It is also possible to select the number of lubrication points as follows:

- Total 14 lubrication points: 8 on the steering and 6 on the mast (the only alternative with manual central lubrication).
- Total 18 lubrication points: 8 on the steering and 6 on the mast and 4 on the assembly.
- Total 23 lubrication points: 8 on the steering and 6 on the mast and 9 on the assembly (with central levelling assembly).

Central lubrication comprises the following components:

- Pump unit, with lubricant reservoir.
- Distribution block.
- Lines, to all selected lubrication points.
- Grease nipples, at all selected lubrication points.

NOTE

Brake pedal, mast wheels on inner mast, upper and lower rollers on forks is always greased manually.

9.14.1 Pump unit

Pump unit, description

The pump unit consists of a reservoir with agitator, pump housing with integrated motor, timer, pump element and filler nipple.

The unit works using lubrication cycles (pause and running time, and read time). A pressure limiting valve is fitted to the pump element, ensuring that the pressure in the system does not become too high.

The central lubrication is controlled as follows:

There is a circuit board with a timer in the pump. This can be used to set the running and pause time of the pump motor.

This is normally set so that the running time is four minutes and pause time six hours.

In addition, from the cab via a button on the instrument panel, the operator can manually start a lubrication cycle of four minutes, if desired.

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9.14.2 Distribution block

Distribution block, description

The number of distribution blocks may vary, depending on how many (and which) lubrication points have been selected. The first distribution block (i.e. the block closest to the pump unit) is always present.

The distribution block comprises progressively controlled pistons. These are driven by the lubricant and do not have springs or seals. The lubricant pressurises and drives the pistons in the distributor.

The pistons move in a predetermined way, and this pattern of movement is repeated time after time. Each piston has to finish its movement before the next piston can start to move. The pistons are dependent of each other. It is technically impossible for a lubrication point to be missed out.

The system's first distribution block (i.e. the block closest to the pump) has an indicator pin. If the pin moves forward and backward (in time with the piston movements), this means that all the system's distribution blocks are working. If a distribution block is unable to supply grease to its lubrication point, the pin stops and accordingly the entire system.

9.14.3 Lines

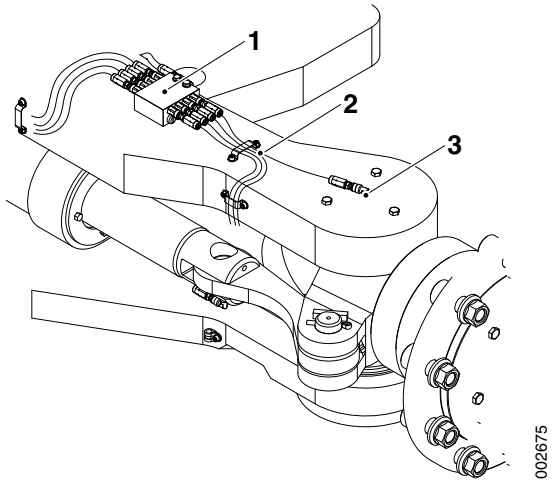
Lines, description

The lubricant is carried to the lubrication points through hoses.

9.14.4 Grease nipples

Lubrication points, description

The lubrication points have fittings to which the lines are connected. The fittings can be straight or angled.



1. Distribution block on steering axle
2. Lines
3. Lubrication point with coupling

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9.15 Paint/coatings

Paint/coatings, description

The machine is painted with paint which is applied by brush or spray.

For colour code (RAL), see machine card.

Check the machine frequently for stone chips, dents and paint scratches, repair them at once to prevent corrosion on the underlying metal. Only use touch-up paint for small stone chips and scratches. More extensive paint damage should be repaired by a paint workshop.

NOTE

Touching up, the surfaces to be touched up must be carefully cleaned.

Please contact Kalmar Industries for information about other surface treatment and material colours.

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10 Common hydraulics

10.2 Safety valves

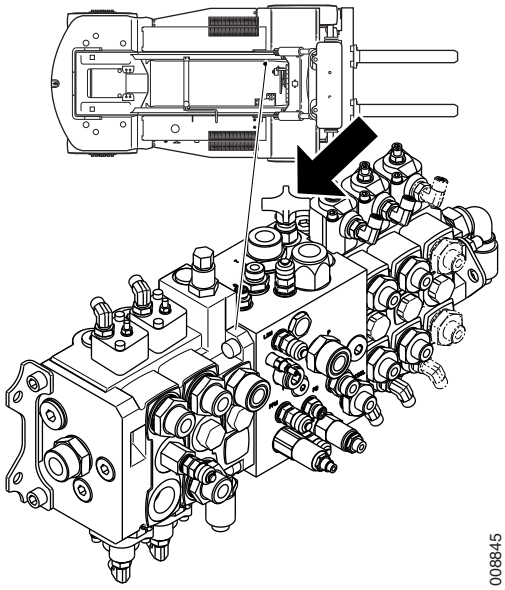
10.2.1 Accumulator drain valve

Accumulator drain valve, description

An accumulator drain valve is located in the valve block. Using its controls the accumulator must be drained before work on the hydraulic system. The accumulator is drained by unscrewing the valve's control screw.

A hissing sound indicates that the pressure is being released (hydraulic oil is returning to the hydraulic tank). When the sound ceases, close the accumulator drain valve again (by tighten the control screw).

In order to verify that the accumulator pressure released, measure using a pressure gauge on the pressure outlet by the accumulator charge valve (see *Measuring nipple, description page 15*).



Accumulator drainage valve control

10.2.2 Pipes and hoses

Pipes and hoses, description

See *Pipes and hoses, general page 12*.

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10.3 Tanks and accumulators

10.3.1 Tank

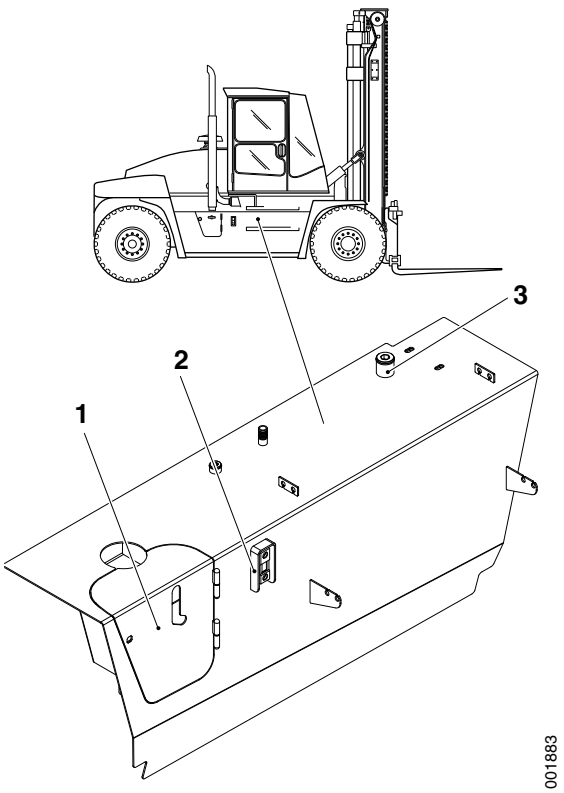
Tank, description

The main task of the hydraulic oil tank is to function as storage for the oil acting in the hydraulic system.

The hydraulic oil tank is a part of the side cover on the machine's right-hand side. Oil is filled through a hole on top of the tank (for oil quality and volume, see section *F Technical data*, group *10 Common hydraulics*). At the bottom of the tank is a drain plug.

The tank is equipped with a filtered breather that allows volume changes in the tank, due to temperature variations and use. See *Breather filter hydraulic oil tank, description page 26*.

The oil level is checked with the sight-glass on the side of the tank (when all hydraulic cylinders are in bottom position).

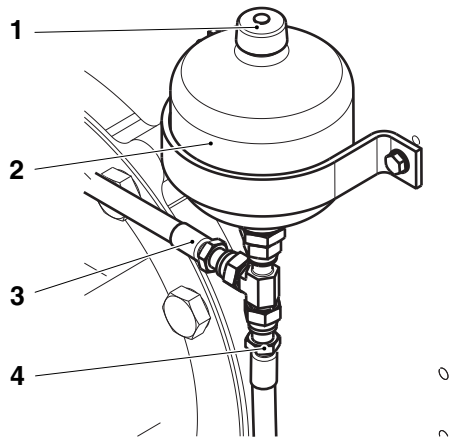


1. Cover to tipping mechanism
2. Level glass
3. Oil filling

NOTE

When filling hydraulic oil, make sure that the pumps are filled with oil before the system is activated since they're located higher than the tank.

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1. Test outlet for checking gas pressure
2. Accumulator
3. Pressure connection from accumulator charging valve
4. Pressure connection to brake valve

10.3.2 Accumulator

Accumulator, description

The accumulator store pressure so that there is a pressure reserve in the event of the engine stopping or faults in the brake system.

The accumulator is divided into two areas by a diaphragm. One side of the diaphragm is pressurized with nitrogen gas. The other side is pressurized by hydraulic oil which compresses the nitrogen gas.

The accumulator has a test outlet on the top for checking the pressure of the nitrogen gas (and topping up the nitrogen with special filling equipment).

The accumulator pressure on the pressure side is measured on the valve block.

When the accumulator is filled with hydraulic oil the diaphragm is pressed up and the pressure of the nitrogen gas rises. When the hydraulic system requires supply from the accumulator, the diaphragm forces the oil back into the system.

Pressurized oil from the accumulator is used by the service and parking brake systems, and to feed the servo hydraulics' pressure reducing valve, see section 4 Brakes and section 7 Load handling.

NOTE

If the accumulator delivers a low oil pressure, the hydraulic oil pumps may be damaged and the hydraulic functions cease to work.

Accumulator, checking

NOTE

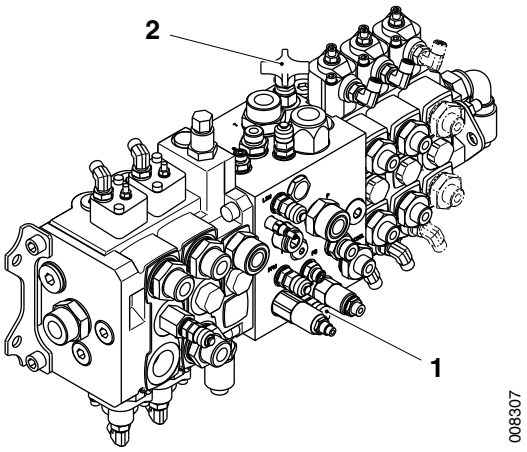
Read the safety instructions for oil before working, see section B Safety.

NOTE

A Special tool for checking the accumulators can be ordered from Kalmar Industries. Below is procedure without special tool described.

1 Machine in service position, see section *B Safety*.

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1. Measuring nipple, pressure to accumulator (ACCM)
2. Accumulator drain valve's control

2 Connect a pressure gauge (0–25 MPa) to the measuring outlet for accumulator pressure (position 1) on the main valve.

3 Turn on the main electric power and start the engine.

4 Charge the accumulator until the accumulator charging valve changes to cooling.

5 Turn off the engine.

6 Lower the pressure by means of braking carefully several times while checking the pressure on the pressure gauge.

When the pressure reaches **approx. 7.0 MPa** the pressure must decrease immediately to 0 MPa.

If the pressure decreases immediately when the engine is turned off then the accumulator has no pre-charge pressure. Check that the accumulator drain valve is closed. Otherwise this indicates inner leakage and the accumulator must be replaced.

If the pressure can be reduced slowly to a pressure below **7.0 MPa** then the pre-charge pressure is too low and the accumulator must be replaced or given to authorised personnel for maintenance.

7 Check that the accumulator’s connection is sealed tightly.

8 When the accumulator are fully charged. Turn off the engine and turn the start key to position I.

9 Check that at least **8** brake applications (pedal depressions) can be performed before the pressure drops to **7.0 MPa**.

At **11.5 MPa** the error code for low brake pressure must come on.

Accumulator, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, See section *B Safety*.

2 Depressurize the hydraulic systems, See section *B Safety*.

3 Clean the accumulator and the surrounding area.

4 Place a receptacle under the accumulator.

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5 Disconnect the hydraulic hose from the accumulator.

6 Undo the clamp that holds the accumulator to the chassis.

7 Transfer the connection adapter to the new accumulator.

NOTE

Check that the seal is intact and is fitted correctly.

8 Check that the new the accumulator has the correct pre-charge pressure, in accordance with the pressure plate.

9 Fit the new accumulator.

10 Connect the hose to the accumulator.

NOTE

Check that the O-rings are intact and are fitted correctly.

11 Turn on the main electric power and start the engine

12 Check that the accumulator's connection is sealed tightly.

13 Remove the receptacle, treat the waste oil as environmentally hazardous waste.

10.3.3 Sensor, low brake pressure

Sensor, low brake pressure, description

This sensor is located in the brake valve.

See section *4 Brakes*, group *4.3.8 Switch normally open (NO), low brake pressure*.

10.3.4 Pipes and hoses

Pipes and hoses, description

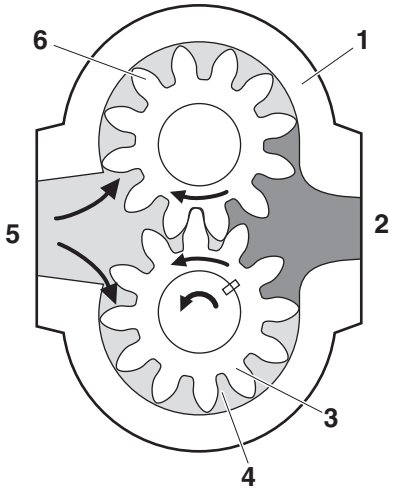
See *Pipes and hoses, general page 12*.

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10.4 Pumps

10.4.1 Gear pump with fixed displacement

Gear pump with fixed displacement, description



000660

1. Pump housing
2. Outlet
3. Drive gear
4. Gear tooth spacing
5. Inlet
6. Idler gear

All hydraulic pumps with fixed displacement are gear pump type. They are driven by splines from the engine. The pump shafts are fitted with slide bearings which are lubricated by the oil flowing through.

The gear pumps pump oil using two gears which run against each other in an oval housing. One of the gears is driven while the other rotates freely and follows the first one.

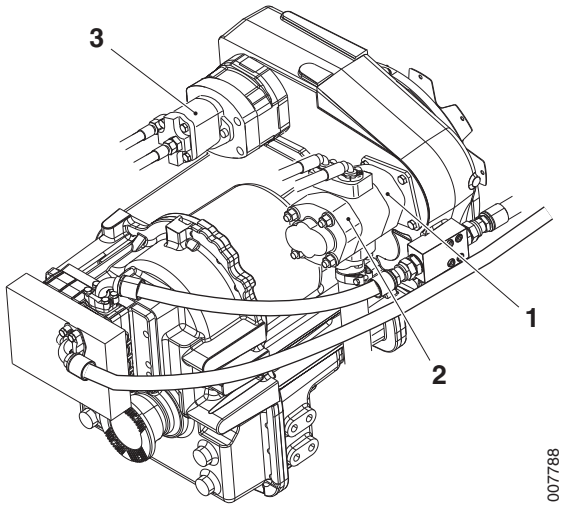
The motion of the gears creates suction between gears and housing. With each revolution that the gears turn they pump a certain quantity of oil (fixed displacement). The pump flow varies with the speed of the input shaft.

There are thrust plates on each side of the pump gears which form a seal between the suction and pressure sides.

The displacement, i.e. how many cubic centimetres of oil the pump can supply per pump revolution, can differ between the different gear pumps.

NOTE

It is essential that the clearance between the gears and between gears and housing is correct. Insufficient gear clearance wear damage. Excessive gear clearance reduces the efficiency of the pump.



007788

Hydraulic oil pumps, standard version transmission Dana

1. Hydraulic oil pump for steering and load handling
2. Hydraulic oil pump for lifting, lowering and tilting.
3. Hydraulic oil pump for brake system and servo circuit for load handling.

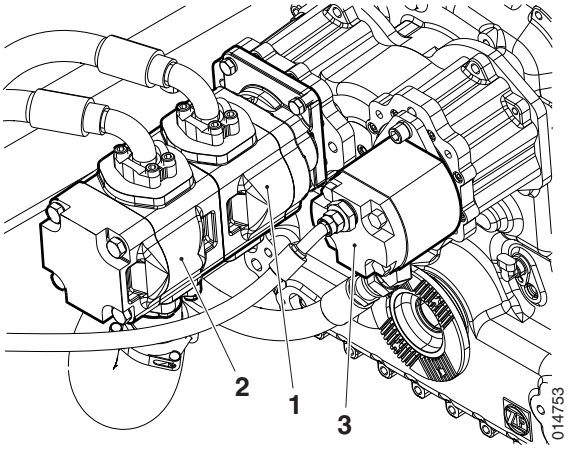
Transmisson Dana

The pumps have the following functions:

1. Pump 1 supplies the steering system and load handling. The priority valve in the valve block ensures that there is always pressure for steering. The remaining fluid flow is available for load handing.
2. Pump 2 supplies lifting, lowering and tilting.
3. Pump 3 supplies the brake and cooling circuit in the brake system via an accumulator charging valve, and the servo circuit for loading handling.
4. Pump 4 for lever steering / mini-wheel ⊕. Installed between the gearbox and hydraulic oil pump for the brake system, and the servo circuit for load handling (position 3).
5. Pump 5 for OptimumLift ⊕. Installed between the gearbox and hydraulic oil pump for the brake system, and the servo circuit for load handling (position 3).

The pumps are assembled in 2 pump banks and connected to the gearbox power take-off.

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Hydraulic oil pumps, standard version transmission ZF
1. Hydraulic oil pump for steering and load handling
2. Hydraulic oil pump for lifting and tilting.
3. Hydraulic oil pump for brake system and servo circuit for load handling.

Transmisson ZF

The pumps have the following functions:

1. Pump 1 supplies the steering system and control valve load handling. The priority valve ensures that there is always pressure for steering. The remaining fluid flow is available for control valve load handing.
2. Pump 2 supplies lifting and tilting via control valve load handling.
3. Pump 3 supplies the brake and cooling circuit in the brake system via an accumulator charging valve, and the servo circuit for loading handling.

The pumps are assembled in 2 pump banks and connected to the gearbox power take-off.

A hydraulic oil pump is added for joystick control/mini-wheel ⊕.

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Gear pump with fixed displacement, replacement

NOTE

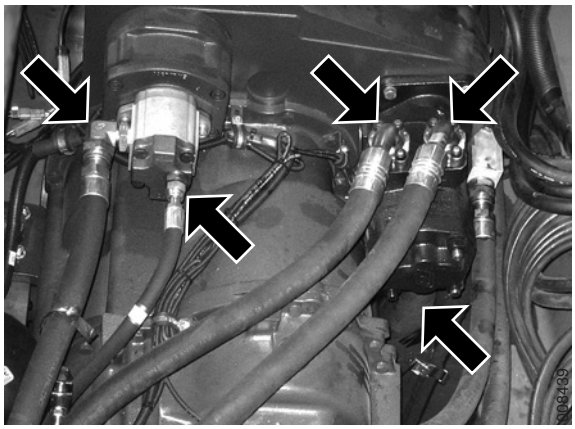
Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.

2 Depressurize the hydraulic system, see section *B Safety*.

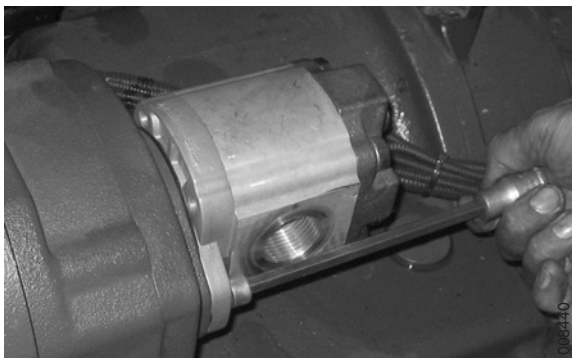
3 Clean the hydraulic oil pumps and the area round them.

4 Mark up and detach the hydraulic hoses from the pump.



NOTE

Plug all connections immediately to protect the hydraulic system from impurities.



5 Remove the pump.

Remove the retaining bolts, and pull the pump backwards and lift it away.

6 Transfer the connection adapters to the new pump.

NOTE

Check that the O rings are intact and fitted correctly.

7 Check the pump seals, replace if necessary.

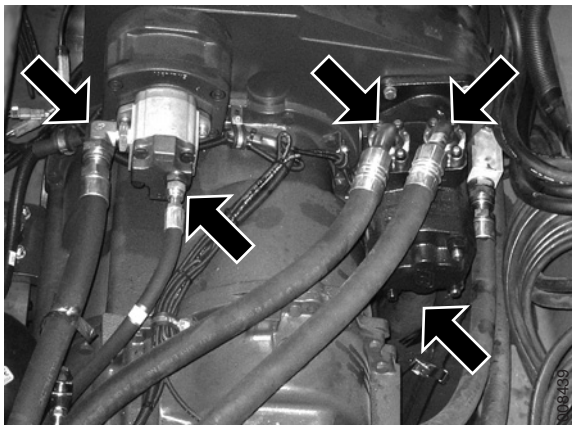


8 Fit the gear pump and axial piston pump.

Fit the pump and check that the gear grips the shaft.

Fit the pump's retaining bolts, use thread locking fluid on the screws to lock the screws and seal the screw holes in the transmission.

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9 Connect the hydraulic hoses in accordance with the markings.

NOTE

Check that the O rings are intact and fitted correctly.

10 Turn on the power supply and start the engine.

11 Check that the hose connections and seal between gear pump and axial piston pump are tight.

NOTE

Pre-fill the pumps with oil through the pressure connection before taking it into service.

If necessary, vent the pumps by loosening the hoses on the delivery side.

12 Check the hydraulic oil level with all hydraulic cylinders fully retracted. Top up if needed.

NOTE

If the pump is replaced due to malfunction, change the oil and filter as well.

⚠ CAUTION

Overfilling of oil.

Leakage and environmental damage.

The hydraulic oil level is checked with all hydraulic cylinders fully retracted.

10.4.3 Pipes and hoses

Pipes and hoses, description

See *Pipes and hoses, general page 12*.

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10.5 Hoses, pipes and valves

10.5.1 Pipes and hoses

Pipes and hoses, general

Hoses with ORFS couplings are used almost exclusively. For maximum service life and function, the following should be observed when replacing hoses.

1. To avoid stresses in the connection, there should be a length of straight hose after the connection.
2. The hose may not be twisted. (A twist of 7% reduces service life by 90%.)
3. Minimize the number of bends by using correct couplings.
4. Avoid sharp bends.
5. Keep the hoses clean internally. Leave the plugs in place as long as possible when installing.
6. Check the position of the O-rings and tighten to the correct torque, See section *F Technical data*.

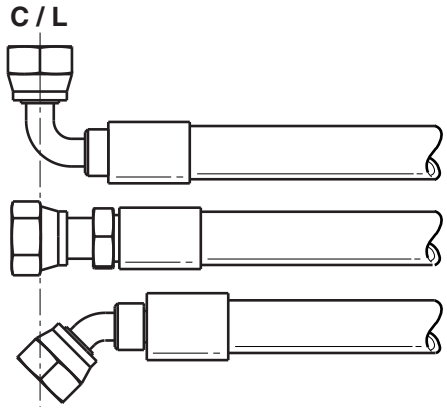
NOTE

Straight coupling requires a counterhold wrench to prevent damage to the O-ring.

7. The O-rings must not be oiled when fitted.

Hose length

Hose length is measured on a laid-out hose between the sealing surfaces. On angled connections, measure from the sealing surface's centre line [C/L] according to the figure.



C/L line for measuring hose length

Cleanliness

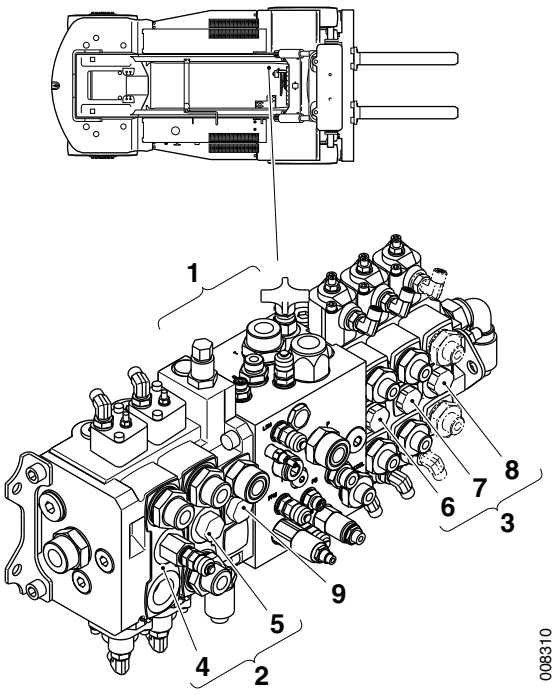
The function and service life of hydraulic components depend to a great extent on how clean the hydraulic oil is. Therefore, it is very important to prevent dirt from entering the brake and hydraulic system.

Some simple advice to keep the hydraulic system clean.

- Always clean the area around a component before starting to work.
- Plug hose connections immediately after disconnecting. If possible, use correct plugs for the connection type. If plugs are missing, use clean plastic bags and cable ties or tape to seal the connection.
- Never reuse oil that has been drained from the machine.
- If possible, filter the oil before pouring it into the machine, oil barrels often contain impurities.

  When filling hydraulic oil, fill through the tank’s filler cover.

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Main valve controlled with hydraulic servo
The main valve comprises valve block and surrounding direction valves.
1. Valve block
2. Direction valve (lift and lower, and tilt)
3. Direction valve (side shift, spreading and levelling)
4. Lift and lower section
5. Tilt section
6. Side shift section
7. Spreading section
8. Levelling section
9. Intake section

10.5.2 Main valve

Main valve, general

There are two types of load handling control valve: hydraulic servo and electrical servo.

The direction valves in the main valve controls all load handling functions. The main valve is located to the left on the frame in the engine compartment. The control valve is controlled by hydraulic or electric servo valves.

The main valve principally comprises the following parts:

- Intake section (between valve block and tilt section)
- Control sections, in a number that corresponds to the machine's functions (the direction valves)
- Combined control and outlet section (the direction valves)

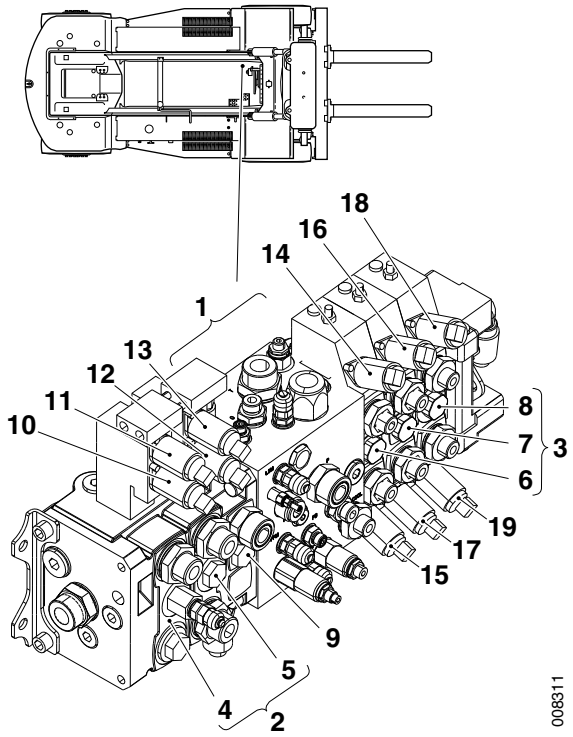
For more information on load handling functions, see section *7 Load handling*.

Hydraulic servo

Actuation of the control valve is proportional to servo pressure. This means that the magnitude and direction of the flow from the direction valves can be controlled by adjusting the servo pressure to the valves.

A low hydraulic pressure (servo pressure) from the control levers actuates the spring-centred control spools in the direction valves. The control spool for the function in question controls the main flow from the hydraulic oil pump to the hydraulic cylinders for that function. The speed of the function is controlled by the flow, which is proportional to the movement of the control lever.

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Main valve controlled with electric servo
The main valve comprises valve block and surrounding direction valves.

1. Valve block
2. Direction valve (lift and lower, and tilt)
3. Direction valve (side shift, spreading and levelling)
4. Lift and lower section
5. Tilt section
6. Side shift section
7. Spreading section
8. Levelling section
9. Intake section
10. Solenoid valve, lower (Y6004)
11. Solenoid valve, lift (Y6005)
12. Solenoid valve, tilt out (Y6010)
13. Solenoid valve, tilt in (Y6011)
14. Solenoid valve, side shift left (Y6020)
15. Solenoid valve, side shift right (Y6021)
16. Solenoid valve, spreading in (Y6019)
17. Solenoid valve, spreading out (Y6018)
18. Solenoid valve, fork levelling up (Y6022)
19. Solenoid valve, fork levelling down (Y6023)

Electric servo

The control valve is controlled proportional by servo valves. This means that the magnitude and direction of the flow from the direction valves can be adjusted.

Electrically controlled pressure reducing valves (servo valves) convert electrical current into a low hydraulic pressure that is proportional to the current, known as the servo pressure. The servo pressure acts on the spring-centred control spool in the control valve for the function in question and thereby controls the main flow.

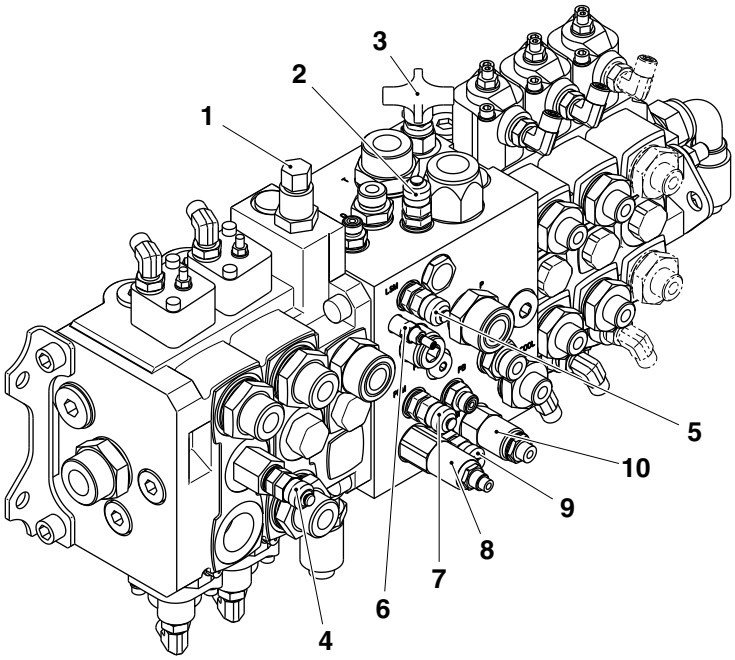
The speed of the function is controlled by the flow, which is proportional to the movement of the control lever.

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Measuring nipple, description

Located on the main valve are a number of measuring nipples and adjustment options for certain functions. Most measuring nipples are located on the valve block and an occasional one on the direction valves.

For pressure values for the various measuring nipples, see *the pressure sign (located beside the cab tipping control for the machine)*.



008312

1. Pressure limiting valve for lift and lower
2. Measuring nipple, pressure to side shift and spreading (PM)
3. Accumulator drain valve
4. Measuring nipple, pressure to lift and tilt (P2)
5. Measuring nipple, pressure to steering (LSM)
6. Pressure relief valve for steering
7. Measuring nipple, pressure to servo control levers (PPM)
8. Adjustment of pressure to servo control levers (PP)
9. Measuring nipple, pressure to accumulator (ACCM)
10. Accumulator charge valve (adjustment of max. pressure to accumulator)

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Hydraulic pressure, inspection and adjustment

⚠ WARNING

The hydraulic pressure must only be adjusted by authorised personnel.

NOTE

Read the safety instructions for oil before work, see section B Safety.

1 Warm the machine up so that the hydraulic oil reaches working temperature, about 50 °C.

2 Switch off the engine.

3 Connect a pressure gauge to the relevant measurement union on the main valve, please refer to the figure under *Measuring nipple, description page 15* for positioning the measurement unions.

4 Start the engine. Check each function as below.

Accumulator charging (ACKM)

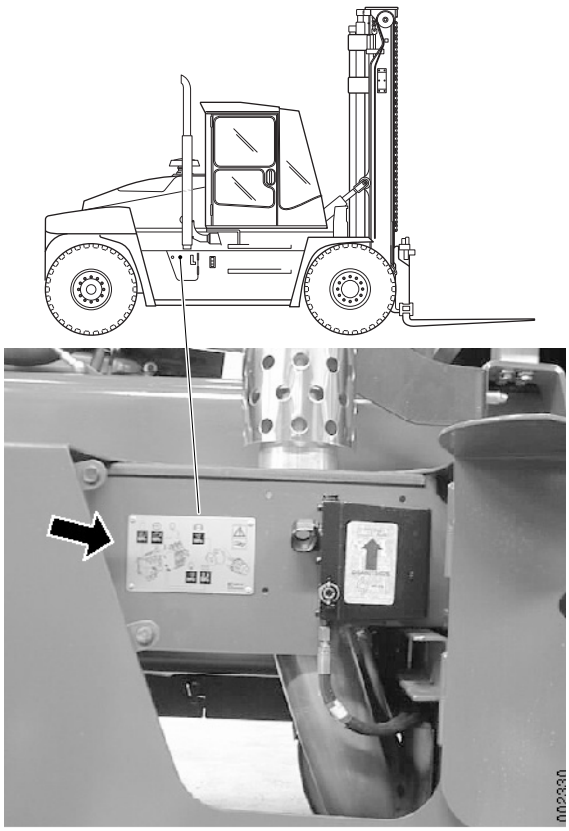
- Allow the accumulator to charge until charging switches over to cooling the brakes. Read the pressure off and compare with the permissible pressure on the pressure sign.
- Apply the brakes repeatedly and read off the pressure at which the accumulator starts to be charged again. This should be about 13.5 MPa.
- Adjust as necessary, using the adjustment screw for accumulator pressure (position 10).

Steering (LSM)

- Increase the engine speed to about 1100 rpm.
- Turn the steering to full lock right or left and continue to activate the function.
- Read the pressure off and compare with the permissible pressure on the pressure sign.
- Increase the engine speed to about 1800 rpm. Read the pressure again. The difference should not exceed ±1.0 MPa.
- Adjust as necessary, using the adjustment screw for steering pressure (position 6).

Lift and tilt (P2)

- Increase the engine speed to about 1100 rpm.
- Activate the tilt to its end position and continue to activate the function.
- Read the pressure off and compare with the permissible pressure on the pressure sign.
- Increase the engine speed to about 1800 rpm. Read the pressure again. The difference should not exceed ±1.0 MPa.



Pressure data sign

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– Adjust as necessary, using the adjustment screw for lift and lower (position 1)

Side shift, spreading (PM)

– Increase the engine speed to about 1100 rpm.

– Activate side shift or spread to its end position and continue to activate the function.

– Read the pressure. This pressure is not adjustable.

Servo pressure for control levers (PPM)

– Read the pressure off and compare with the permissible pressure on the pressure sign.

– Adjust as necessary, using the adjustment screw PP (position 8).

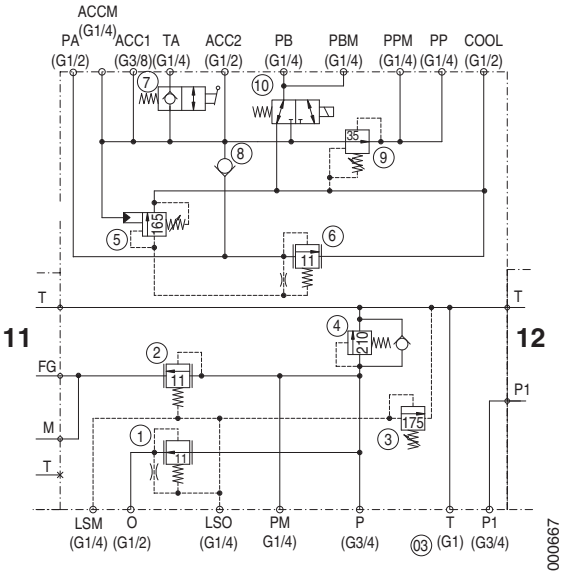
Valve block, description

A range of hydraulic functions are collected in the main valve's valve block.

The valve block's main parts are as follows:

- **Accumulator charge valve.** Guides oil either to the accumulator or through the drive axle to the wheel brakes for cooling. Adjustable boost pressure.
- **Priority valve for accumulator charging.** Controlled by the accumulator charge valve and prioritises charging of the accumulator ahead of cooling. (A restriction for the charging means that a small quantity of oil also flows to oil cooling during accumulator charging.)
- **Pressure limiting valve, steering system.** Measures the LSM pressure, i.e. the pressure to the steering. Adjustable.
- **Pressure reducing valve** between the steering valve LS-signal and the pump pressure. Its function is therefore to maintain a max. pressure difference between the load signal from the steering valve and pressure supplied to the steering valve.
- **Priority valve for steering.** Gives basic pressure in the main valve. Acted on by the steering valve LS-signal and ensures that the steering circuit receives sufficient supply. See *Priority valve, description page 19*.
- **Pressure reducing valve for servo** to control levers (adjustable).
- **Pressure limiting valve** for side shift, spreading and levelling sections (fixed preset).
- **Accumulator drain valve.** The valve opens the connection between the accumulator and tank. (The oil is drained through the wheel brake to the tank.)
- **Electric valve for parking brake.**

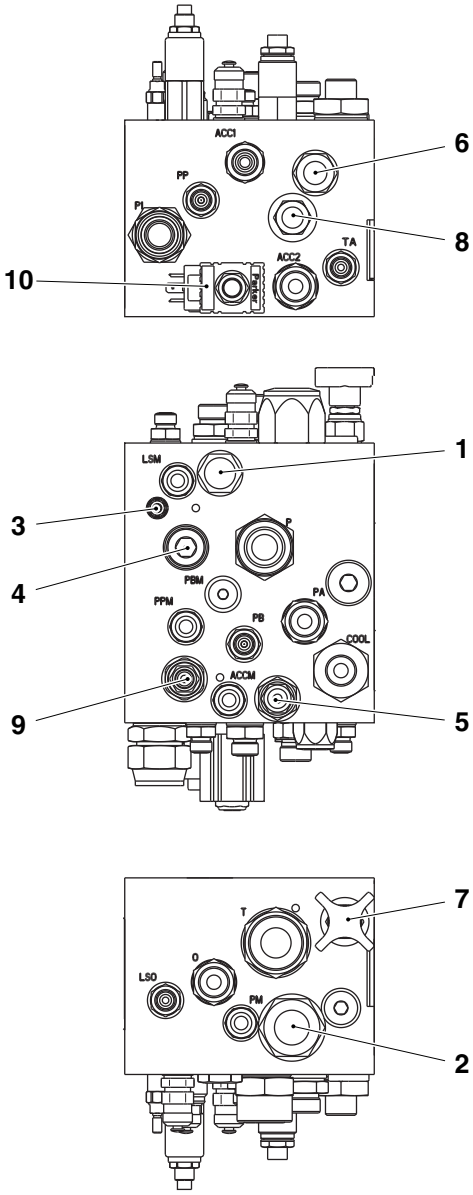
Tightening torques for the different valves (cartridges) in the valve block are in section *F Technical data*, group *10.5.2 Main valve*.



Schematic description of the valve block. The direction valves for the control sections are located on each side.

1. Pressure reducing valve (steering)
2. Priority valve (steering)
3. Pressure limiting valve (steering)
4. Pressure limiting valve (side shift, spreading and levelling)
5. Accumulator charge valve
6. Priority valve (accumulator charging)
7. Accumulator drain valve)
8. Non-return valve (accumulator)
9. Pressure limiting valve (servo pressure)
10. Electric valve (parking brake)
11. Direction valve (lift and lower, and tilt)
12. Direction valve (side shift, spreading and levelling)

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The locations of the different valves on the valve block (seen from different angles).

1. Pressure reducing valve (steering)
2. Priority valve (steering)
3. Pressure limiting valve (steering)
4. Pressure limiting valve (side shift, spreading and levelling)
5. Accumulator charge valve
6. Priority valve (accumulator charging)
7. Accumulator drain valve
8. Non-return valve (accumulator)
9. Pressure reducing valve
10. Electric valve (parking brake)

Control valve for servo control of main valve, description

The control valves are integrated into the valve block with a number of direction valves that respond to the machine's functions.

Each direction valve, or section, is equipped with two pressure reducing valves. The valve slides are hardened and precision ground for minimal internal leakage.

The control forces are low and the output proportional to the lever angle, which gives gentle control of the working hydraulics.

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10.5.3 Priority valve

Priority valve, description

Priority valve for steering circuit is located in the valve block and gives 11 bar basic pressure in the main valve.

The priority valve is affected by the steering valve's LS-signal and makes sure that steering circuit receives sufficient feed. Thus, the valve gives priority to supplying pressure to the steering function before load handling.

10.5.5 Proportional valve

Proportional valve, description

The proportional valve is an electrically controlled pressure reducing valve for electric remote control of hydraulic functions. The output signal is a proportional hydraulic servo pressure used to control the slides in the directional valves.

The proportional valve consists of a solenoid as well as pre-control valve and is connected directly to the directional valve's slide.

The solenoid controls the pre-control valve with proportional force. On the end surface of the solenoid, there is an air bleeder screw.

The pre-control valve gives an output control pressure that is, for all practical purposes, linearly proportional to the input current. The pre-control valve is closed in neutral position.

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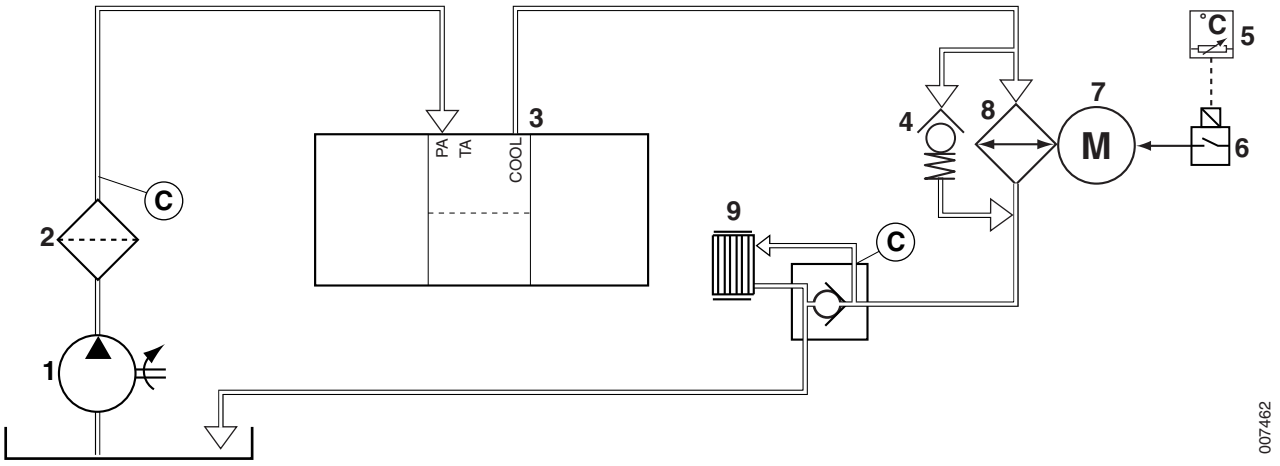
10.6 Temperature control, cleaning and hydraulic oil

Temperature control, general

The cooling system lowers the temperature of the hydraulic oil in the machine. The cooling system consists of a separate electrically driven fan installed in the return pipe from the control valve.

Thanks to the oil cooler, the reduction of hydraulic oil temperature benefits the entire hydraulic system.

Temperature control and cooling system via electrically operated cooler, description



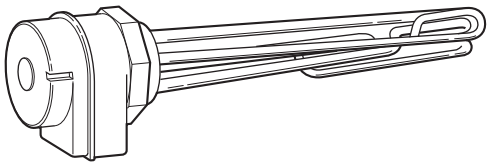
Pos	Explanation	Signal description	Reference
1	The hydraulic oil pump pumps oil from the hydraulic oil tank.	-	*Tank, description page 4* *Gear pump with fixed displacement, description page 8*
2	The high pressure filter cleans the oil.	-	*High-pressure filter, description page 27*
3	The accumulator charging valve directs oil to charging of accumulators or through the brake system's cooling circuit.	Max. 0.1 MPa	Section *4 Brakes,* group *4.3.13 Accumulator charging valve*
4	A thermal bypass valve directs the hydraulic oil past the cooler and direct to the tank if the temperature is below 55°C. When the oil temperature is above 65°C, all oil is directed through the cooler	55-65 °C	*Thermal by-pass valve, description page 25*

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Pos	Explanation	Signal description	Reference
5	Switch (NO) (opening switch) hydraulic oil temperature (S240-1) opens and pulls relay (K359) for the electrical cooling fan if the hydraulic oil temperature is high.	The fan starts at 60 °C and shuts off when the temperature falls below 50 °C.	*Switch (NC) cooling fan, description page 25*
6	The relay (K359) supplies the electric cooling fan (M668) with current.	U = 24 V	*Cooling fan, description page 25*
7	The cooling fan (M668) increases the air flow through the hydraulic oil cooler and thus increases the cooling effect.	-	*Cooling fan, description page 25*
8	The hydraulic oil cooler cools the hydraulic oil	-	*Cooling fan, description page 25*
9	Oil is directed back to the hydraulic oil tank via the service brake coolers.	-	

Hydraulic diagram, see section *E Schematics group 10 Common hydraulics*

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10.6.1 Tank heater

Tank heater, description

The tank can be equipped with a tank heater. The tank heater is primarily intended for cold climates. The tank heater is powered by high voltage and is available with different input voltages (rated voltage) The heater is mounted above the foot step on the right-hand side of the machine.

The tank heater can be equipped with an adjustable thermostat which maintains a constant temperature level. The thermostat is mounted directly on the heating coil and can be adjusted using the control on the terminal box.

Tank heater, replacement

WARNING

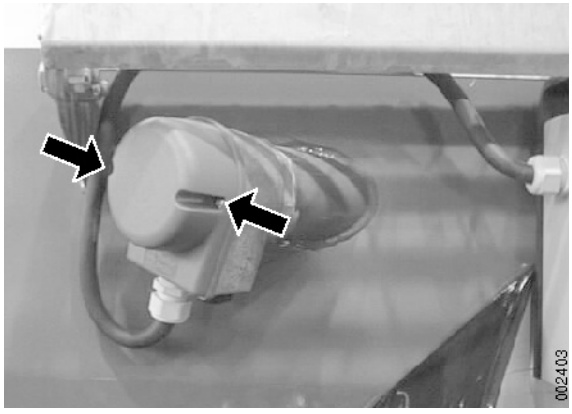
The tank heater is connected to high voltage (110 - 400 V).

Connection and reconnection of the tank heater may only be performed by personnel authorised for work with high voltage.

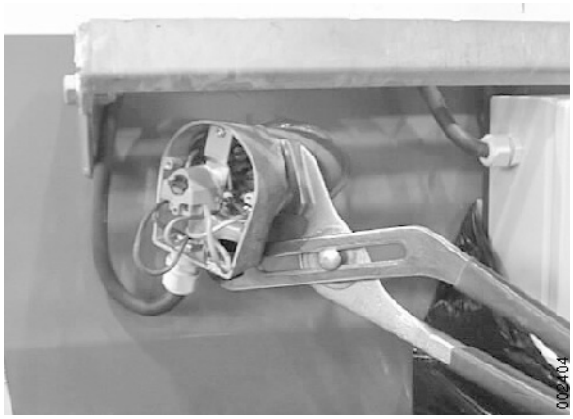
NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*.
2 Depressurize the hydraulic system, see section *B Safety*.
3 Drain the machine of hydraulic oil. Use a pumping device.
4 Remove the two screws that hold the plastic cover.
5 Unplug the electric cables from the connections.
6 Remove the lock nut which holds the wiring harness in the heater.



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7 Remove the heater from the machine.

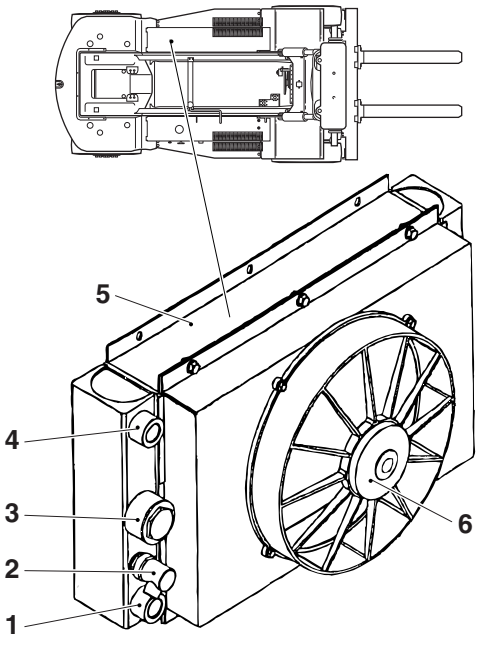
8 Replace the heater.

9 Fit in reverse order.

10.6.2 Hydraulic oil cooler

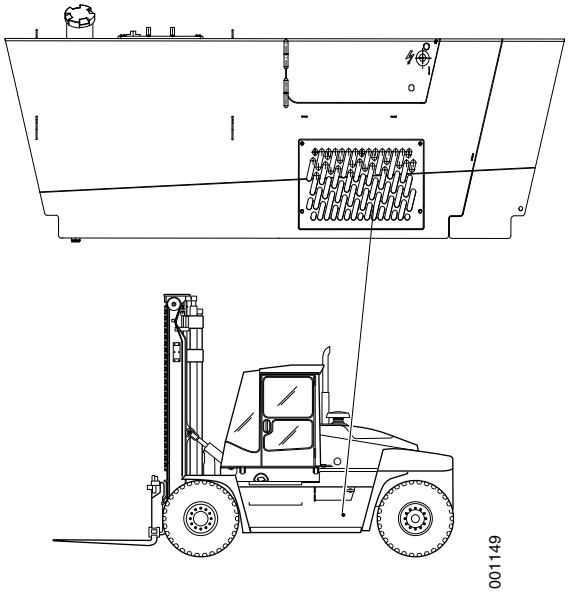
Hydraulic oil cooler, description

The hydraulic oil cooler is the flow-through type with electric cooling fan and built-in thermal by-pass valve. The oil is cooled when it passes the cooler. The fan starts when oil temperature exceeds 60°C and stops when the temperature falls below 50 °C.



Hydraulic oil cooler
1. Inlet
2. Switch (NC) cooling fan
3. Thermal by-pass valve
4. Outlet
5. Cooling core
6. Cooling fan

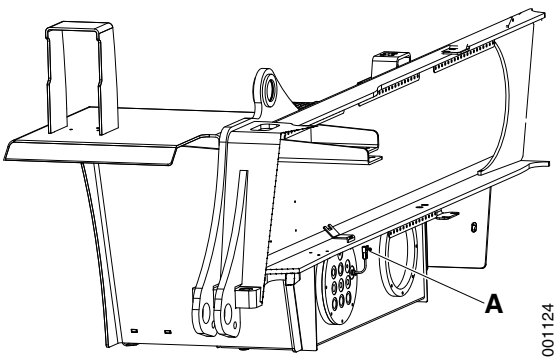
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It is possible to detect that extra cooling is fitted due to openings in the fuel tank cover that allow air passage through the cooler.

10.6.3 Sensor hydraulic oil temperature

Sensor hydraulic oil temperature, description



A. Sensor hydraulic oil temperature

Sensor hydraulic oil temperature (B776) senses the temperature of the hydraulic oil before it reaches the cooler. The sensor is located by the plate in the hydraulic tank (by the suction line).

Sensor hydraulic oil temperature (B776) is supplied with voltage by and sends voltage signal proportional to oil temperature to Control unit general (ECU790).

The signal can be checked from the diagnostics menu, see section *8 Control system*, group *8.4.1.1 View inputs, menu 3, ECU 790 input K2:21*.

Sensor hydraulic oil temperature, replacement

NOTE

Read the safety instructions for oil before working, see section B Safety.

1 Machine in service position, see section *B Safety*

2 Depressurize the hydraulic system, see section *B Safety*.

3 Detach the electrical connectors from the sensor.

4 Replace the sensor (position 1).

5 Fit in the reverse order.

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10.6.4 Switch (NC) cooling fan

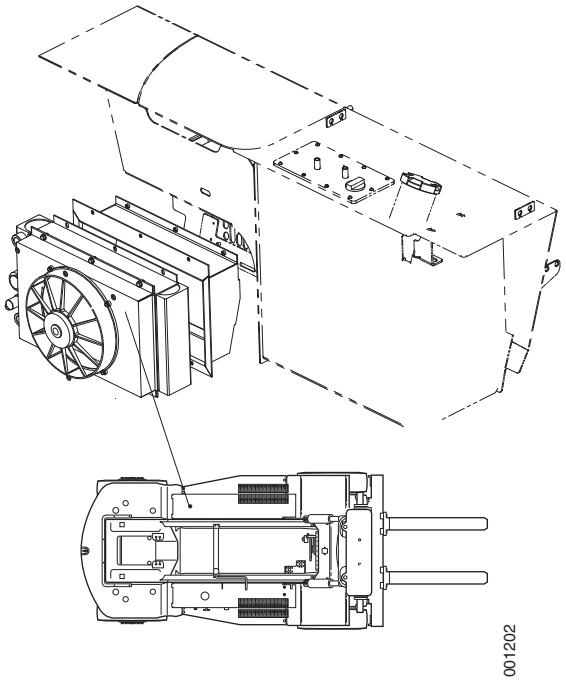
Switch (NC) cooling fan, description

At a certain temperature, the switch (NC) cooling fan sends a signal that activates the cooling fan.

See illustration at *Hydraulic oil cooler, description page 23*.

10.6.5 Cooling fan

Cooling fan, description

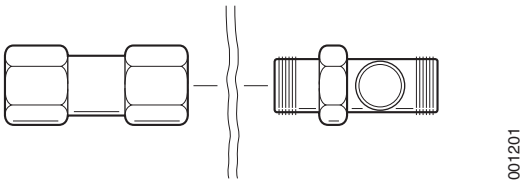


The cooling fan is located behind / underneath the fuel tank, on the inside of the hydraulic oil cooler. The fan forces (draws in) air from the machine's outside in through the cooler.

The fan is activated by the sensor for hydraulic oil temperature, see *Sensor hydraulic oil temperature, description page 24*.

10.6.6 Thermal by-pass valve

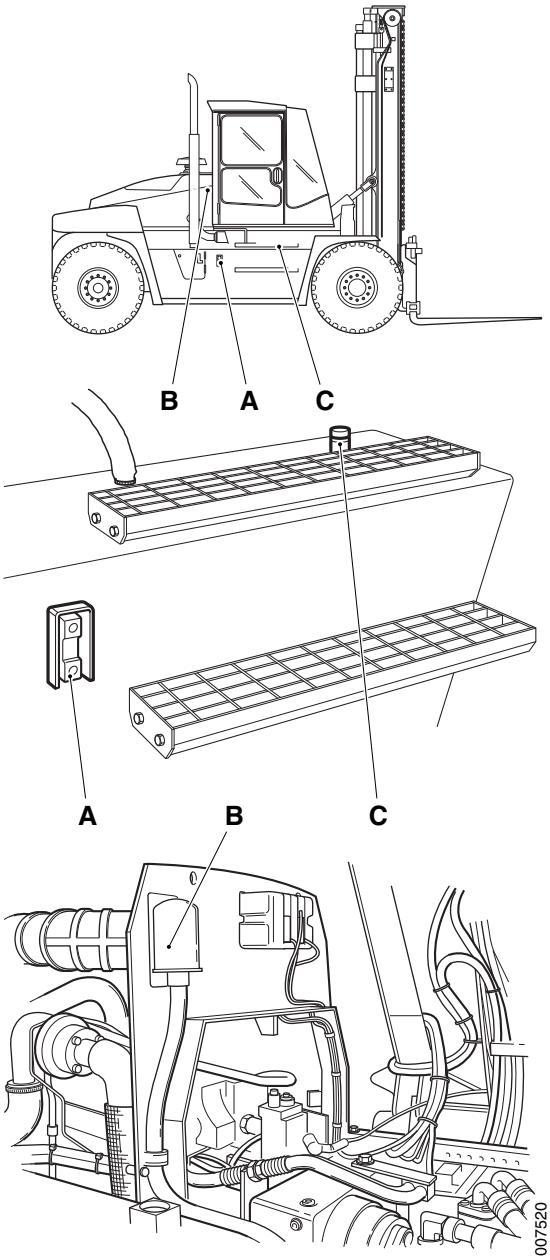
Thermal by-pass valve, description



The thermal by-pass valve is a temperature-controlled bimetal valve integrated in the hydraulic oil cooler. (See also illustration at *Hydraulic oil cooler, description page 23*.)

At low oil temperatures, the oil can pass straight through the valve. At a certain temperature, the valve closes completely, forcing the oil to flow through the cooler's cooling core.

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A Sight-glass
B Breather filter
C Filling

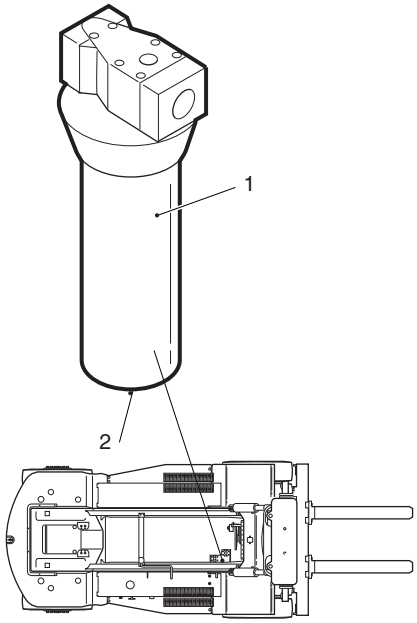
10.6.7 Breather filter hydraulic oil tank

Breather filter hydraulic oil tank, description

A breather filter of spin-on type is connected to the hydraulic oil tank. The filter is located immediately behind the cab to the right. It can be seen when the cab is tilted and/or when the engine cover is raised.

The breather filter cleans moisture and dust from the air that passes from the tank's breather.

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1. High-pressure filter
2. Drain plug.

10.6.8 High-pressure filter

High-pressure filter, description

There are three high-pressure filters with loose filter insert that clean the oil directly after each respective hydraulic pump before the oil reaches the valve block. The filters are of the same type after all the pumps, however, the filter is slightly smaller after pump 3 (brake, accumulator, servo). The filter after pump 3 is mounted lowest in the machine and is easiest to access from below.

The oil is cleaned when it is forced out and through the filter insert, which is a fibreglass cartridge, and then onward.

Between the inlet and the outlet in the filter head, there's a by-pass valve that protects the insert. If the resistance through the filter surface becomes too high, the by-pass valve opens a passage past the insert. The by-pass function opens if the oil is viscous (cold or wrong viscosity) or if the filter insert is clogged by dirt. The valve's opening area becomes ever larger as the pressure drop increases, i.e. the degree of clogging.

The high-pressure filters must be replaced according to the interval in the lubrication schedule as well as in connection with work on the hydraulic system.

NOTE

When the filter is clogged, the oil passes without cleaning. Therefore, it is very important to replace the filter according to the prescribed interval.

⊞

For mini-wheel/lever steering, there is an additional filter of the larger type after pump 4 (see *Gear pump with fixed displacement, description page 8*).

10.6.9 Hydraulic oil

Hydraulic oil, safety

NOTE

Read the safety instructions for oil before working, see section B Safety.

Hydraulic oil, description

Lubrizol is added to the hydraulic oil for the lubrication of the brake discs. See section *F Technical data*, and *Oil and lubricant recommendation*.

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10.6.10 Pump 3 - accumulator charging, flushing/cooling system and servo system control levers

Pump 3 - accumulator charging and flushing/cooling system, description

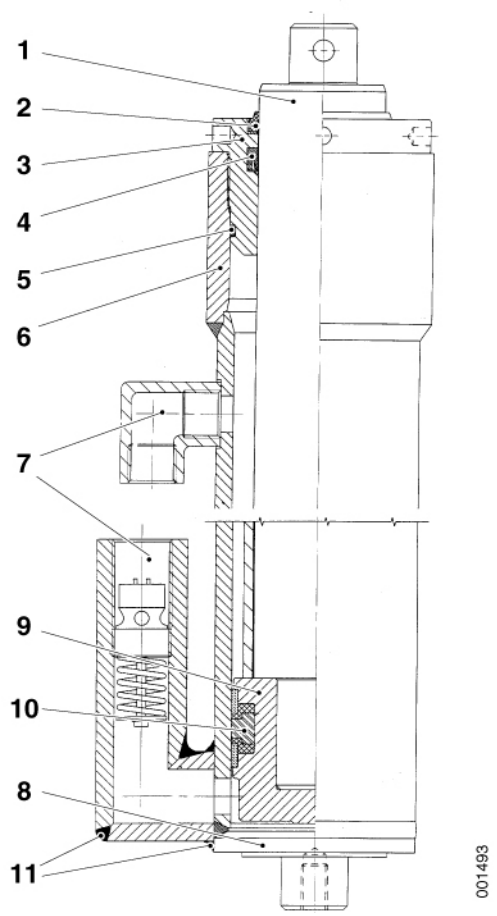
See *Gear pump with fixed displacement, description page 8*.

10.6.11 Pipes and hoses

Pipes and hoses, description

See *Pipes and hoses, general page 12*.

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1. Piston rod
2. Scraper
3. Cylinder head
4. Piston rod seal
5. O-ring with thrust ring
6. Cylinder barrel
7. Sleeve coupling
8. Welded cylinder end
9. Piston
10. Piston seal, double-acting
11. Example of weld

10.7 Auxiliaries

10.7.1 Hydraulic cylinders

Hydraulic cylinders, repairs

Fault tracing, leakage

CAUTION

All fault tracing should be carried out with as low a pressure in the system as possible so that the leakage can be detected. High pressure causes the seals to close tighter, which prevents detection of leaks.

1 Carefully check the source of the leakage before taking any action. It may be possible to rectify the fault without disassembly.

2 Check for external leakage:

- At cylinder end welds
- At sleeve coupling welds
- Between cylinder barrel and cylinder head

  This could be due to a defective O-ring or damaged O-ring sealing surfaces. Both faults can be rectified with the cylinder in situ.
- Between cylinder head an piston rod

  This could be due to a damaged piston rod or damaged or worn piston rod seal.

3 Check for internal leakage. Pressurize the cylinder and check whether the piston sinks back.

This could be due to a worn piston seal.

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Dismantling of cylinders

CAUTION

Before dismantling always check that the piston rod is clean and free from all residual paint. Also check that connections and couplings are free from burrs and impact marks.

Make sure that the chamfer up to the chromium surface of the piston rod is free from burrs and residual paint.

1 Remove the cylinder from its mounting and undo the connections.

2 Plug the cylinder connections and hoses without delay.

3 If the cylinder is opened - observe the strictest cleanliness.

Inspection of surfaces

1 Inspect the sealing surfaces, always bearing mind the function of the seals and the type of sealing surfaces they have, see the following descriptions:

- O-ring groove, internal and external
- piston rod seal in the cylinder head
- Sealing groove on the piston
- cylinder barrel surface
- piston rod surface. The piston rod is chromium plated with a layer thickness of 20-50 micrometer (µm). Slight damage to the chromium plating need not necessarily be the direct cause of leakage.
- all sliding surfaces (dynamic surfaces), e.g. cylinder barrel and piston rod. These are always the hardest to seal.

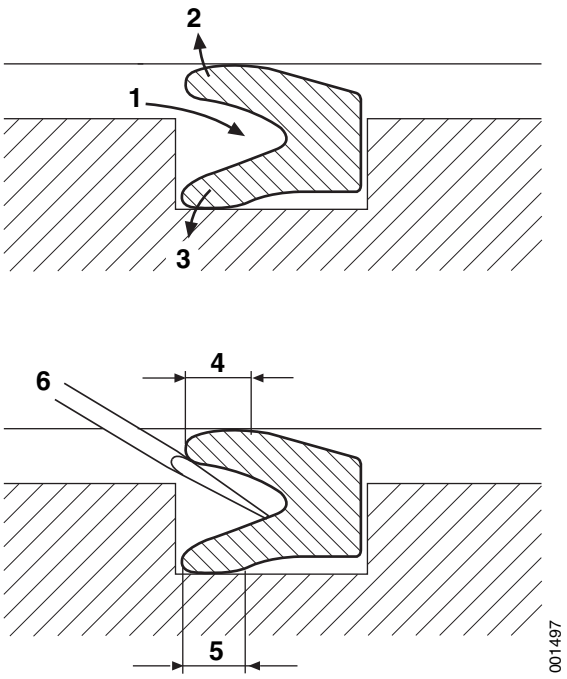
CAUTION

When mounting the cylinder head:

Introduce it absolutely straight, preferably by hand and never strike it with a mallet.

If the cylinder head is skew as it enters, this could damage the sealing lip of the piston rod seal and its sealing function would then be lost. This applies to all types of piston rod seal

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1. Hydraulic pressure
2. The sealing lip is pressed outwards against the piston rod
3. The sealing lip is pressed inwards against the cylinder head
4. Sealing surface, piston rod
5. Sealing surface, cylinder head
6. Screwdriver

Function and removal of the seals

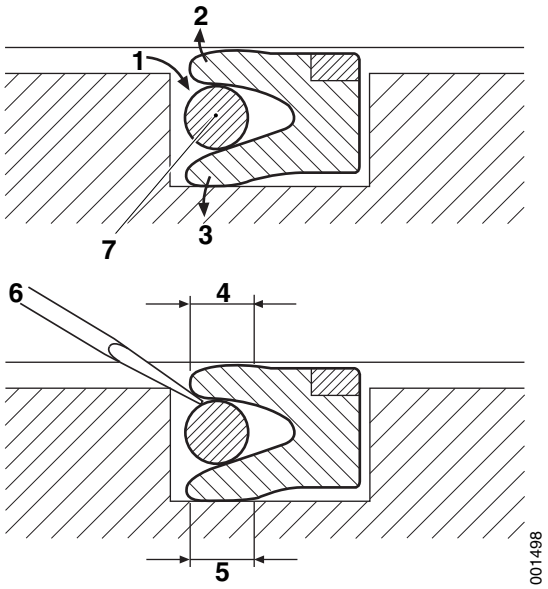
Piston rod seal

The piston rod seal sits in a groove in the cylinder head and seals against the piston rod. This seal is highly vulnerable as it seals both dynamically and statically, i.e. it seals against a moving surface on the piston rod while the sealing surface against the cylinder head is fixed. There are different kinds of piston rod seal:

- Single V-ring seal
- Pre-stressed V-ring seal with thrust ring
- Compressible seal

The single V-ring seal has a V-shaped section with two lips, each sealing in its own direction. The hydraulic pressure acts in the V shape and presses the sealing lips outwards against the sealing surfaces on the piston rod and in the cylinder barrel. Even minor damage to the sealing lips can cause major leakage. Check the sealing lips by carefully feeling all round the seal with a fingernail. Use a screwdriver to remove the seal, see illustration. Lever outwards and prise up the seal. It is extremely important always to insert the screwdriver in the V shape so that it cannot touch and so damage any sealing surface. A mark made by the screwdriver on a sealing surface will have a devastating effect and give rise to serious leakage.

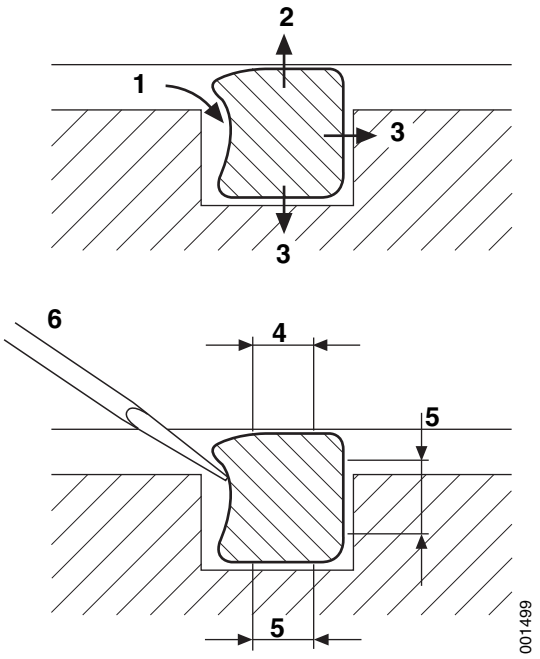
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1. Hydraulic pressure
2. The sealing lip is pressed outwards against the piston rod
3. The sealing lip is pressed inwards against the cylinder head
4. Sealing surface, piston rod
5. Sealing surface, cylinder head
6. Screwdriver
7. O-ring

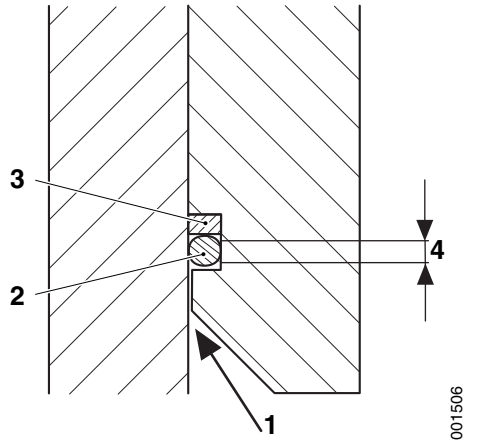
In addition, the pre-stressed V-ring seal has an O-ring in the V-shaped space of the seal. The O-ring has a highly efficient sealing effect at low hydraulic pressures as even when not under load the sealing lips are pressed outwards against the sealing surfaces. It is just as susceptible to damage as the V-ring seal. Inspect in the same way. Use a screwdriver to remove the seal, see illustration. Lever outwards and prise up the seal. It is extremely important always to insert the screwdriver in the V shape so that it cannot touch and so damage any sealing surface. A mark made by the screwdriver on a sealing surface will have a devastating effect and give rise to serious leakage.

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1. Hydraulic pressure
2. The sealing lip is pressed outwards against the piston rod
3. The sealing lip is pressed inwards against the cylinder head
4. Sealing surface, piston rod
5. Sealing surface, cylinder head
6. Screwdriver

The compressible piston rod seal consists of a solid rubber section and has a larger sealing surface than the V-ring seals. Use a screwdriver to remove the seal, see illustration. Lever outwards and prise up the seal. With this type of seal where the sealing surfaces cover such a large part of the sealing groove it is especially important to ensure that the screwdriver does not slip and leave any marks.



1. Hydraulic pressure
2. O-ring
3. Thrust ring
4. Sealing surface, cylinder head

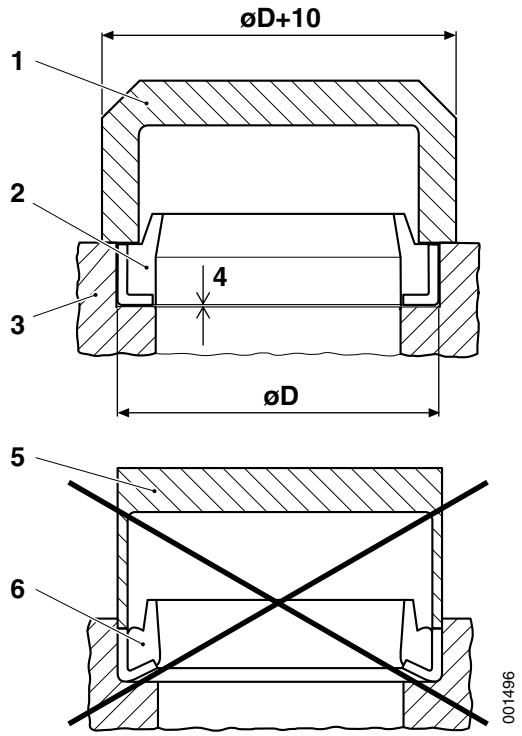
Thrust ring and O-ring

The thrust ring and O-ring combination is used for sealing between two fixed surfaces, such as between cylinder barrel and cylinder head.

The purpose of the thrust ring is to lend rigidity to the O-ring so that it is not deformed. The O-ring is pressed against the thrust ring and the sealing surface by the hydraulic pressure in the cylinder.

When fitting the cylinder head: Exercise care to avoid damaging the O-ring.

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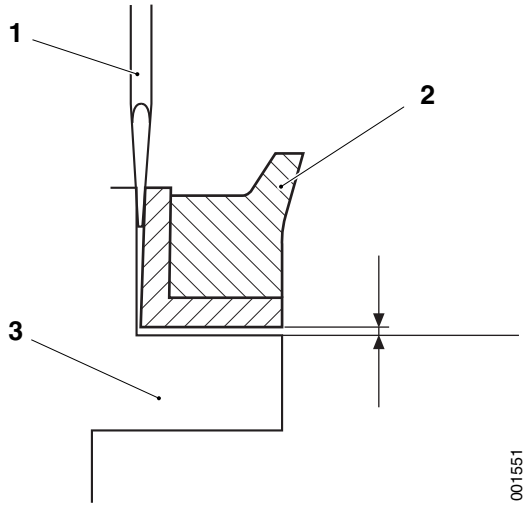
1. Correct assembly tool
2. Scraper, correctly fitted
3. Cylinder head
4. Clearance between scraper and bottom of cylinder head recess
5. Incorrect assembly tool
6. Deformed scraper

Scraper

The purpose of the scraper is to scrape the piston rod clean and prevent impurities from entering the cylinder barrel.

The scraper should be fitted using a special assembly tool. This tool should have a larger outside diameter than the scraper so that the pressing force exerted on the scraper ceases at the precise moment when the scraper is pressed into position. If the scraper is pressed in additionally the metal cap will be deformed (see lower illustration) with poorer scraper functionality as a result.

To prevent the scraper from bottoming in its recess in the cylinder head, the recess is slightly deeper than the width of the scraper.



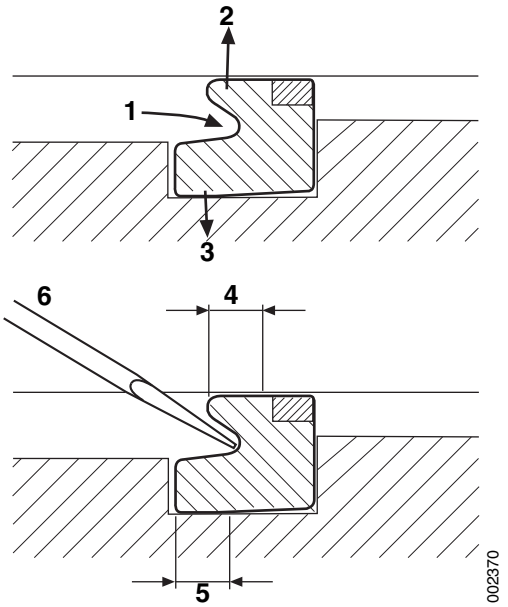
1. Screwdriver
2. Scraper
3. Cylinder head

A screwdriver can be used to remove the scraper. The screwdriver should always be applied to the outer edge of the scraper, see illustration. Carefully tap the screwdriver down between scraper and cylinder head. Then prise out the scraper. Make sure no damage is made to the cylinder head.

CAUTION

No tool must be applied from the inside. This could give rise to burrs on the cylinder head which could in turn damage the piston rod. Burrs may also damage the piston rod seal when fitting the piston.

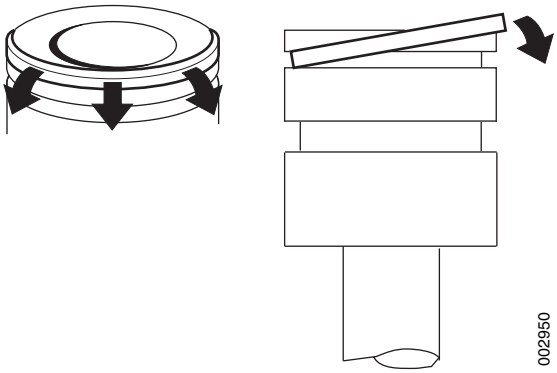
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1. Hydraulic pressure
2. The seal is pressed outwards against the cylinder barrel.
3. The seal is pressed inwards against the piston
4. Sealing surface, cylinder barrel
5. Sealing surface. piston
6. Screwdriver

On the single-acting V-ring seal it is always the long side that seals against the fixed surface and the short side that seals against the moving surface.

Use a screwdriver to remove the seal, see illustration. Lever outwards and prise up the seal. It is extremely important always to insert the screwdriver in the V shape so that it cannot touch and so damage any sealing surface. A mark made by the screwdriver on a sealing surface will have a devastating effect and give rise to serious leakage.



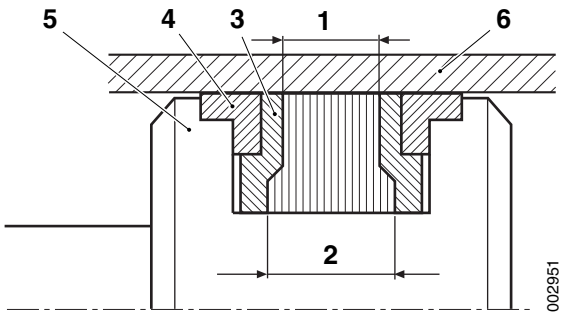
The seal must always be fitted as an assembly together with the thrust ring.

Always assemble by hand. No tools should be used as they could easily damage the surface of the piston.

For easier assembly the seal can be heated in hot water to make it soft.

Lubricate with hydraulic oil.

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1. Moving sealing surface against cylinder barrel
2. Fixed sealing surface with piston
3. Guide ring
4. Thrust ring
5. Piston crown
6. Cylinder barrel

Double-acting piston seal

The double-acting seal functions with pressure from both sides, e.g. in a steering cylinder

All of the interior surface of the cylinder barrel is a sealing surface and it is therefore extremely important that it is completely free from damage.

Exercise care when fitting the piston in the cylinder barrel, making sure that the seal is not damaged by the cylinder barrel threads.

Dismantling:

1 Remove guide rings and thrust rings.

2 Move the seal over to one side of the sealing groove.

3 Press it up so that there is a gap between seal and piston.

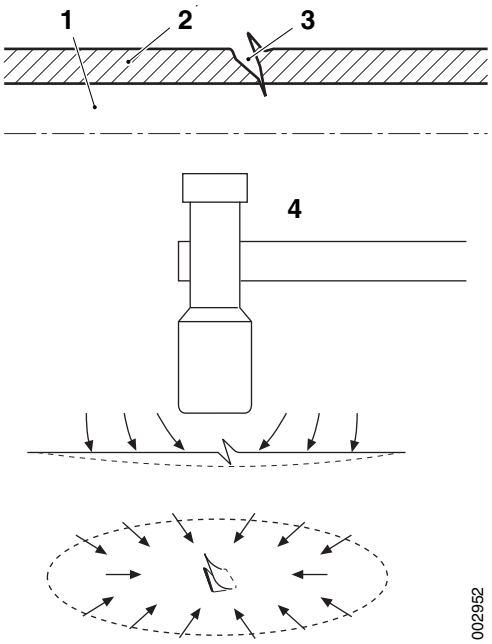
4 Without damaging the surface of the piston - cut off the seal with a knife.

5 Carefully examine the seal to find any damage that can cause leakage. This will be easier if you bend the seal sharply bit by bit and feel over the sealing surface with a fingernail.

Assembly:

1 All double-acting piston seals are of similar design: a middle sealing body. then thrust rings and farthest out guide rings.

2 First fit the sealing body, then the thrust rings and finally the guide rings - all must be done by hand without tools to avoid damage.



1. Piston rod
2. Chromium plating
3. Impact marks
4. Highly-polished hammer

Repairing the piston rod surface

A small impact mark on a piston rod may be sufficient to cause leakage. The chromium plating on the piston rod has a thickness of 20-50 micrometer (µm) and can be treated to make good minor damage. This may be a satisfactory alternative to costly disassembly.

1 Locate the damage using your fingertips and fingernails.

2 Use a small, highly-polished hammer and work the surrounding material inwards towards the damage, starting from the outside.

3 Instead of a small sharp mark there will now be a small uniform concavity in the chromium plating.

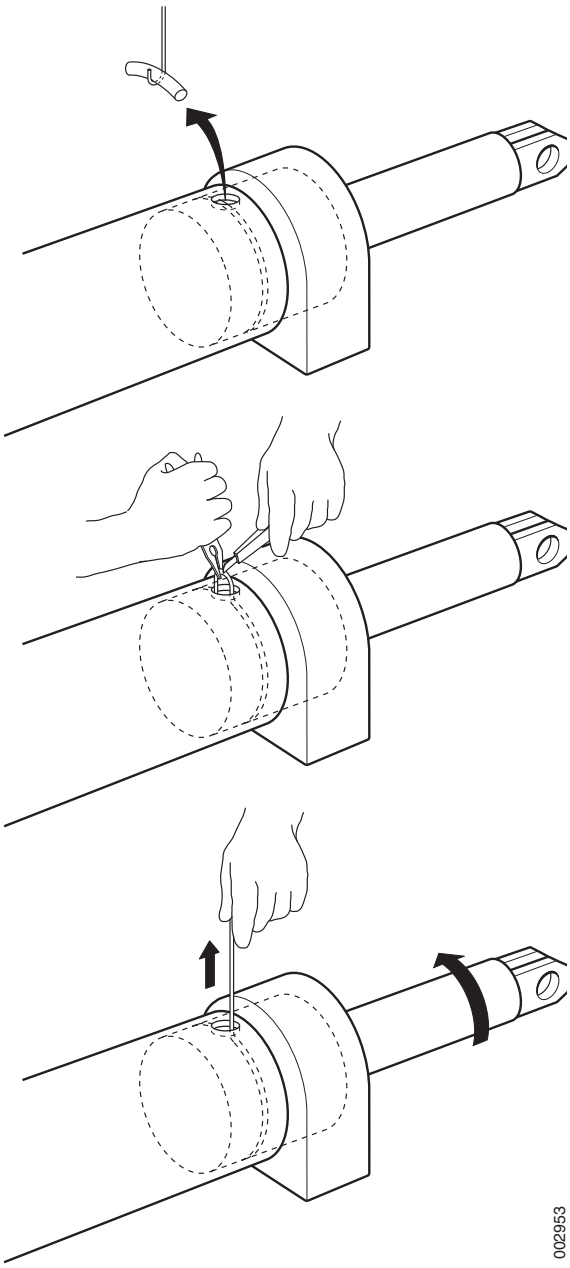
4 Polish with emery cloth, progressing from number 240 to 600. Wrap the emery cloth round a file to give it good support. Note that there must always be chromium plating present at the damage.

5 It is important to treat small impact marks before disassembly and assembly to avoid damaging the cylinder head.

6 Repairing larger damage on a piston rod

- fill the damage with weld metal, use chromium or stainless steel electrodes
- remove all slag completely
- file the weld down to the same level as the chrome
- polish evenly using emery cloth

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Dismantling steering cylinders

It can prove extremely difficult to extract the piston rod from the cylinder barrel on steering cylinders because the O-ring in the cylinder head fastens in the retaining ring groove in the cylinder barrel. It is therefore best to remove the O-ring before trying to withdraw the piston rod from the cylinder.

1 Unscrew the end washer at the cylinder head.
2 Unscrew the connecting nipple for the hydraulic hose.
3 Introduce the piston rod with piston crown until the O-ring is visible through the nipple hole.
4 Bend the end of a length of heavy-duty steel wire, piano wire or the like into the shape of a hook. Use this to snag the O-ring.
5 Pull the O-ring up slightly and hold it with a pair of needle-nose pliers.
6 Continue to pull the O-ring out through the hole.
7 Hold the O-ring steady and cut it with a knife.
8 Rotate the piston rod while pulling the O-ring out through the hole.
9 Remove the retaining ring from the cylinder barrel.
10 Carefully extract the piston rod from the cylinder barrel.

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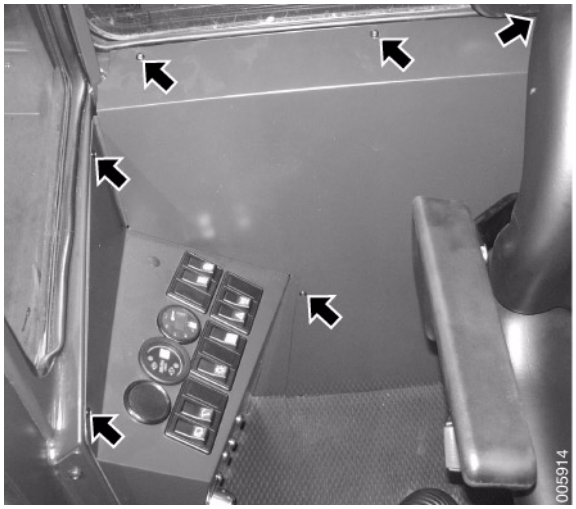
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11 Common electrics

11.1 Controls and instruments

11.1.1 Operating time gauge

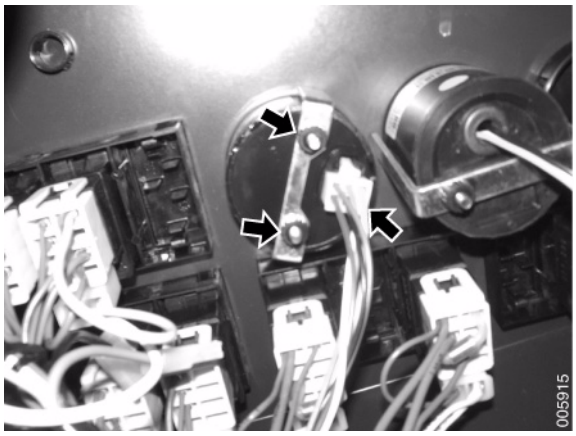
Operating time gauge, replacement FlexGuard/ FlexCab



1 Machine in service position.

2 Remove the four screws from the rear right panel and remove the panel.

3 Remove the two screws from the instrument panel and remove the panel.



4 Unplug the connector from the operating time gauge.

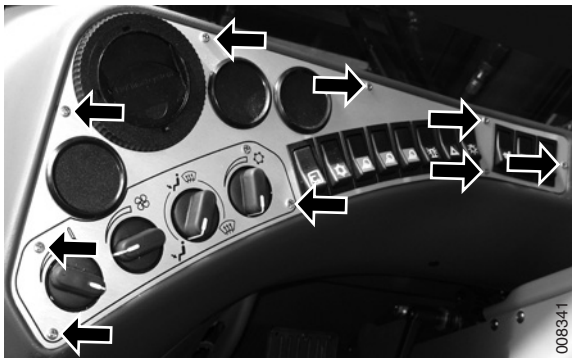
5 Remove the two screws on the rear piece of the operating time gauge.

6 Replace the operating time recorder.

7 Fit in reverse order.

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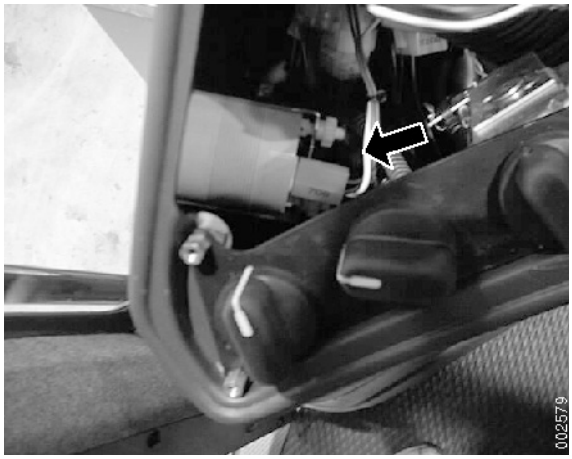
Operating time gauge, replacement SpiritDelta/ SpiritDelta Space



1 Machine in service position.

2 Remove the screws that hold the panel in place.

3 Lift away the panel.



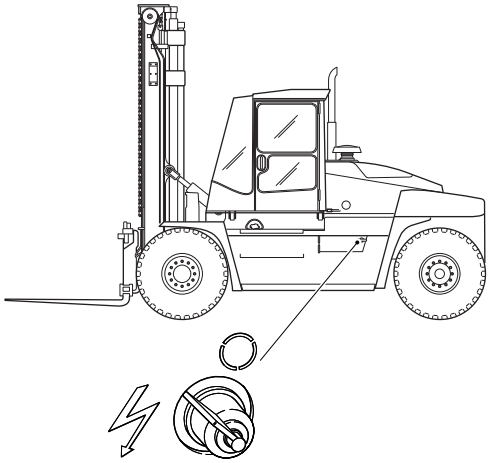
4 Unplug the connector from the operating time recorder.

5 Remove the two screws on the rear piece of the operating time recorder.

6 Replace the operating time recorder.

7 Fit in reverse order.

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A. Position for battery disconnector

11.2 Electric protection

11.2.1 Battery disconnector

Battery disconnector, description

The plus terminal of the series-connected batteries is connected to the machine's electrical system via the battery disconnector. The battery disconnector cuts off all voltage feed from the batteries to the machine's electrical system.

IMPORTANT

Never turn off the voltage with the battery disconnector when the engine is running, the alternator may be damaged.

The battery disconnector can not be used for emergency stop!

Battery disconnector, replacement

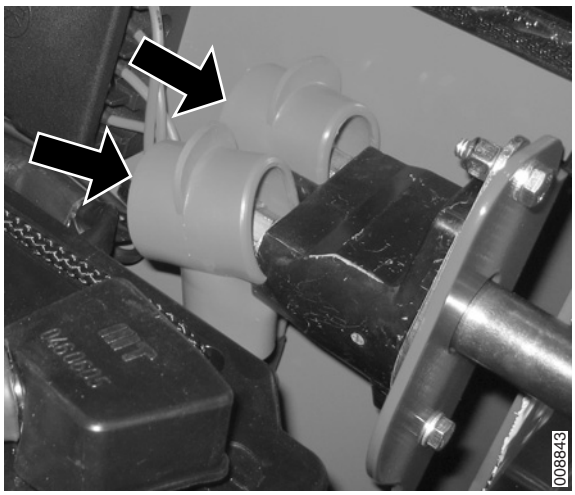
1 Machine in service position, see section *B Safety*.

2 Open the cover concealing the battery.

3 Disconnect the negative cable and then the positive cable from the battery.

WARNING

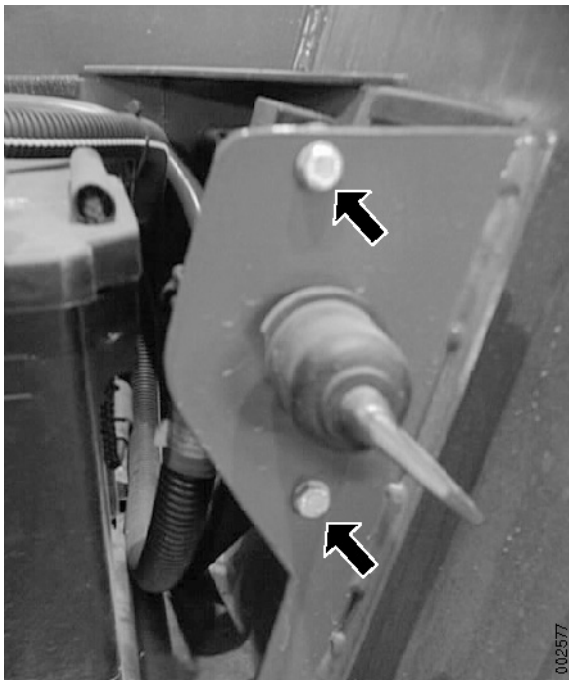
Be careful to keep the positive and negative cables apart to avoid short circuiting.



4 Thread off the rubber protectors on the battery disconnector.

5 Remove the two nuts and release the cables from the battery disconnector.

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6 Remove the two screws which hold the main battery disconnector in the bracket.

7 Replace the battery disconnector.

8 Fit in reverse order.

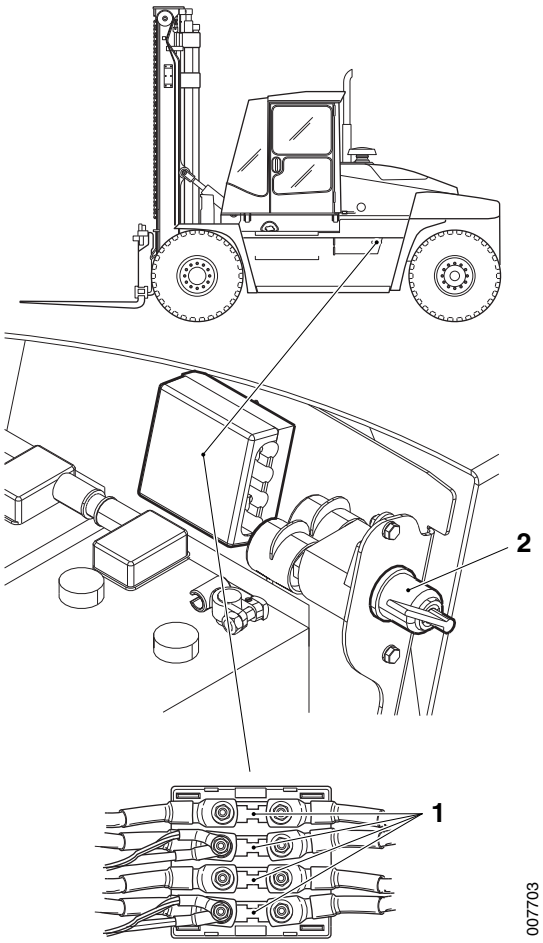
11.2.2 Fuses

Fuses, description

The main fuses splits the machine's voltage feed in smaller parts to maintain as many functions as possible in case of damage in the cabling.

Circuit fuses are grouped in fuse holders that are located in the electrical distribution box in the cab.

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1. Main fuses (25 A)
2. Battery disconnector

Fuses, replacement

Checking and replacement of main fuses:

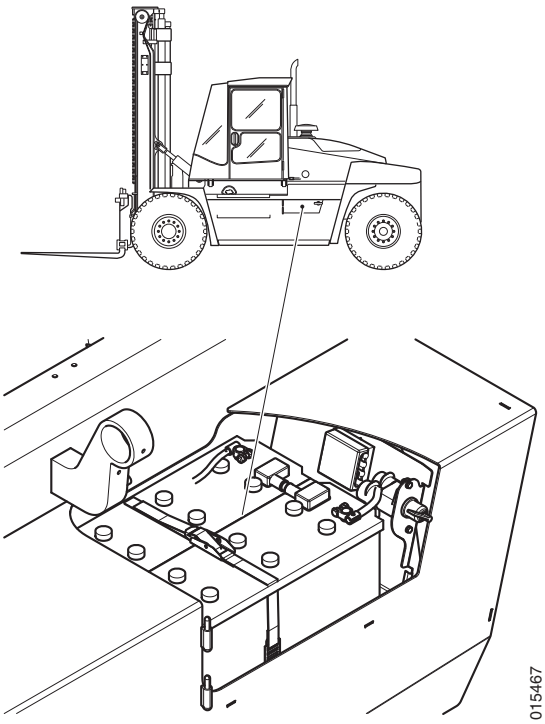
1. Turn off the main electric power with the battery disconnector (position 2).
2. Remove the plastic cover.
3. Check and replace fuses as needed. Fuses are rated at 25 A.
4. Turn on the electric power again.

Checking and replacement of fuses:

1. Turn off the main electric power with the battery disconnector.
2. Remove the cover over the electrical distribution box in the cab.
3. Remove the cover from the fuse holder.
4. Check that fuses are intact. Replace when needed.

   The fuse chart provides information about each fuse.

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11.3 Batteries

11.3.1 Start battery

Start battery, description

The two series-connected batteries are located behind a cover (by the fuel tank) on the machine's rear left-hand side.

The battery's minus terminal is connected to the chassis and the plus terminal is connected to the battery disconnector.

The batteries are charged by the alternator, see *Alternator, description page 11*.

WARNING

Battery electrolyte contains corrosive sulphuric acid

Risk of corrosive injuries, health hazard!

Electrolyte on skin should be removed immediately. Wash with soap and plenty of water. If electrolyte has splashed into the eyes, rinse immediately with plenty of water and seek immediate medical attention.

WARNING

Risk of explosion!

Personal injury!

Hydrogen gas is formed at the batteries. During welding sparks may ignite the hydrogen gas, resulting in a powerful explosion. Disconnect the battery with the battery disconnector.

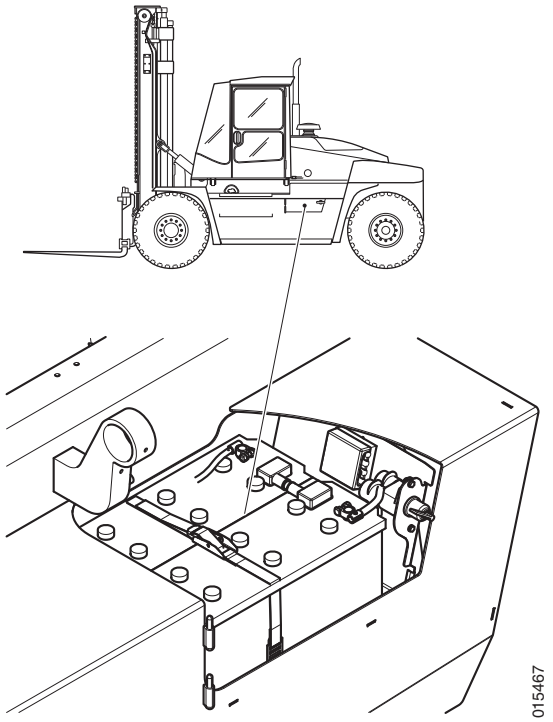
WARNING

Short-circuiting of battery (means capacity is lost)

Risk of explosion! Fire hazard! Personal injury!

The battery's terminals may not be connected to each other or commonly to ground (chassis).

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Starter battery, replacement

1 Machine in service position, see section *B Safety*.

2 Disconnect the cables from the battery terminals. Disconnect the negative cable first.

3 Replace batteries.

4 Connect the cables to the battery terminals. Connect the negative cable last of all.

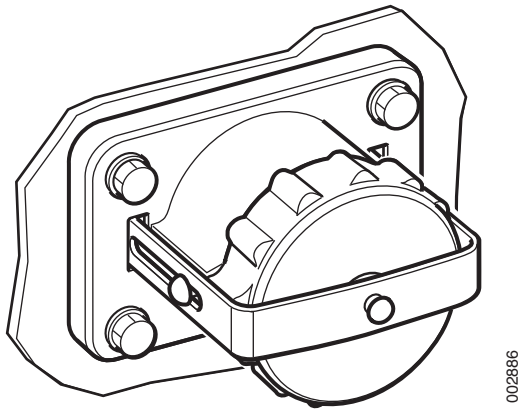
NOTE

Exercise care when reconnecting the cables to avoid a short circuit.

11.3.3 Auxiliary start connector

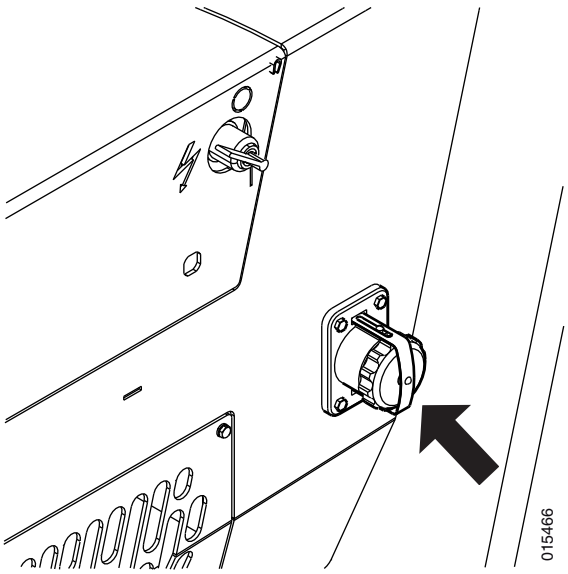
Auxiliary start connector, description

The auxiliary start connector is located on the left side of the machine. The connector is used for starting the machine with the help of start batteries, or can be used as a start aid for another machine; see chapter *Distribution of electricity, general page 12*.



Auxiliary start connector

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Auxiliary start connector, replacement

1 Machine in service position, see section *B Safety*.

2 Disconnect the cables from the battery terminals. Disconnect the negative cable first.

3 Undo the two cables, undo the four fixing screws and remove the auxiliary start connector.

4 Fit in reverse order.

NOTE

Exercise care when reconnecting the cables to avoid a short circuit.

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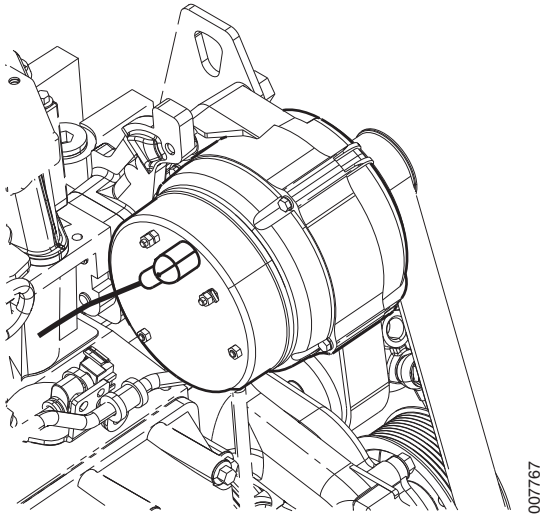
11.4 Alternator

11.4.1 Alternator

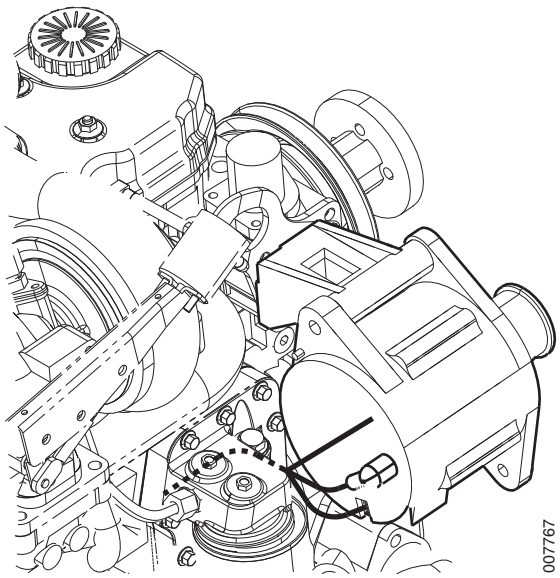
Alternator, description

The alternator generates current to the batteries during operation. The alternator is of the alternating current type with built-in charging regulator.

The alternator is belt-driven by the engine. A possible malfunction is indicated by the warning lamp for low battery charging.



Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE



Cummins QSB6.7

Alternator, replacement

See *supplier documentation engine*.

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11.5 Distribution of electricity

Distribution of electricity, general

This section describes the distribution of electric power and communication between the control units.

System communication has three main sections:

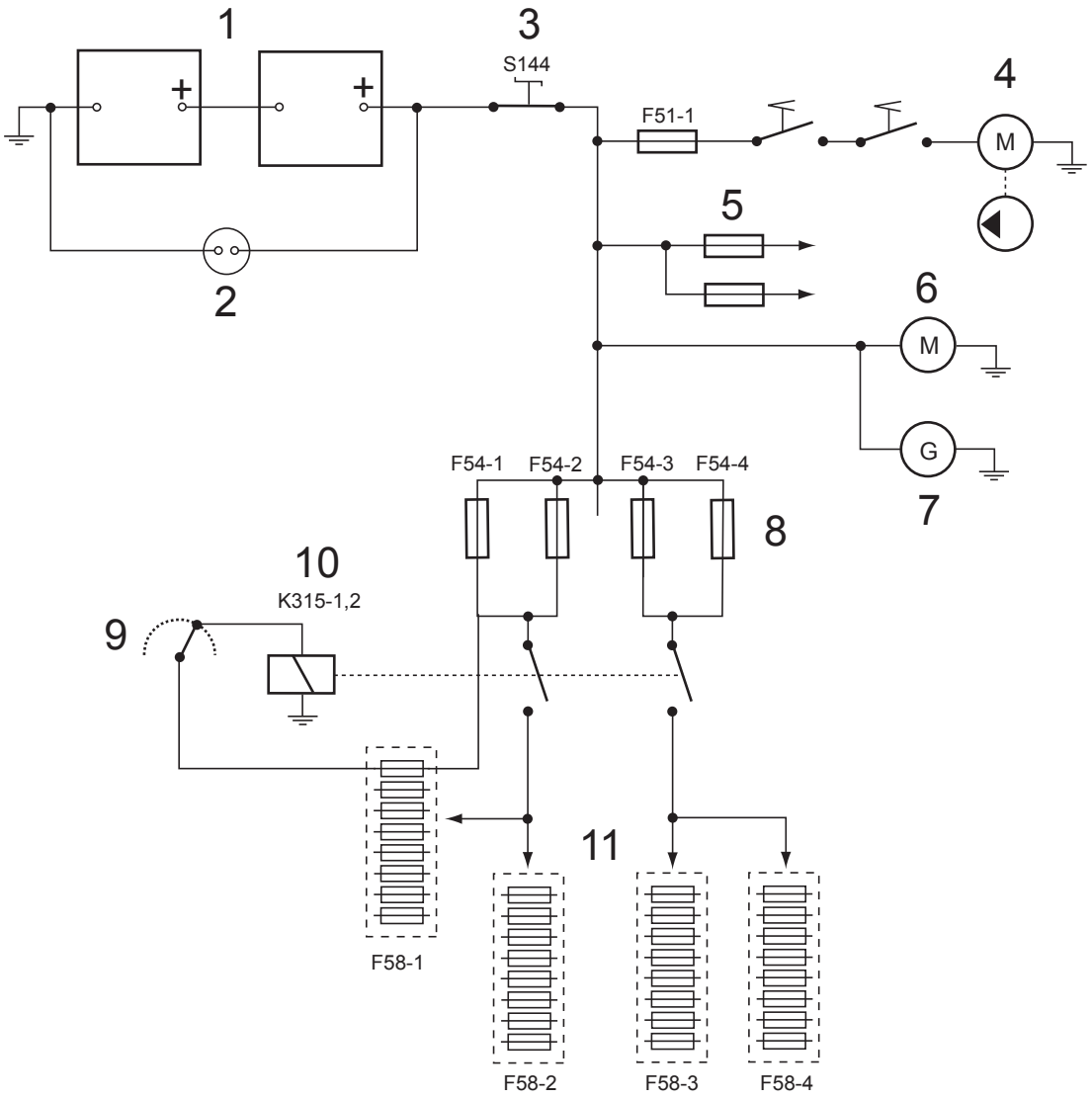
- Power supply of control units
- Redundant CAN bus communication (a control unit can drop away without the system losing all functionality)

  See *CAN bus, description page 49*.
- CAN bus communication for drivetrain (the drivetrain has its own communication system)

  See *CAN bus drivetrain (ECU 793, ECU 794), description page 52*.

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11.5.1 Power supply



1. Two series-connected 12 V batteries.
2. Auxiliary start connector ⊕
3. Battery disconnector
4. Hydraulic pump cab tipping ⊕
5. Fuses, engine help function
6. Starter motor
7. Alternator
8. Main fuses
9. Ignition switch
10. Starter switch relay
11. Fuses, fuse box

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11.5.1.1 Battery voltage, terminal 30 volts

Battery voltage, terminal 30 volts, description

The voltage before the ignition switch is usually called terminal 30 volts. It is always approx. 24V, even if the ignition is switched off (ignition key in position 0).

This voltage is connected to the cab tipping pump (4), which means that the cab can be tipped without having to turn the ignition key. The voltage is supplied via fuses (5) to the engine's auxiliary functions, such as pre-heating and fuel injection. The starter motor (5) and alternator (6) are connected directly to the battery (via the battery disconnector).

11.5.1.2 Ignition voltage, terminal 15 volts

Ignition voltage, terminal 15 volts, description

The voltage after the ignition switch is usually called terminal 15 volts. This is at 24V only if the ignition is switched on (ignition key in position 1). Otherwise this voltage is 0V.

The current is distributed by means of the ignition relay (10) and is then transferred to the other functions in the machine via the four fuse boxes (11) located in the distribution box behind the driver in the cab, please refer to *Fuses, replacement page 7*.

11.5.1.3 Frame connections

Frame connections, description

Power supply takes place with cable harnesses (cables) which are drawn across the machine.

A grounding point in the chassis serves as a central grounding point, including for the starter motor, From there the ground cable is routed to a common point in the electrical distribution box to which the ground cables of all electrical consumers are connected.

11.5.2 Electrical distribution box

Electrical distribution box, description

The electrical distribution box is located to the left behind the driver's seat in the cab. The electrical distribution box houses fuses, relays, diodes, grounding points and connection terminals.

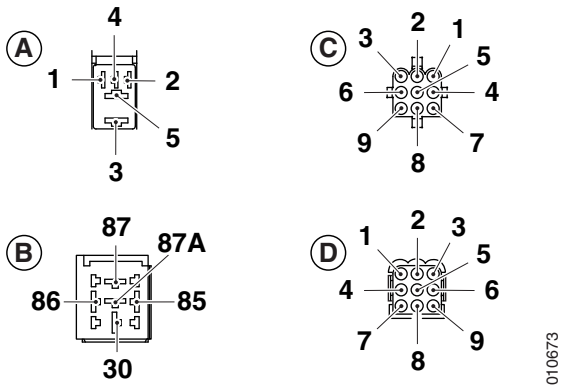
All mini relays (20 A/10 A) and micro relays (10 A/5 A) have quenching diodes. In addition to these are two mini relays (40 A) which work as main relays. The two main relays have no quenching diodes and have slightly different contact pins compared with other relays.

All relays are the flat pin type relay. The size of the pin differs however between the different types (6.3 and 9.5 mm on main relay, 6.3 mm on other mini relays and 4.8 and 6.3 mm on micro relay).

NOTE

Changing between relay types is not permitted.

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Sockets for relays and terminal boxes.

The sockets to relays and terminal boxes are shown in the illustration as well as numbering and location of the different pins.

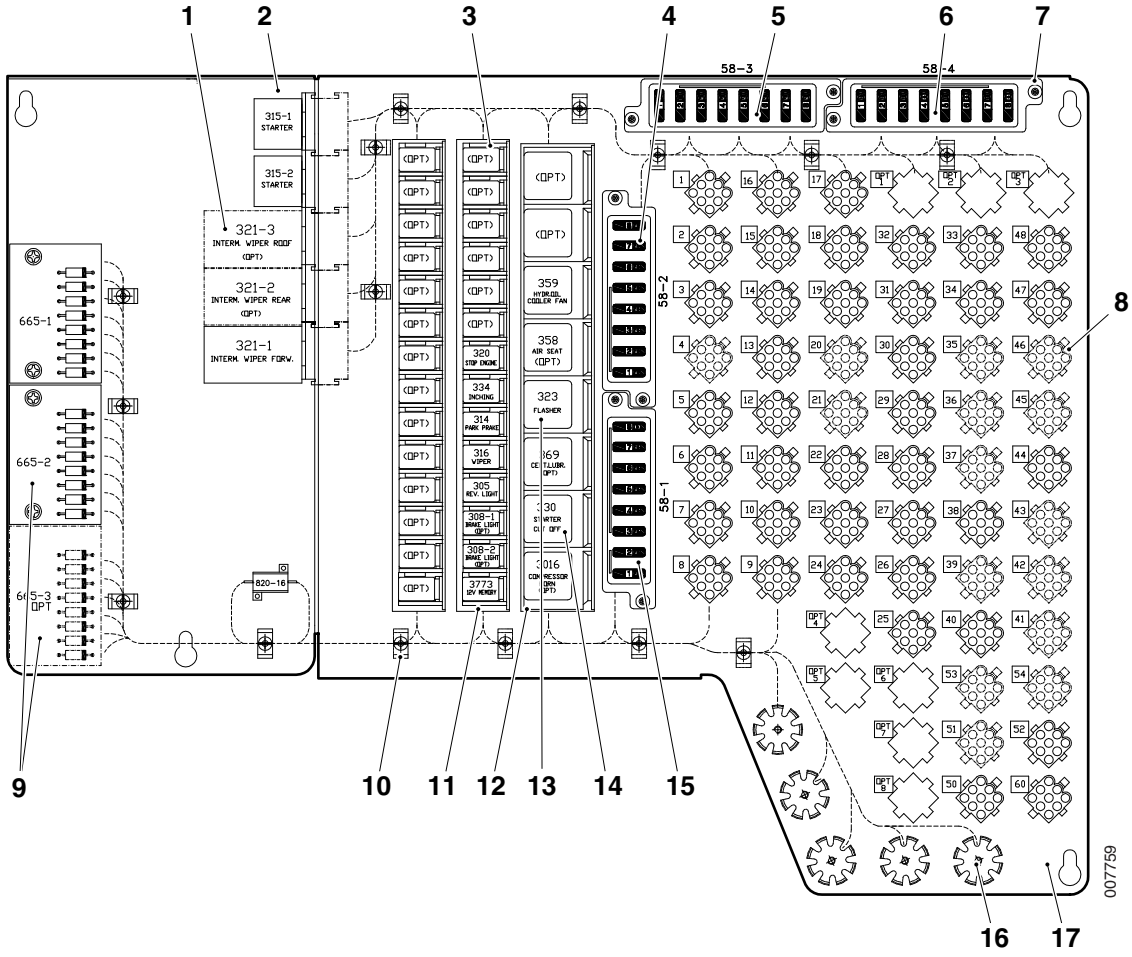
Sockets seen from cable side with pin numbering for:

A. Micro relay

B. Mini relay

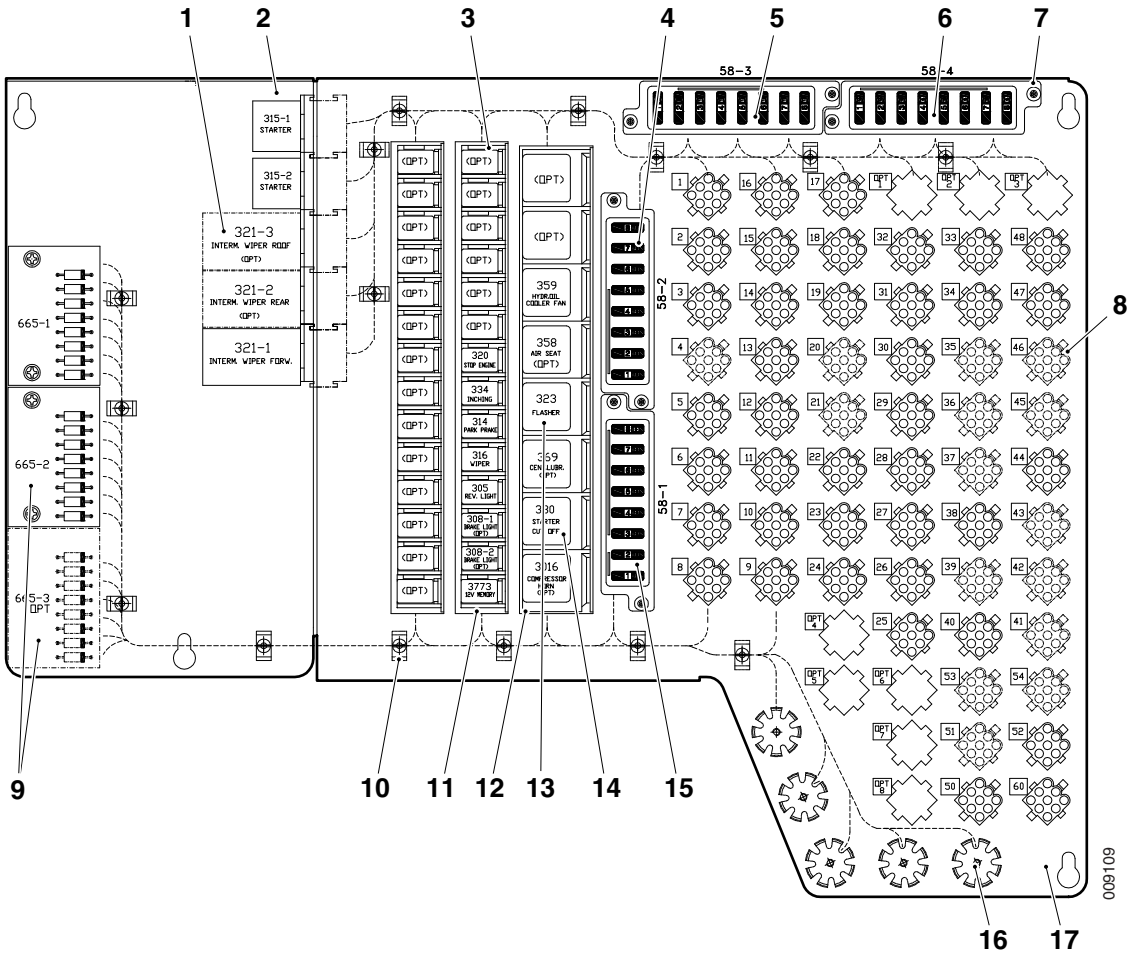
C. Terminal box (socket housing)

D. Terminal box (pin housing)



Electrical distribution box

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Electrical distribution box, machine equipped with reversible driver's seat option. ⊕

In addition to the following positioning, see table Connecting terminal boxes and Section *E. Schedules* under *Common electrics, Component list* for post number etc.

1. Relay, interval wiper
2. Relay, ignition
3. Micro relays
4. Fuse holder 58-2
5. Fuse holder 58-3
6. Fuse holder 58-4
7. Fuse holder
8. Socket housing with 9 pins
9. Circuit board with diodes
10. Screw, holder and strap
11. Socket, relay 5-pin
12. Socket, relay 9-pin
13. Blink module, 200 W, 24V
14. Mini relay
15. Fuse holder 58-1
16. Cable shoe (to ground), washer and screw
17. Fitting plate

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Connecting terminal boxes

The following table describes the connecting terminal boxes numbered in the illustration above the fuse box. (X is the sign for connecting terminal box in the wiring diagram).

NOTE

The table shows all available functions. The functions used on a specific machine may vary depending on which engine/driveline, supervising system and optional equipment the machine is equipped with.

Number	Main function	Pin/Detailed function
X1	**Cable cabin - steering wheel** **Gear selector**	1. Gear selector 2. Gear selector 3. Optional forward/reverse selector, supply 4. Gear selector control, supply 5. - 6. Reverse 7. Neutral 8. Forward 9. Forward/reverse control, supply
X2	**Cable cabin - steering wheel** **Direction indicator/high-low beam**	1. Switch direction indicator, supply 2. Direction indicator, left 3. Direction indicator, right 4. Switch headlamp flasher, supply 5. Switch high/low beam, supply 6. Low beam 7. High beam 8. - 9. -
X3	**Cable cabin - steering wheel** **Horn, windscreen wipers, windscreen washer**	1. Lever for wiper, washer, horn, supply 2. Horn, supply 3. Pump windscreen washer, supply 4. Interval windscreen wipers, supply 5. Relay windscreen wipers, supply 6. Forward/reverse alternative place standard lever, supply 7. Forward/reverse alternative place 8. Warning lamp Air filter/exhaust filter (Unicat) 9. Forward/reverse alternative place

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Number	Main function	Pin/Detailed function
X5	**Cable cabin - right instrument panel** **Switches lighting, hazard warning flasher, actuator ventilation**	1. Switch lighting, supply 2. Switch high/low beam, supply 3. Rear lights, position light, supply 4. Warning lamp, Hazard 5. Warning lamp, Hazard 6. Warning lamp, Hazard 7. Switch actuator ventilation, ground 8. Switch actuator ventilation 9. Switch hazard light before ignition, supply
X6	**Cable chassis** **Lighting**	1. Direction indicator front left, supply 2. High beam front, supply 3. Low beam front, supply 4. Reverse alarm front, supply 5. Direction indicator front right, supply 6. Position light front, supply 7. Rear light front, supply 8. Break light front, supply 9. Reverse alarm, ground
X7	**Cable cabin - steering wheel panel** **Ignition switch, display**	1. Glow ignition signal 2. Start motor, signal 3. Ignition switch, supply 4. Signal to main relay on/off 5. - 6. ECU 795, supply 7. - 8. - 9. Ignition switch P-position
X8	**Cable cabin - left instrument panel** **Elevate/lower seat, working lights**	1. Indication central lubrication 2. Working lights roof, extra 3. Working lights roof, extra 4. Condenser unit, supply 5. Elevate/lower seat, ground 6. Elevate/lower seat, supply 7. Supply position (side) light 8. Working lights chassis, signal 9. Switch working lights chassis

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Number	Main function	Pin/Detailed function
X9	**Cable cabin - steering wheel panel** **Rear and roof wiper**	1. Switch rear intermittent wiper, supply 2. Switch rear wiper, supply 3. Switch rear intermittent wiper 4. Switch rear wiper 5. EDU 795, ground 6. Switch roof intermittent wiper 7. Switch roof wiper 8. Switch roof wiper, supply 9. Switch roof intermittent wiper, supply
X10	**Cable cabin - right instrument panel** **Right instrument panel**	1. Switch pause heater 2. Pause heater, signal 3. Motor seat up/down 4. Motor seat up/down 5. - 6. Hour counter, signal 7. Reverse alarm on/off 8. Reverse alarm on/off 9. Hour counter, ground
X11	**Cable cabin - steering wheel panel** **Steering wheel panel**	1. Indicator light high beam 2. - 3. Indicator light direction indicator, supply 4. Indicator light direction indicator 5. Indicator light high beam, ground 6. Inching on/off 7. Inching on/off 8. Warning lamp, charging 9. -
X12	**Cable cabin - front panel** **Fan, wiper motor front**	1. Fan, supply 2. AC on/off 3. Temperature sensor AC, signal 4. Condenser unit, FlexCab 5. Windscreen wiper front, ground 6. Windscreen wiper front 7. Windscreen wiper front 8. Windscreen wiper front 9. Fan motor, ground

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Number	Main function	Pin/Detailed function
X13	**Cable cabin - left instrument panel** **Left instrument panel: working lights, seat heating, rotating hazard light**	1. Switch working lights mast, supply 2. Switch working lights roof, supply 3. Warning lamp, Hazard 4. Working lights mast 5. Working lights roof 6. Rotating hazard light on 7. Switch seat heating, supply 8. Seat heating 9. Switches lights, ground
X14	**Cable cabin - panel + seat**	1. Switch, parking brake 2. Parking brake, signal 3. Seat switch, signal 4. Parking brake, indication 5. Seat heating, ground 6. Seat switch, supply 7. Position switch, rotating driver seat forward 8. Seat heating, supply 9. Position switch, rotating driver seat backward
X15	**Cable cabin - chassis** **Fuel and air filer sensors, washer pump, working lights mast**	1. Working lights mast, supply 2. Working lights mast, ground 3. Air filter sensor, ground 4. Solenoid valve for deactivation of hydraulics, ground 5. Washer pump, supply 6. Washer pump, ground 7. Solenoid valve deactivation of hydraulics 8. Air filter sensor 9. -
X16	**Cable cabin - chassis** **Gearbox**	1. - 2. - 3. - 4. - 5. - 6. - 7. Speed sensor 8. Speed sensor 9. Speed sensor

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Number	Main function	Pin/Detailed function
X17	**Cable cabin ECU792 - chassis** **Engine, gear box**	1. ECU 792, supply 2. - 3. ECU 792, supply 4. Travel direction selector (forward/reverse) on left armrest on 5. - 6. - 7. - 8. - 9. ECU 792, ground
X18	**Cable cabin - chassis** **Engine**	1. D+ from generator 2. Stop signal, engine (VOLVO) 3. Signal to hour meter 4. Ignition on 5. Starter motor signal 6. ECU 794 ground (VOLVO) 7. Feed ECU 794 (VOLVO) 8. - 9. Magnetic coupling AC
X19	**Cable cabin - chassis** Actuator/water level	1. - 2. - 3. - 4. - 5. - 6. - 7. - 8. Coolant Level Switch 9. Coolant water level 5 V ref
X20	**Cable cabin - chassis** Electrical servo	1. PWM lift/down D796:K2.3, load 2. PWM Valves lift D796:K2.10, supply 3. PWM Lift/up D796:K2.4, load 4. PWM Tilt/out D796:K2.5, load 5. PWM Valves tilt D796:K2.10, supply 6. PWM Tilt/in D796:K2.6, load 7. PWM Side shift/left D796:K2.7, load 8. PWM Valves side shift D796:K2.10, supply 9. PWM Side shift/right D796:K2.8, load

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Number	Main function	Pin/Detailed function
X21	**Cable cabin - chassis** **Electrical servo**	1. PWM spreading/out D796:K2.11, load 2. PWM Valves fork position D796:K2.10, supply 3. PWM spreading/in D796:K2.12, load 4. PWM Option/out D796:K2.13, load 5. PWM Valves option D796:K2.10, supply 6. PWM Option/in D796:K2.14, load 7. - 8. - 9. -
X22	**Cable cabin - chassis** **Central lubrication, rear main beams, alarm reverse driving**	1. Central lubrication 2. Central lubrication 3. Central lubrication 4. Central lubrication, ground 5. High and low beam, VBFS rear, ground 6. Low beam VBFS rear, supply 7. High beam VBFS rear, supply 8. Alarm reverse driving, supply 9. Alarm reverse driving, ground
X23	**Cable cabin - chassis** **Lighting**	1. Direction indicator rear left, supply 2. Brake lights rear, supply 3. Rear lights, supply 4. Ground 5. Direction indicator rear right, supply 6. Rotating beacon, supply 7. Working lights 8. Headlamps, ground 9. Frame working lights, ground
X24	**Cable roof** **Condenser, pressure sensor AC, roof wiper**	1. Condenser, ground 2. AC, signal on 3. AC, supply condenser 4. Pressure sensor AC, supply 5. Pressure sensor AC, signal 6. Roof windscreen wiper 7. Roof windscreen wiper 8. Roof windscreen wiper 9. Roof windscreen wiper

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Number	Main function	Pin/Detailed function
X25	**Cable roof** **Radio, interior lightning**	1. Radio, 12 V supply 2. Radio memory, 12 V supply 3. Option 4. Option 5. Interior lightning cabin, supply 6. Option 7. Option 8. Option 9. Radio, interior lightning, ground
X26	**Cable roof** **Reversing light, working light roof, rotating beacon**	1. Extra working lights roof 2. Extra working lights roof 3. Roof working lights, feed 4. Roof working lights, feed 5. Reversing light 6. Rotating beacon 7. Option 8. Reversing light, ground 9. Working lights roof, ground
X27	**Cable under cabin** **Compressor air supplied seat**	1. Compressor, supply (opt) 2. Temp water, pause heat (opt) 3. Reverse, additional dir. selector (OPT) 4. Forward, additional dir. selector (OPT) 5. Supply, additional dir. selector (OPT) 6. Compressor, air supplied seat, ground 7. Switch Seat turned 40 deg (OPT) 8. Switch, Hydraulics disable (OPT) 9. Switch return, Hydraulics disable (OPT)
X28	**Cable under cabin** **Brake pressure, inching**	1. Pressure switch low brake pressure 2. Pressure switch low brake pressure, ground 3. Pressure switch brake pedal/inching 4. Pressure switch brake pedal/inching 5. Pressure switch brake pedal, brake light, supply 6. Pressure switch brake pedal, brake light 7. Brake light Hydrostatic drive 8. Brake light Hydrostatic drive 9. Horn, supply

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Number	Main function	Pin/Detailed function
X29	**Cable under cabin** **Actuator ventilator, indicator reversible operator's seat**	1. Actuator ventilation, supply 2. Actuator ventilation, ground 3. Signal actuator, 0 V = rotating left, 24 V = rotating right 4. Compressor horn, supply 5. Compressor horn, ground 6. Seat position potentiometer reversible operator's seat 7. Seat position potentiometer reversible operator's seat 8. Seat position potentiometer reversible operator's seat 9. Switch seat position reversible operator's seat
X30	**Cable under cabin** **Valves steering, valves rotating driver's seat, pause heating**	1. Valve Y636-1 steering forward, rotating driver's seat 2. Valve Y636-2 steering reverse, rotating driver's seat 3. Valves Y636-1, Y636-2, ground 4. - 5. Brake rotating driver's seat 6. Brake rotating driver's seat 7. Water pump pause heating + 8. Water pump pause heating - 9. Water temperature sensor, pause heating
X31	**Cable under cabin** **Accelerator pedal standard and rotating driver's seat, idle switch**	1. Potentiometer accelerator pedal, signal 2. 5 V analogue reference accelerator pedal 3. 0 V analogue reference accelerator pedal 4. Potentiometer brake pedal, signal 5. Accelerator pedal 2 6. Brake pedal channel 2 7. Brake pedal 2 8. - 9. -

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Number	Main function	Pin/Detailed function
X32	**Cable chassis** **Parking brake, oil cooler, lifting height**	1. M-valve parking brake 2. M-valve parking brake 3. Pressure switch, parking brake 4. Pressure switch, parking brake 5. Hydraulic oil cooler, temperature switch 6. Hydraulic oil cooler + 7. Sensor lifting height/Optimum lift 8. Sensor lifting height/Optimum lift 9. Hydraulic oil cooler -
X33	**ECU 790**	1. Gear changing 1:st 2. Gear changing 2:nd 3. Switch parking brake, signal 4. Parking brake pressure, signal 5. Inching/declutch 6. Reverse 7. Seat orientation, seat facing forward 8. Forward 9. Brake light hydrostatic transmission
X34	**ECU 790 automatic gear changing**	1. Starter motor 2. Ignition shut off 3. Horn 4. Forward 5. Reverse 6. Seat contact 7. ECU 790, supply +24 V 8. ECU 790, supply +24 V 9. ECU 790, ground
X35	**ECU 790 revolution sensor/high pressure sensor, hydrostatic transm./lift sensor**	1. Revolution sensor, frequency input 2. Revolution sensor, frequency 0 V reference 3. 5 V reference hydrostatic transmission high pressure sensor 4. 0 V reference hydrostatic transmission high pressure sensor 5. High pressure sensor forward 6. High pressure sensor reverse 7. Lift sensor 5 V reference 8. Lift sensor 0 V reference 9. Lifting lever sensor 0.5 - 4.5 V

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Number	Main function	Pin/Detailed function
X36	**ECU 790 monitoring sensors**	1. Fuel level 2. 0-reference rheostat 3. Hydraulic oil temperature 4. 0-reference rheostat 5. - 6. 0-reference rheostat 7. Outside temperature 8. - 9. Pressure sensor, lift cylinder
X37	**ECU 790**	1. Seat turned 40 deg. 2. - 3. - 4. - 5. - 6. Tilt pin sensor signal 7. - 8. - 9. -
X38	**ECU 790 accelerator pedal**	1. Accelerator pedal 2. Brake pedal 3. Turn seat CW 4. Overload protection (opt) 5. Load cell right 6. 5 V reference 7. 0 V reference 8. Parking brake ON 9. Low rotation speed, seat orientation
X39	**Hydraulic joystick**	1. Hydraulic joystick, side shift 2. Hydraulic joystick, auxiliary function 3. Hydraulic joystick, fork spreading 4. Hydraulic joystick, side shift 5. Hydraulic joystick, auxiliary function 6. Hydraulic joystick, fork spreading 7. - 8. - 9. -

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Number	Main function	Pin/Detailed function
X40	**ECU 790 monitoring scale**	1. Turn seat CCW 2. Seat turned output 3. - 4. Low brake pressure 5. Coolant level 6. Reversing light 7. Key position 3 8. 0 V reference 9. Load cell left
X41	**ECU 792 lever steering/mini steering wheel**	1. Valve mini steering wheel right 2. Valve mini steering wheel left 3. Valve mini steering wheel right 4. Position steering axle 5. Position steering axle 5 V analogue reference 6. Position steering axle 0 V analogue reference 7. Valve mini steering wheel left 8. - 9. -
X42	**ECU 792 lever steering/mini steering wheel**	1. Position of linear lever ECU 792: K1:31 2. Position of linear lever 5 V ref ECU 792: K1:1 3. Position of linear lever 0 V ref ECU 792: K1:14 4. Mini-wheel channel A 5. Mini-wheel channel B 6. Indicator guide wheel 7. Indicator guide wheel, supply 8. Indicator guide wheel, ground 9. -
X43	**ECU 790 lever steering/mini steering wheel**,	1. Switch horn, supply / switch alternative steering, mini steering wheel 2. Optimum lift/rpm ECU 790:K2:28 3. Spreading/spreading input ECU 790:k1:20 4. 5th function pos input ECU 790:k1:21 5. Feed valve Optimum lift/rpm ECU 790:K2:12 6. Switch forward/reverse selector 3 forward 7. Switch forward/reverse selector 3 reverse 8. Horn 9. Indication lamp mini-steering On/off, ground

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Number	Main function	Pin/Detailed function
X44	**ECU 793**	1. ECU 793, Supply 2. ECU 793, Supply 3. - 4. - 5. - 6. - 7. ECU 793, ground 8. ECU 793, ground 9. ECU 793, ground
X45	**ECU 790**	1. - 2. - 3. - 4. - 5. - 6. - 7. Speed sensor, supply 8. 0 V reference K2:2 9. Speed sensor K2:1
X46	**ECU796 electrical servo linear levers**	1. Linear lever lift D796:K1.9, signal 2. Linear lever tilt D796:K1.10, signal 3. Linear lever side shift D796:K1.11, signal 4. Linear lever fork position D796:K1.12, signal 5. Linear lever optional hydraulic function D796:K1.13, signal 6. Linear lever 10V analogue reference D796:K1.27 7. Linear lever 0V analogue reference D796:K1.26 8. Emergency stop hydraulic functions, supply 9. Emergency stop hydraulic functions
X47	**Supply ECU 796, paper functions, electronic scale**	1. D796:K1.1, supply +24 V 2. Emergency stop hydraulic functions, supply 3. CAN D796:K1.7, supply +24 V 4. - 5. Stop lowering sensor, ground 6. Switch paper functions, supply 7. D796 K1:30 Hydraulics disable 8. D796:K2.1, ground 9. D796:K1.14/K1.28, ground

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Number	Main function	Pin/Detailed function
X48	**Cable panels**	1. 12 V 2. Ground 3. Reading-lamp 4. 12 V before ignition 5. 12 V 6. AC compressor ECC 7. Central lubrication 8. Central lubrication 9. Ground
X49	**Not used**	1. - 2. - 3. - 4. - 5. - 6. - 7. - 8. - 9. -
X50	**Cables converter, rear wipers**	1. Rear windscreen wipers 2. Rear windscreen wipers 3. Rear windscreen wipers 4. Rear windscreen wipers, ground 5. 12 V converter, supply 6. 12 V converter, ground 7. 12 V 8. - 9. -
X51	**ECU 792 lever steering/mini steering wheel**	1. - 2. Mini-wheel/Lever steering on/off ECU 792:K1:2 3. Gear up ECU 792:K1:4 4. Gear down D792:K1:5 5. - 6. - 7. - 8. Alternative steering on ECU 792:K1:40 9. -

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Number	Main function	Pin/Detailed function
X52	**Electronic scale**	1. Scale, supply 2. Scale, signal left 3. Scale, 0 V reference 4. Motor elevate/lower seat column 5. Motor elevate/lower seat column 6. - 7. - 8. - 9. Scale, signal right
X53	**Steering wheel panel**	1. - 2. Seat turn CCW 3. Seat turn CW 4. Switch seat rotation supply 5. - 6. - 7. - 8. - 9. -
X54	**Electric motor seat turning**	1. Low speed 2. CW 3. CCW 4. - 5. Supply turning motor 6. - 7. - 8. - 9. -
X60	**Supply cabin**	1. Supply 24 V 2. Supply 24 V 3. Supply 24 V 4. Supply 24 V 5. Ground 6. Ground 7. Ground 8. Ground 9. Supply 24 V

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Number	Main function	Pin/Detailed function
X70	**ECU 796 paper functions**	1. Switch paper functions, supply +24V 2. - 3. Switch automatic clamping D796:1.36 4. Switch shift hydraulic function D796:1:40 5. Switch vertical positioning D796:1.32 6. Switch locking upper arm D796:1.37 7. - 8. - 9. -
X71	**ECU 796 indicator lights, sensor tilt angle/elevation height**	1. Indicator light, paper handling unit K2:10, supply 2. Red Lamp D796:K3:14 3. Yellow lamp D796:3:13 4. Green lamp D796:3:12 5. 0 V analogue reference sensor tilt angle/elevation speed K1:26 6. 10 V analogue reference sensor tilt angle/elevation speed K1:27 7. Side shift/upper arms up/down D796:K3:15 8. Analogue input elevation height K1:16 9. Analogue input tilt angle K1:17
X72	**ECU 796 pressure sensor paper handling unit, switch extender**	1. Pressure sensor, paper handling unit, supply 2. Pressure right clamp P1 3. Pressure right clamp P2 4. Pressure sensor, paper handling unit, ground 5. Extender inner position 6. Pressure left clamp P2 7. Pressure left clamp P1 8. Valve, upper arms off 9. Supply valve, upper arms off
X73	**ECU 796 switch preselection elevation height**	1. Switch preselection elevation height, supply 2. Switch preselection elevation height D796:1.31 3. Increase preselected elevation height D796:1.33 4. Decrease preselected elevation height D796:1.34 5. Switch clamping pressure K1:22 6. 10 V reference switch clamping pressure K1:27 7. 0 V reference switch clamping pressure K1:26 8. - 9. -

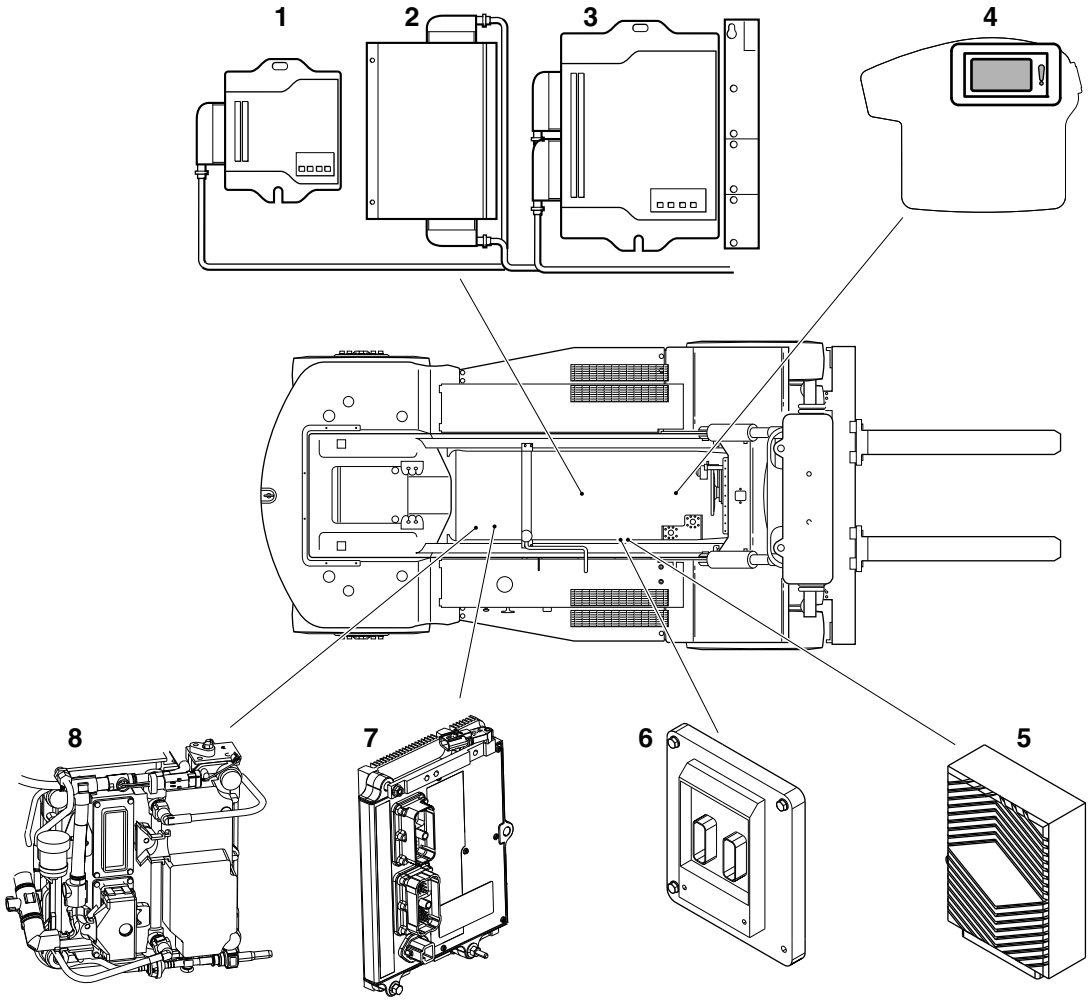
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Number	Main function	Pin/Detailed function
X74	**ECU 796 sensor lowering stop**	1. Sensor, lowering stop, supply +24 V 2. Sensor, lowering stop K1:41, signal 3. Valve, extender/rotation, side shift/rotation 4. Sensor, lowering stop, ground 5. Valve clamp pressure 1 6. Supply clamping valves 7. Laser 8. Supply laser, switch hydraulic functions 9. Valve clamp pressure 2
X75	**ECU 790 Seat rotation**	1. 5 V ref K1:35 2. Input, seat position K1:37 3. 0 V ref K1:36 4. Output, seat turning brake 5. Input, seat turn CCW 6. Input, seat Turn CW 7. Right Pedal 40/180 deg 8. Left pedal channel 2 9. Left pedal 40/180 deg
X77	**ECU 796 key switch forced handling, paper functions**	1. - 2. Key switch forced handling paper functions, supply 3. - 4. - 5. - 6. - 7. Key switch, forced handling 8. - 9. -
X81	**Cable, roof working lights**	1. - 2. - 3. Reverse light left 4. Reverse light right 5. Rotating beacon roof, ground 6. Working lights roof, ground 7. Working lights roof, ground 8. Working lights roof, ground 9. Working lights roof, ground

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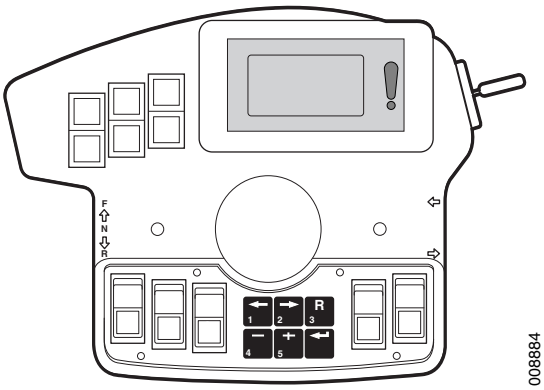
11.5.3 Control units

Control units, position



1. Control unit, steering (ECU 792) ⊕
2. Control unit hydraulics (ECU 796) ⊕
3. Control unit general (ECU 790)
4. Control unit terminal (EDU 795)
5. Control unit transmission (ECU 793)
6. Control unit Volvo engine (ECU 794)
7. Control unit Cummins engine (ECU 794)
8. Control unit CAT engine (ECU 794)

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11.5.3.1 Control unit terminal (EDU 795)

Control unit terminal (EDU 795), description

The terminal, which comprises a display and function keys located on the steering wheel panel, is program controlled and can carry out most individual functions depending on the program it is equipped with.

The display is a graphical LCD display with a resolution of 128 * 64 points and with background lighting.

Beside the display are ten red LEDs connected together. These are used to alert the driver's that there is new information in the display.

To enable management of the system are six function keys.

Control unit terminal (EDU 795), specification

PIN-out (connections)

Connector: Number	Type of input/output	Function
K1:1	RS232 0-ref	RS232 0-ref
K1:2	RS232 RxD	RS232 RxD
K1:3	RS232 TxD	RS232 TxD
K1:4	CAN Shield	CAN Shield
K1:5	CAN 2 -	CAN 2 low (J1939)
K1:6	CAN 2 +	CAN 2 high (J1939)
K1:7	+ 24 V, CPU Right	+ 24 V Right (Battery +24V)
K1:8	+ 24 V, CPU Left	+ 24 V Left (Battery +24V)
K1:9	Power supply 0 V	Battery minus
K1:10	CAN 1 DATA, - Right	Redundant CAN - right
K1:11	CAN 1 DATA, + Right	Redundant CAN + right
K1:12	CAN 1 DATA, - Left	Redundant CAN - left
K1:13	CAN 1 DATA, + Left	Redundant CAN + left
K1:14	Digital output (buzzer) NPN	Buzzer

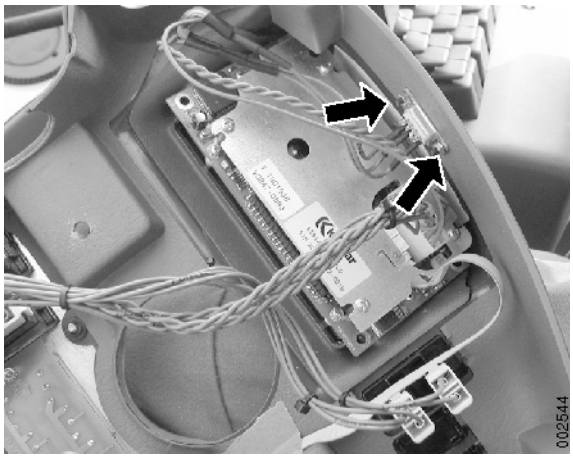
Control unit terminal (EDU 795), replacement

1 Machine in service position.

2 Upload the parameters from the old display before it is removed, using Kalmar Smart Link. For information about Kalmar Smart Link, see section *8 Control system group 8.6 Software*.

3 Remove the centre cover from the steering wheel.

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4 Remove the steering wheel and steering panel covers, please refer to section *9 Frame, body, cab and accessories, Group 9.1.1 Multi-function lever, replacement.*

5 Unplug the connector from the terminal.

6 Remove the two screws securing the terminal to the steering wheel cover.

7 Replace the terminal.

8 Fit in the reverse order.

9 Download parameters and software to the new display, using Kalmar Smart Link.

NOTE

If EDU 795 is replaced, the right program must be downloaded with Kalmar Smart Link. All parameters must be downloaded (with settings and calibrations). Contact Kalmar Industries for information.

11.5.3.2 Control unit general (ECU 790)

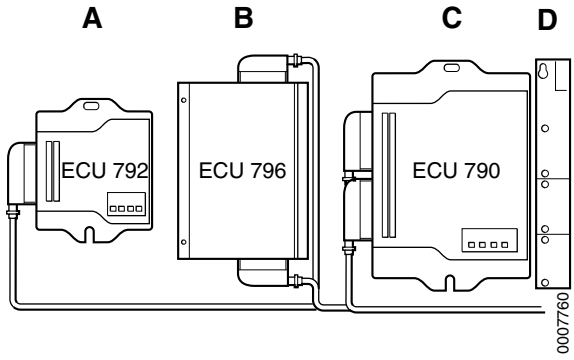
Control unit general (ECU 790), description

Control unit general (ECU 790) is located next to the electrical distribution box behind the operator in the cab.

The indication lamps have the following meanings:

Table 1. Indication lights, general control unit (ECU 790)

Green (Power)	Battery voltage OK
Green (System)	Internal 5 VDC OK
Amber (Mode)	Software check, flashes 0.5 Hz if the program is OK, flashes 5 Hz if no program is downloaded, fixed light glow if set-up mode
Red (Status)	Activated if error occurs.



A. ECU 792
B. ECU 796
C. ECU 790
D. Electrical distribution box

Functions in KCS:

- Monitoring
- ETC (Electronic Throttle Control) - Used for/by Monitoring functions (rpm limitation), for hydrostatic drive and OptimumRev
- Scale
- OptimumLift
- Rotating operator’s seat
- Automatic engine stop 5 minutes after operator’s seat is vacated (five minutes is the normal default, but the time can be changed by a service technician authorised by Kalmar Industries)

Control unit general (ECU 790), specification

PIN-out (connections)

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Connector: Number	Type of input/output	Function
K1:1	Analogue in + 24 V	Battery +24V, 16 - 36 V
K1:2	CAN DATA, + Left	Redundant CAN + left
K1:3	CAN DATA, - Left	Redundant CAN - left
K1:4	CAN DATA, + Right	Redundant CAN + right
K1:5	CAN DATA, -Right	Redundant CAN - right
K1:6	CAN Shield	CAN Shield
K1:7	+24V Redundant power supply	Redundant feed left
K1:8	+24V Redundant power supply	Redundant feed right
K1:9	Digital input	Gear selector input 1 / Brake active (2-pedal hydrostatic)
K1:10	Digital input	Gear selector input 2 / side shift, pressure switch F3 active (hydrostatic)
K1:11	Digital input	Switch, reversible driver’s seat (reverse)
K1:12	Digital input	Forward direction selector lever
K1:13	Digital input	Reverse direction selector lever
K1:14	Digital input	Parking brake, sensor pressure switch, 0V = parking brake active, 24V = parking brake released
K1:15	Digital input	Declutch / Tilt, pressure switch F2 active (hydrostatic)
K1:16	Digital input	Speed limitation 2, 0V = activated, 24V = inactivated
K1:17	Digital input	Ignition switch position 3, start
K1:18	Digital input	Operator's seat turned 40 degrees / Turnable driver seat button CCW (forward)
K1:19	Digital input	Seat sensor, NC or NO logic, programmed with Kalmar Smart Link
K1:20	Digital input	Spreading, pressure switch F4 (hydrostatic)
K1:21	Digital input	End position damping, OptimumSpeed/OptimumRev/fork function 5 pressure switch (hydrostatic)
K1:22	Digital input	Low brake pressure, sensor accumulator tank
K1:23	Digital input	Switch for parking brake, 0V = parking brake active, 24V = parking brake released
K1:24	5 V ref	5 V ref
K1:25	0 V ref	0 V ref
K1:26	Analogue input 0-5V	Right pedal (throttle pedal)
K1:27	Analogue input 0-5V	Left pedal (throttle/brake)
K1:28	Analogue input 0-5V	Lift joystick pressure sensor F1 (DCE60-90HE, Optimum lift/Optimum Drive)

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Connector: Number	Type of input/output	Function
K1:29	Analogue input 0-5V	Scale, chain tensioner left
K1:30	Analogue input 0-5V	Scale, chain tensioner right
K1:31	Analogue input 0-5V	Power cell, shaft tilt cylinder
K1:32	Analogue input 0-5V	Direction hydraulic motor (DCE60-90HE)
K1:33	Analogue input 0-5V	Pressure transmission forward (DCE60-90HE)
K1:34	Analogue input 0-5V	Pressure transmission reverse (DCE60-90HE)
K1:35	5 V ref	5 V ref
K1:36	0 V ref	0 V ref
K1:37	Analogue input 0-5V	Turnable driver seat sensor position 0-5V (Spirit Delta Space) Turnable driver seat position, resistans grid 4.5-2.5-0.5V (Spirit Delta)
K1:38	Analogue input 0-5V	Switch, coolant level (not Volvo TAD650VE, TAD660VE, TAD750VE, TAD760VE) DCE50-90: 0.95-1.45V = normal level, 3.75-4.25V = low level DCE90-180, DCD200-300: 0V = normal level, 5V = low level
K1:39	Analogue input 0-5V	Right pedal (throttle pedal) Reversible driver’s seat (180°) / reversible driver’s seat (40°)
K1:40	Analogue input 0-5V	Left pedal (throttle/brake) Reversible driver’s seat (180°) / reversible driver’s seat (40°) (one pedal DCE 60-90HE). Inching when driver’s seat is rotated 40°.
K1:41	Analogue input 0-5V	Left pedal channel 2, ZF inching sensor
K1:42	Analogue input 0-5V	
K2:1	Frequency input	Vehicle speed (DCE50-90HM/DCE60-90HE)
K2:2	0V pulse	0 V Pulse in
K2:3	Frequency input	Engine speed (DCE60-90HE)
K2:4	0V pulse	0 V Pulse in
K2:5	Encoder channel A	
K2:6	Encoder channel B	
K2:7	0 V pulse encoder	
K2:8	Rheostat (0-200 Ohm)	Fuel level, LPG level
K2:9	0V	0 V rheostat in
K2:10	Digital output	1-255 min stop, 24V for stop on. The conditions are that the parking brake switch is on and the seat sensor is not operated.
K2:11	Digital output	Motor turnable driver seat, CCW (forward)
K2:12	Digital output	OptimumLift, feed 24V to valve, Brake lights (DCE60-90HE)

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Connector: Number	Type of input/output	Function
K2:13	Digital output	Hydraulic motor PDC
K2:14	Digital output	Parking brake valve, 24V = released parking brake
K2:15	Digital output	
K2:16	RS232 RX	Programming port, D-sub 9 pin
K2:17	RS232 TX	Programming port, D-sub 9 pin
K2:18	RS232 0V	Programming port, D-sub 9 pin
K2:19	Temperature/Analogue input	
K2:20	Temperature/Analogue input	
K2:21	Temperature/Analogue input	Temperature, hydraulic oil
K2:22	Temperature/Analogue input	
K2:23	PWM low side driver (mA)	Turnable driver seat, low speed
K2:24	PWM low side driver (mA)	Turnable driver seat, high = brake released
K2:25	PWM high side driver (mA)	Pump forward EDC
K2:26	PWM high side driver (mA)	Pump reverse EDC
K2:27	PWM low side driver (mA)	Hydraulic motor PDC
K2:28	PWM low side driver (mA)	OptimumLift current through proportional valve
K2:29	Digital output	Motor turnable driver seat,CW (reverse)
K2:30	Analogue output	Spare, Sauer-Danfoss valve
K2:31	Analogue output	Spare, Sauer-Danfoss valve
K2:32	0 V ref	0 V ref
K2:33		Not used
K2:34		Not used
K2:35		Not used
K2:36		Not used
K2:37		Not used
K2:38	High driver digital out	Turnable driver seat, forward position
K2:39	High driver digital out	Start motor activated when 24V

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Connector: Number	Type of input/output	Function
K2:40	High driver digital out	Reversing light
K2:41	High driver digital out	Turnable driver seat, reverse position
K2:42		Battery 0 V

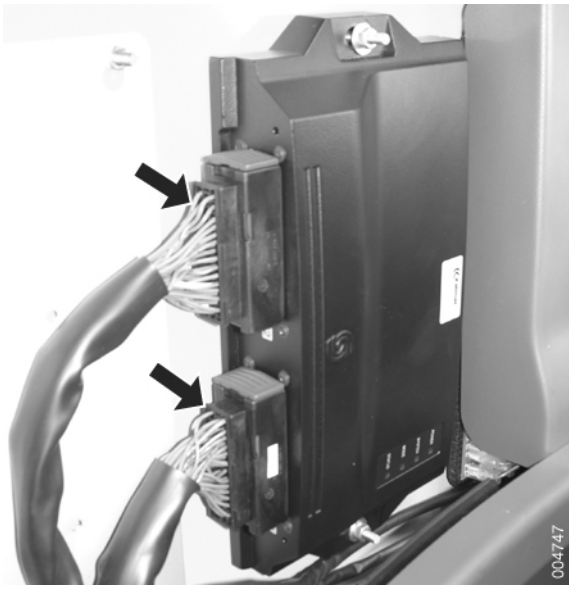
Control unit general (ECU 790), replacement

1 Machine in service position, see section *B Safety*.

2 Remove the covers behind the driver's seat.

3 Upload the parameters from the existing control unit before it is removed, using Kalmar Smart Link. For information about Kalmar Smart Link, Please refer to section *8 Control system*, group *8.6.1 Kalmar Smart Link*.

4 Unplug the connectors from the control unit.





5 Remove the two screws securing the control unit.

6 Replace the control unit.

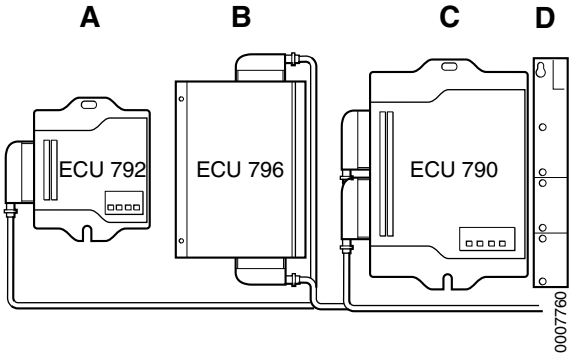
7 Fit in the reverse order.

8 Download parameters and software to the new control unit, using Kalmar Smart Link.

NOTE

If ECU 790 is replaced, the right program must be downloaded with Kalmar Smart Link. All parameters must be downloaded (with settings and calibrations). Contact Kalmar Industries for information.

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A. ECU 792
B. ECU 796
C. ECU 790
D. Electrical distribution box

11.5.3.3 Control unit hydraulics (ECU 796)

Control unit hydraulics (ECU 796), description

Control unit hydraulics (ECU 796) is located next to the electrical distribution box the operator in the cab.

The indication lamps have the following meanings:

Table 2. Indicator lights, control unit ECU 796

All LEDs give constant light for 3 seconds when started up.	
Green	Power, constant light at 22-28 VDC, flashing outside these limits
Amber	CAN bus communication and application OK
Red	Flashes if the supply voltage to the PWM board is less than 12 VDC.

Functions in KCS:

- Electrical servo
- Pre-selected lifting height
- Vertical latch
- Paper handling functions

Control unit hydraulics (ECU 796), specification

PIN-out (connections)

Connector: Number	Type of input/output	Function
K1:1	Power supply	Battery +24V, 16 - 36 V
K1:2	CAN DATA, + Left	Redundant CAN + left
K1:3	CAN DATA, -Left	Redundant CAN - left
K1:4	CAN DATA, + Right	Redundant CAN + right
K1:5	CAN DATA, -Right	Redundant CAN - right
K1:6	CAN, 0 - Ref	CAN Shield
K1:7	Redundant feed	Redundant feed left +24 V
K1:8	Redundant feed	Redundant feed right +24 V
K1:9	Analogue input 1, 0-10V	Hydraulic function 1 / Joystick left y-coordinate
K1:10	Analogue input 2, 0-10V	Hydraulic function 2 / Joystick left x-coordinate
K1:11	Analogue input 3, 0-10V	Hydraulic function 3 / Joystick right y-coordinate
K1:12	Analogue input 4, 0-10V	Hydraulic function 4 / Joystick right x-coordinate
K1:13	Analogue input 5, 0-10V	Hydraulic function 5
K1:14	Battery 0 V	Battery 0 V
K1:15	Battery +24 V	Battery +24 V
K1:16	Analogue input 5, 0-10V	Lift height

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Connector: Number	Type of input/output	Function
K1:17	Analogue input 6, 0-10V	Tilt angle
K1:18	Analogue input 7, 0-10V	Clamping pressure P1 right
K1:19	Analogue input 8, 0-10V	Clamping pressure P2 right
K1:20	Analogue input 9, 0-10V	Clamping pressure P1 left
K1:21	Analogue input 10, 0-10V	Clamping pressure P2 left
K1:22	Analogue input 11, 0-10V	Chosen clamping pressure 1, 2, 3, 4
K1:23	Temperature input 1	Not used
K1:24	Temperature input 2	Not used
K1:25	Temperature input 3	Not used
K1:26	0-Ref output	Not used
K1:27	Ref +10V	Not used
K1:28	Battery 0-Ref	Not used
K1:29	Temperature input 4	Not used
K1:30	Digital input 1	Safety switch
K1:31	Digital input 2	Lift height pre-selection (PLH) ON/OFF
K1:32	Digital input 3	Vertical hold ON/OFF
K1:33	Digital input 4	Increase lift height pre-selection (PLH)
K1:34	Digital input 5	Decrease lift height pre-selection (PLH)
K1:35	Digital input 6	Joystick T1-1 switch for 5:th function
K1:36	Digital input 7	Automatic clamping/opening
K1:37	Digital input 8	Upper arm locked
K1:38	Digital input 9	Extender in inner position
K1:39	Digital input 10	Override all paper functions
K1:40	Digital input 11	Shift hydraulic functions; Side shift to lift and lower upper arm pair, side shift or extender to rotation
K1:41	Digital input 12	Optic stop lower sensor attachment, paper function
K1:42	Not used	Not used
K2:1	Battery 0-Ref	Voltage feed, 0 V
K2:2	Not used	Not used
K2:3	PWM low-side driver output 1 (mA)	Valve hydraulic function 1A/Lower
K2:4	PWM low-side driver output 2 (mA)	Valve hydraulic function 1B/Lift
K2:5	PWM low-side driver output 3 (mA)	Valve hydraulic function 2A/Tilt out

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Connector: Number	Type of input/output	Function
K2:6	PWM low-side driver output 4 (mA)	Valve hydraulic function 2B/Tilt in
K2:7	PWM low-side driver output 5 (mA)	Valve hydraulic function 3A/Side shift left
K2:8	PWM low-side driver output 6 (mA)	Valve hydraulic function 3B/Side shift right
K2:9	24 V in	Voltage feed, 24 V DC (in to ECU, PWM section)
K2:10	24 V out	Voltage feed, 24 V DC (out to valves)
K2:11	PWM low-side driver output 7 (mA)	Valve hydraulic function 4A/spreading out
K2:12	PWM low-side driver output 8 (mA)	Valve hydraulic function 4B/spreading in
K2:13	PWM low-side driver output 9 (mA)	Valve hydraulic function 5A/Extra 5A
K2:14	PWM low-side driver output 10 (mA)	Valve hydraulic function 5B/Extra 5A
K2:15	PWM low-side driver output 11 (mA)	P&P valve upper arms shut off
K2:16	PWM low-side driver output 12 (mA)	-
K3:1	Battery 0-Ref	Voltage feed, 0 V
K3:2	Not used	Not used
K3:3	Desired current value	Clamping pressure valve 1, current
K3:4	Desired current value	Start pump, digital output (ECE 50-90)
K3:5	Desired current value	Pump speed via converter 24/10V (ECE 50-90)
K3:6	Desired current value	Speed limitation (ECE 50-90)
K3:7	Desired current value	Driving interlock (ECE 50-90)
K3:8	Desired current value	Laser
K3:9	24 V in	Voltage feed, 24 V DC (in to ECU, PWM section)
K3:10	24 V out	Voltage feed, 24 V DC (out to valves)
K3:11	PWM desired current value	Clamping pressure valve 2, current
K3:12	PWM desired current value	Green lamp, clamping pressure OK
K3:13	PWM desired current value	Yellow lamp, vertical hold
K3:14	PWM desired current value	Red lamp (overload, extender out, override etc.)
K3:15	PWM desired current value	Valve shift side shift to lift and lower upper arm pair
K3:16	PWM desired current value	Valve shift side shift or extender to rotation

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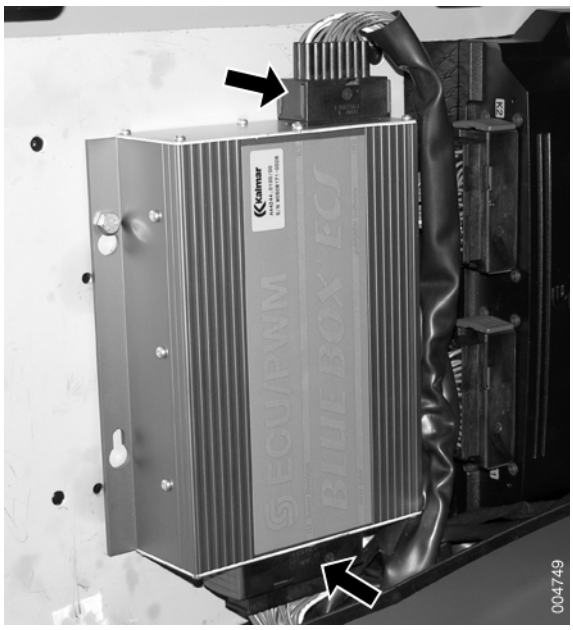
Control unit hydraulics (ECU 796), replacement

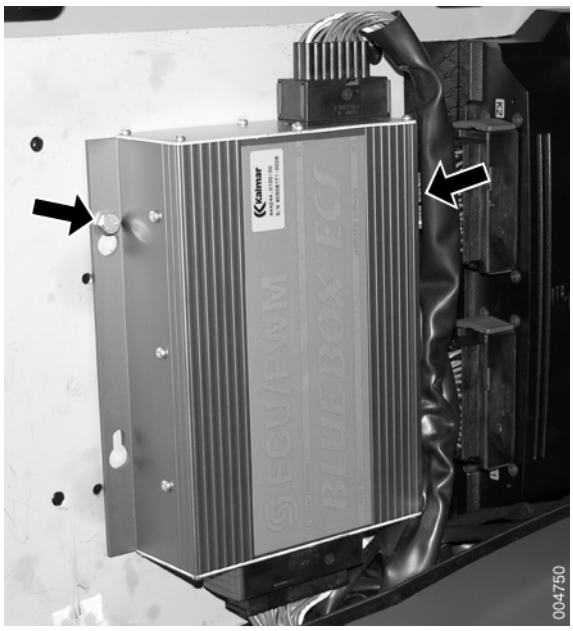
1 Machine in service position, see section *B Safety*.

2 Remove the covers behind the driver's seat.

3 Upload the parameters from the existing control unit before it is removed, using Kalmar Smart Link. For information about Kalmar Smart Link, Please refer to section *8 Control system*, group *8.6.1 Kalmar Smart Link*.

4 Unplug the connectors from the control unit.





5 Remove the two screws securing the control unit.

6 Replace the control unit.

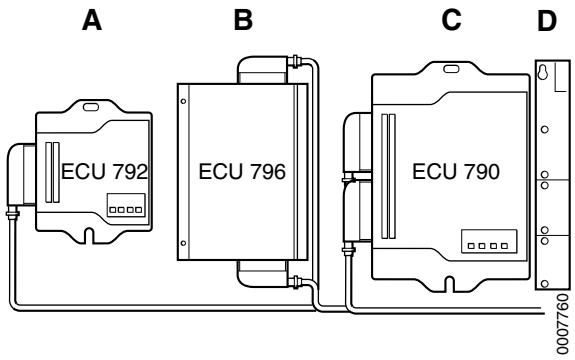
7 Fit in the reverse order.

8 Download parameters and software to the new control unit, using Kalmar Smart Link.

NOTE

If ECU 796 is replaced, the right program must be downloaded with Kalmar Smart Link. All parameters must be downloaded (with settings and calibrations). Contact Kalmar Industries for information.

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A. ECU 792
B. ECU 796
C. ECU 790
D. Electrical distribution box

11.5.3.2 Control unit steering (ECU 792)

Control unit steering (ECU 792), description

Control unit steering (ECU 792) is located next to the electrical distribution box behind the operator in the cab.

The indication lamps have the following meanings:

Table 3. Indicator lights, control unit ECU 792

Green (Power)	Battery voltage OK
Green (System)	Internal 5 VDC OK
Amber (Mode)	Software check, flashes 0.5 Hz if the program is OK, flashes 5 Hz if no program is downloaded, fixed light glow if set-up mode
Red (Status)	Activated if error occurs.

Functions in KCS:

- Lever steering with feedback
- Lever steering without feedback
- Mini-wheel

Control unit steering (ECU 792), specification

PIN-out (connections)

Connector: Number	Type of input/output	Function
K1:1	0 V ref	0 V ref
K1:2	Digital input 0	Mini-wheel/lever steering on/off
K1:3	Digital input 1	Sensor, steering wheel movement (for lever steering/mini-steering wheel)
K1:4	Digital input 2	Upshift gear (manual shifting)
K1:5	Digital input 3	Downshift gear (manual shifting)
K1:6	PWM high side driver	Steering valve, right
K1:7	PWM high side driver	Steering valve, left
K1:8	Analogue input 2, config 1= 0-3030mA	Feedback current Steering valve, right
K1:9	Analogue input 3, config 1= 0-3030mA	Feedback current Steering valve, left
K1:10	Analogue input 2, Config 0=0-5V Config 2= 0-152mA	
K1:11	Analogue input 3, Config 0=0-5V Config 2= 0-152mA	
K1:12	Frequency input 4	

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Connector: Number	Type of input/output	Function
K1:13	RS232 0V	Serial port 0V, D-sub 9 pin, pin 5
K1:14	5 V ref	5 V ref
K1:15	Battery 0V	Battery 0V
K1:16	Frequency input 0	
K1:17	Frequency input 1	
K1:18	Frequency input 2	
K1:19	Frequency input 4	
K1:20	RS232 Tx	Serial port Tx, D-sub 9 pole pin 3
K1:21	RS232 Rx	Serial port Rx, D-sub 9 pole pin 2
K1:22	PWM output 2	
K1:23	Analogue input 4, 0-5V	
K1:24	PWM output 3	
K1:25	Analogue input 5, 0-5V	
K1:26	PWM output 4	
K1:27	PWM output 5	
K1:28	Battery +24V	
K1:29	Battery 0V	
K1:30	Reference thermistor	
K1:31	Analogue input 6, 0-5V	Steering lever
K1:32	Analogue input 7, 0-5V	Sensor steering axle
K1:33	Analogue input 4, 0-5V	
K1:34	Analogue input 5, 0-5V	
K1:35	Analogue 8, 0-5 V	Mini-wheel potentiometer sensor channel A
K1:36	Analogue 9, 0-5 V	Mini-wheel potentiometer sensor channel B
K1:37	CAN High	CAN bus high +
K1:38	CAN Low	CAN bus low -
K1:39	CAN screen 0V	
K1:40	Digital output 0	Mini-wheel/lever steering and lamp on
K1:41	Digital output 1	
K1:42	Battery +24 V	Battery +24 V

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Control unit steering (ECU 792), replacement

1 Machine in service position, see section *B Safety*.

2 Remove the covers behind the driver's seat.

3 Upload the parameters from the existing control unit before it is removed, using Kalmar Smart Link. For information about Kalmar Smart Link, Please refer to section *8 Control system*, group *8.6.1 Kalmar Smart Link*.

4 Unplug the connectors from the control unit.





5 Remove the two screws securing the control unit.

6 Replace the control unit.

7 Fit in the reverse order.

8 Download parameters and software to the new control unit, using Kalmar Smart Link.

NOTE

If ECU 790 is replaced, the right program must be downloaded with Kalmar Smart Link. All parameters must be downloaded (with settings and calibrations). Contact Kalmar Industries for information.

Transmission control unit (ECU 793), description

See section *2 Transmission*, group *2.8.1 Control unit transmission (ECU 793)*.

Control unit engine (ECU 794), description

See section *1 Engine*, group *1.9.1 Control unit engine (ECU 794)*.

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11.5.4 Operation, electrical system

Operation, electrical system, description

The fuse box and supply to the circuits are activated when the ignition key is turned to ignition position.

11.5.5 Cables

Cables, description

The cables are drawn in a cable harness along the side of the frame and held in place with straps and rubber clamps.

There are very few splicing points in the cables between the loads and the fuse box. This is intended to reduce the risk of failure.

Connectors, description

See under *Electrical distribution box, description page 14*.

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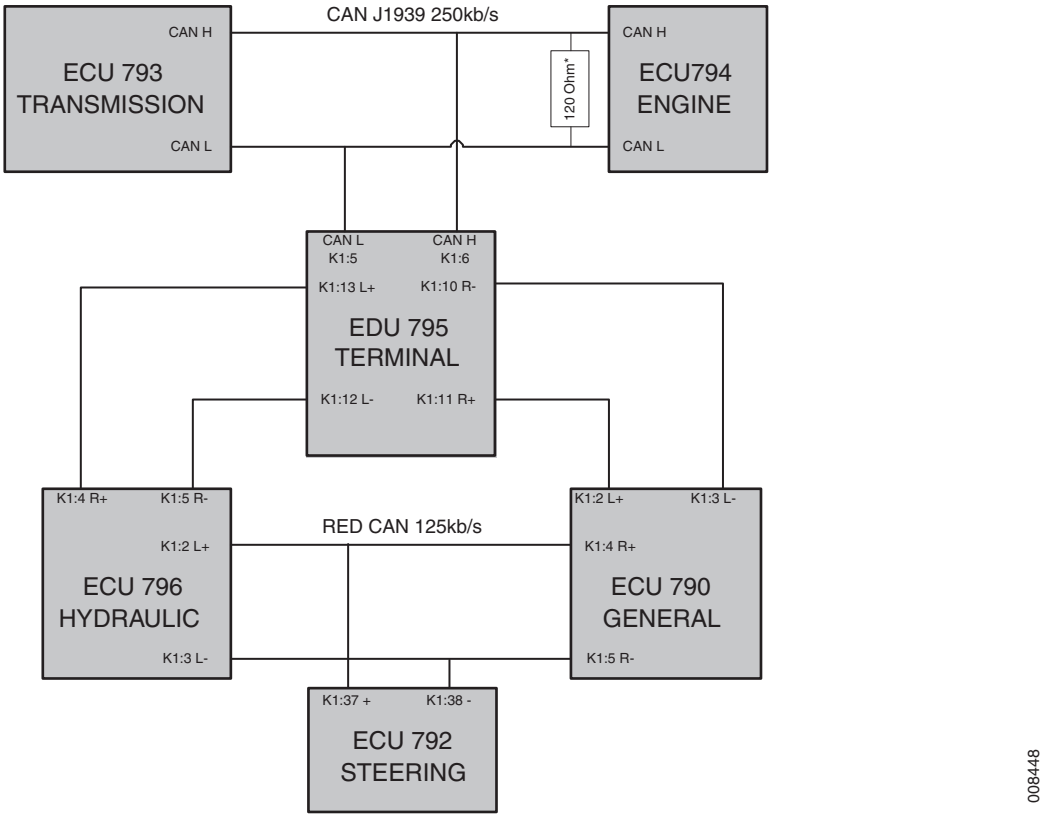
11.6 Communication

Communication, description

The central component parts of the bus communication are the control units that manage the control of the machine's functions. These units integrate with each other and all communication, control signals or signal information, is sent via data buses.

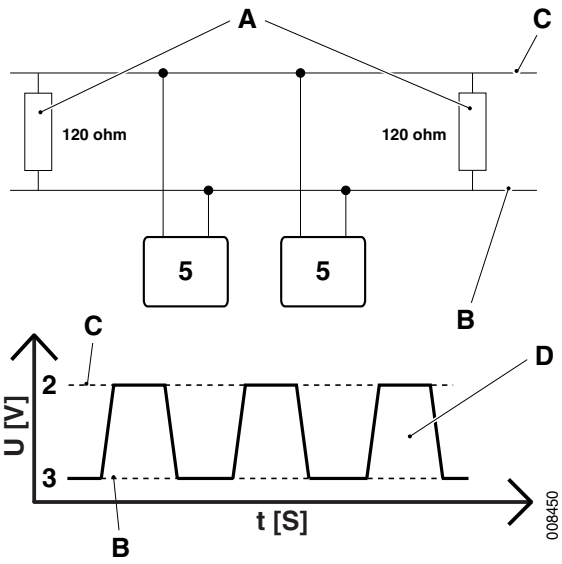
The premise behind the bus network is that a signal is sent out by a transmitter and that the control units requiring information consider it.

Connection is suitably performed with a 2-lead pair-twisted bus cable with impedance of 120 Ohm (30 winding/metre).



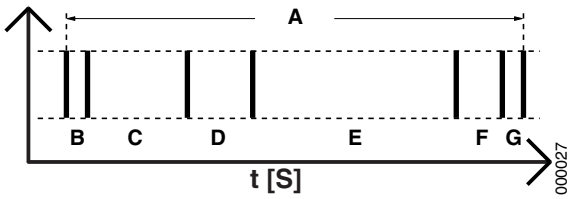
* The built-in resistor in control unit engine (ECU 794) is used in some engines.

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Message continues and signal runs high (voltage high) or low (voltage low).

A. Termination resistance (120 ohm)
B. CAN low (voltage low)
C. CAN high (voltage high)
D. Pulse
E. Node (ECU)



Message continues and signal runs high (voltage high) or low (voltage low).

A. Long message
B. Start bit
C. Identity field / Priority
D. Control field (length of data segment)
E. Data segment
F. Control amount for error detection
G. Confirmation bit (Acknowledge)

11.6.1 CAN bus

CAN bus, description

Communication between the control units takes place using so-called "CAN buses" (Controller Area Network) based on the ISO 11898 standard and CAN specification 2.0B.

The CAN bus is a fast serial control bus with logical hardware circuits. A simple technology which provides high reliability (low frequency) which is a condition for the control signals to be able to control systems in accordance with varying circumstances and conditions.

The CAN standard specifies:

- that the signal traffic is carried by “twisted pair” cables
- that termination resistance, see A in illustration, is necessary to prevent the pulse train from being distorted, see D in illustration. The termination resistance is adapted to the impedance of the cables and can be present in the wiring network or internally in the ECU.
- that the signal value is specified by the potential difference between the cables, CAN high and CAN low (see B and C in illustration)
- form of signal messages
- max. bus speed 1 Mbit/s

The CAN network comprises nodes, see E in illustration, and segments. For example, nodes are control units while segments (bus) are twisted pair cables which carry CAN high and CAN low signal levels from node to node.

Message

Messages are of two types:

- CAN Standard, has identity field of 11 bits
- CAN Extended, has identity field of 29 bits

CAN works with messages sent in frames of max. 8 bytes (64 bits). One complete message is between 11 and 93 bits long. The illustration depicts how a message is built up.

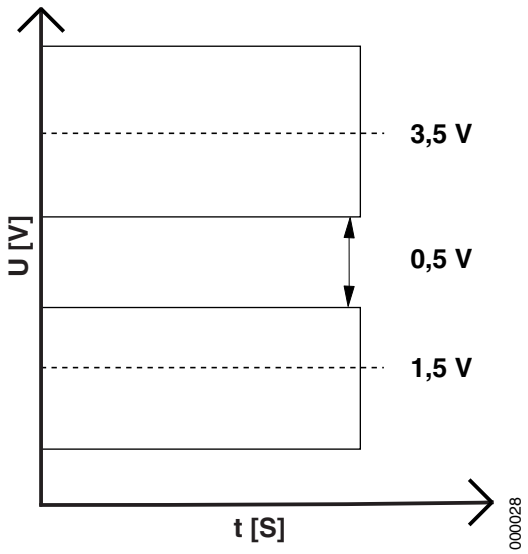
Start bit (B): 1 bit

Indicates that the transmission of a frame, i.e. a message, is now beginning.

Identity field (C): 11 or 29 bits

Describes what kind of information the message contains, e.g. measurement information on engine speed.

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Potential levels CAN high and CAN low

NOTE

Does not specify node address. CAN does not work with node addressing as all nodes receive messages and send them onward.

Control field (D): 6 bits

Specifies length of following data segments, i.e. how long the message is.

Data segment (E): 0-8 bytes

Contains the information to be conveyed to nodes in the network.

Control amount for error detection (F): CRC sequence

Counts a control amount as the message, which enables the checking of a sent message in the receiving node in order to determine if the whole message has been received.

Confirmation (G): 2 bits

The sending node sets bit to logical one (1) when the message is sent. The first node which receives the message sends it onward and sets bit to logical zero (0).

Communication

Each node measures the potential difference on both of its inputs and the potential difference gives logical zero and one respectively. The illustration depicts the approved area in accordance with the standard for potential levels. CAN high has a recommended value of 3.5 V and CAN low 1.5 V. In the worst case approved potential difference may be only 0.5 V but in practice a potential difference of 2 V is recommended for reliable communication.

NOTE

Pulse train can only be observed using an oscilloscope, NOT with a digital multimeter.

When a message is sent all nodes in the network are listening, the message is processed in the node if the information is relevant. The node which first receives the message confirms that the message has been received (sets confirmation bit). The sending node knows that the message has been received by at least one node.

One node at a time sends the message, other nodes are listening and waiting until the bus is available. If two messages are to be sent simultaneously then the sending of the message with the lowest priority (highest value in identity field) is concluded. This means that messages do not need to be re-sent in the event of a communication conflict but only in the event of a bus error (message erroneous).

The CAN bus exchanges around 100 messages per second in the network.

Different bus systems can be used e.g. random sending or primary (master) / secondary (slave),

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HLP – High Layer Protocol

CAN only specifies messages and how communication shall take place, i.e. one protocol. In order to manage the network the CAN protocol needs to be supplemented by a HLP which specifies:

- flow control
- transport of data above a length of 8 bits in 8 bit messages (division)
- how nodes are addressed in the network
- how bits in the message's data field shall be interpreted.

11.6.2 Redundant CAN bus

Redundant CAN bus, description

Communication between ECUs is managed by a so-called “redundant CAN bus system”, which is a network for managing different nodes of different types in a common CAN bus system.

The network is based on one node being central, in this case EDU 795, and a controlling unit (master). Other nodes in the network are secondary (slaves) and manage dedicated areas e.g. hydraulic units.

A condition for communication is that the ignition voltage is active.

The following occurs:

- Most suitable route for an enclosed communication system is analysed.
- Communication is established segment for segment.

NOTE

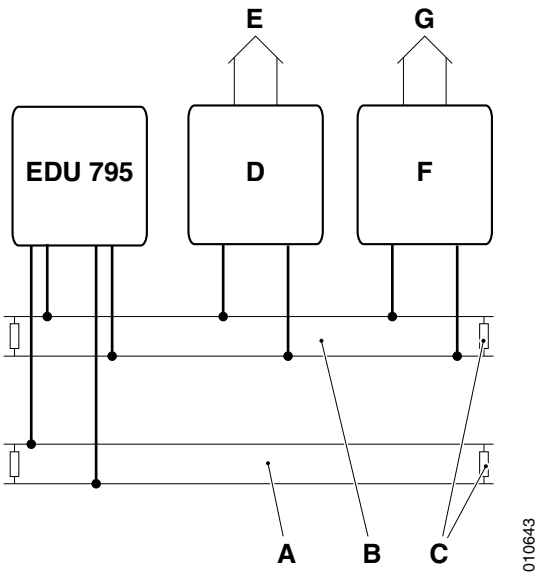
The number of active segments depends on how many control units are active in the machine in question, which depends on the machine's equipment (options).

- Termination resistance in the control nodes secures communication segment for segment. This is indicated as a rapid clicking sound when starting (key to position I in ignition switch) which can be heard in the operator's station.
- When all nodes and segments have closed loops then the communication is established in the system.

The communication loops can be disrupted by cable damage for example and then communication is established by an alternative route (not applicable to ECU 793 and ECU 794). At the same time an exclamation mark in the panel for warning and indicator lights indicates that a communication loop is broken in a segment.

The control system can manage the loss of a segment (not applicable to ECU 793 and ECU 794). If several segments fail then one or several of the nodes lose communication and work independently but usually with limited capacity to perform the task assigned. This is indicated by an error code in the display (EDU 795).

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A. Redundant CAN bus
B. CAN bus drivetrain
C. Terminating resistor (120 ohm)
D. Control unit, engine
E. Control of engine
F. Control unit, transmission
G. Control of transmission

Technical specification:

- 11 bit identity field
- 125 kbit/s
- Termination 120 Ohm (in the ECUs)

11.6.3 CAN bus driveline

CAN bus drivetrain (ECU 793, ECU 794), description

The drivetrain CAN bus is based on the SAE J1939 standard where selected messages are used to control engine and transmission.

SAE J1939 is a standard from SAE (Society of Automotive Engineers) for data communication in vehicles. The standard regulates hardware interface, bit times and message composition.

The engine and transmission control units come from the respective engine and transmission suppliers.

The machine can be ordered with different models of transmission and engine alternatives. These alternatives use this standard and therefore messages for each variant are based on the same structure.

A condition for communication is that the ignition voltage is active.

The following occurs:

- Control units are started
- The CAN bus is ready for communication

Technical specification:

- 29 bit identity field
- 250 kbit/s
- Termination 120 Ohm (in wiring network)

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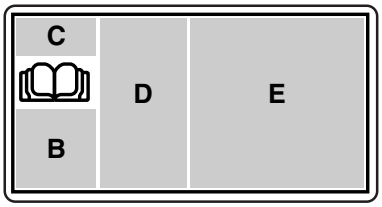
Error codes

Error codes, explanation

The error codes are explained in table form for Engine, Transmission as well as Control system. They are sorted according to error code number.

The error code table has the following information:

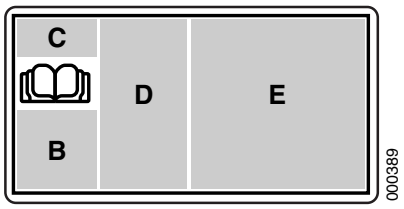
- Code, error code's number, shown in field C on display.
- Description, explanation of the error code and when it's generated.
- Limitation, in case of certain error codes certain functions are impaired or limited to protect the machine and operator.
- Action, information of what should be checked to find the cause of the error code.



B. Error code level (symbol)
C. Error code number
D. Cause of error (symbol)
E. Function (symbol)

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Error code menu, description

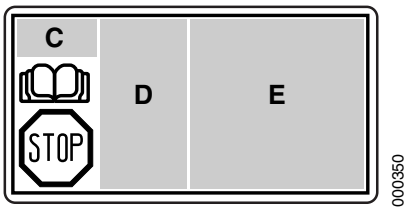


The control system's display is divided into four fields where information is shown (see figure to the left).

- Field B: Error code level shown with a symbol.
- Field C: Indicates error code.
- Field D: Indicates type of error.
- Field E: Indicates which function is affected by error code.
- The book symbol means that there's information in the operator's manual.

Field B: Error code level

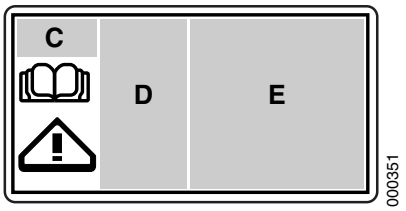
The control system gives error code information in three levels which are indicated with a symbol in the lower left corner (B) on the display unit.



- Stop

  Indicates a serious malfunction that may affect operator safety or cause machine breakdown. The error code must be dealt with immediately. Stop working with the machine and contact service immediately.

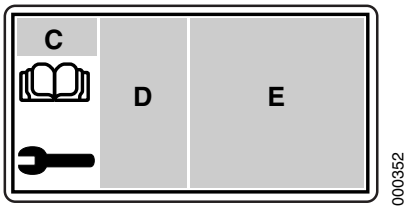
  The error code is shown automatically on the display.



- Warning

  Indicates machine malfunction that should be taken care of as soon as possible. After finished work shift with the machine, contact service as soon as possible.

  The error code is shown automatically on the display.

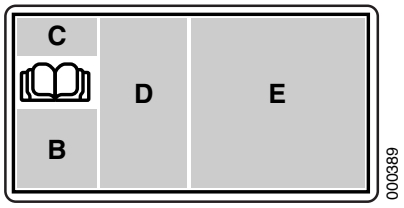


- Information

  Information for the operator that something should be taken care of, for example, low fuel level. Rectify the cause of the error code as soon as possible.

Field C: Error code number

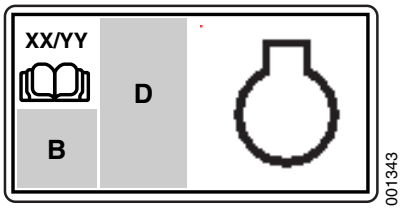
The control system gives error codes from three sub-systems:



- Machine:

  Shown with error code number XXX on display.

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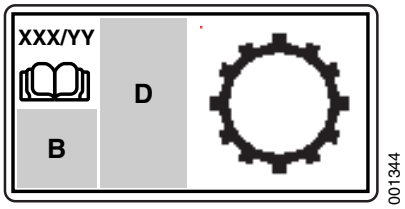


- Engine

  Shown with code 1200 and error code number SPN: XXX and FMI: XXX (position D) in display. SPN means Suspect Parameter Number and is an indication of the failed component and FMI means Failure Mode Identifier and are an indication of what type of fault the component have.

NOTE

If several error codes come from the engine, these are shown rolling, that is, all active error codes are displayed in the same field at approx 1s intervals.



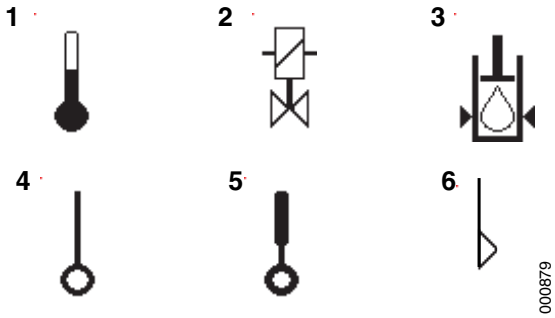
- Transmission:

  Shown with code 900 and error code number SPN: XXX and FMI: XXX (position D) in display. SPN means Suspect Parameter Number and is an indication of the failed component and FMI means Failure Mode Identifier and are an indication of what type of fault the component have.

NOTE

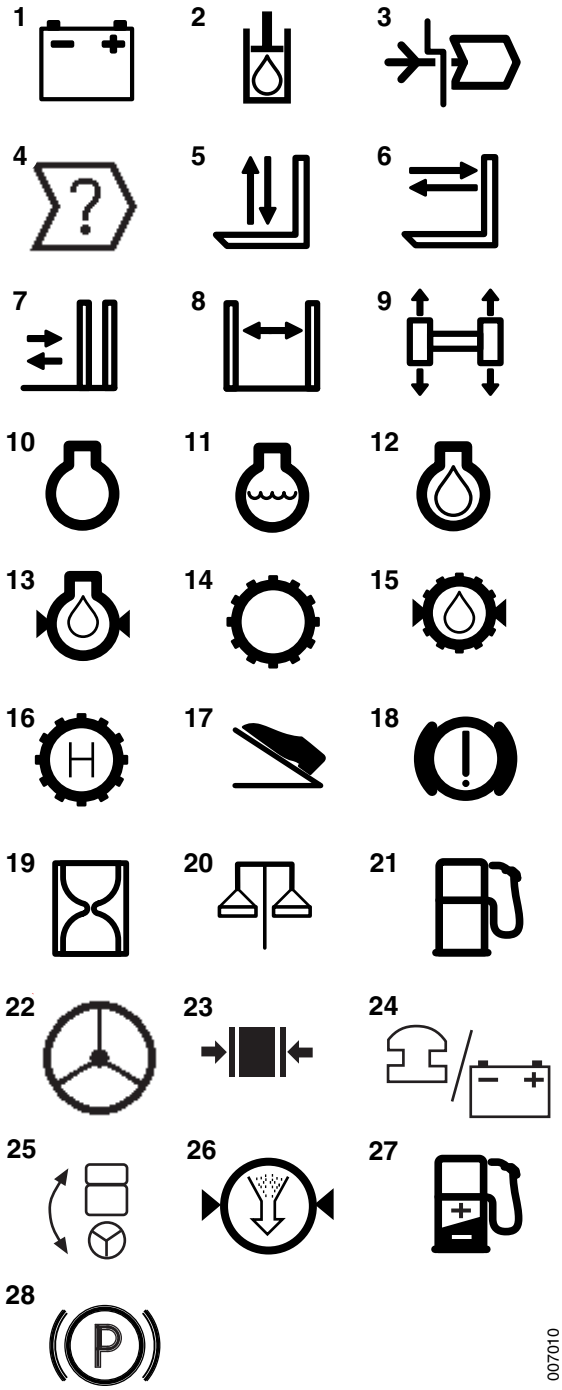
If several error codes come from the engine, these are shown rolling, that is, all active error codes are displayed in the same field at approx 1s intervals.

Field D: Type of error



1. Too high/too low temperature.
2. Incorrect signal to solenoid.
3. Incorrect hydraulic pressure
4. Incorrect sensor signal.
5. Incorrect signal from lever.
6. Too high/too low level.

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Field E: Indicates which function is affected by the error code.

1. Battery voltage.
2. Hydraulic functions.
3. Communication.
4. ECU hardware defect.
5. Lift up/down.
6. Forks tilt.
7. Forks side shift.
8. Forks spreading.
9. Levelling.
10. Engine.
11. Coolant engine.
12. Engine oil.
13. Oil pressure engine.
14. Gearbox.
15. Oil pressure gearbox.
16. Hydrostatic transmission.
17. Pedal.
18. Brake system.
19. Time.
20. Electronic scales.
21. Fuel.
22. Steering.
23. Clamping attachment.
24. Emergency stop.
25. Reversible driver's seat.
26. Air or particle filter.
27. Fuel economy.
28. Parking brake.

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Reading out error code

WARNING

Stop alarms indicate a malfunction in the machine which may affect safety of the operator and others in the vicinity or may cause a breakdown.
– Read off the error code, Switch off the engine and carry out actions according to the error code table.

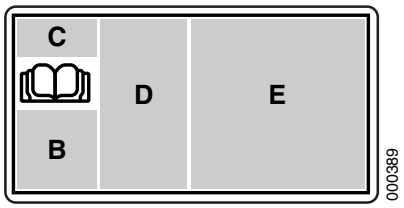
Warning and information alarms indicate malfunctions of such character that work does not have to be stopped. The machine's capacity may be limited and certain functions may not work.
– Carry out actions according to the error code table as soon as possible.

1 Stop the machine and identify the error code level and special error code number, see section *Error code menu, description page 4*. Stop the engine in the event of a Stop alarm or let the engine run in the event of Warning or Information alarms.

NOTE

If several error codes come from the engine, these are shown rolling, that is, all active error codes are displayed in the same field at approx 1s intervals.

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2 The error code is shown automatically on the display.

Note all error codes.

Scroll the error codes by pressing the Reset (R) function key. The error codes if they are still active will occur after a defined time that can be different depending on type of alarm. Error code information disappears once its cause has been remedied.

Deactivate display of error codes by pressing the Reset (R) function key:

- In the event of Stop: If the cause of the error code remains, the error code will reappear within one minute.
- In the event of Warning or Information: If the cause of the error code remains, the error code will reappear within three minutes.
- If the cause of the error code is gone, error code display will automatically deactivate within 30 seconds.

3 Park the machine in a suitable location.

For error code level "STOP" – Stop the engine.

For error code level "WARNING" or "INFORMATION" – Leave the engine running or switch the machine off.

4 Read the information for the error code/error codes in the error code table and perform the recommended actions.

5 Restart the engine and check in the display that error codes are gone according to step 2.

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1 Engine

Error codes engine, general

- The display shows error codes as specified in SAE J1939

  SPN / FMI
- J1587 indicates error code according to SAE J1587 (for Volvo: Vodia).

  PID, PPID, SID, PSID / FMI

Table 1. Specification FMI

FMI	Description	SAE-text
0	Too high value.	Valid data, but higher than normal operating range.
1	Too low value.	Valid data, but lower than normal operating range.
2	Incorrect data.	Intermittent or incorrect data.
3	Electrical problem.	Abnormally high voltage or short-circuiting to higher voltage.
4	Electrical problem.	Abnormally low voltage or short-circuiting to lower voltage.
5	Electrical problem.	Abnormally low current or open circuit.
6	Electrical problem.	Abnormally high current or short-circuiting to frame ground.
7	Mechanical problem.	Incorrect response from mechanical system.
8	Mechanical problem or electrical problem.	Abnormal frequency.
9	Communication error.	Abnormal update rate.
10	Mechanical problem or electrical problem.	Abnormally wide variations.
11	Unknown malfunction.	Non-identifiable error.
12	Component error.	Defective unit or component.
13	Incorrect calibration.	Values outside calibration values.
14	Unknown malfunction.	Special instructions.
15	Too high value.	Data valid but above normal operating range - Least severe level.
16	Too high value.	Data valid but above normal operating range - Moderately severe level.
17	Too low value.	Data valid but below normal operating range - Least severe level.
18	Too low value.	Data valid but below normal operating range - Moderately severe level.
19	Communication error.	Received network data in error.
20-30		Reserved for SAE assignment.
31	FMI is not available or the condition that is identified by the SPN exists.	Not available or condition exists.

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Error codes engine alternative Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE

		Description	Limitation	Action
Code	**J1587**			
94/1	PID94/1	Low fuel pressure (feed).	No limitation.	Change fuel filter. Change fuel pre-filter. Check if pressure can be built up with the hand pump.
94/3	PID94/3	Sensor fuel pressure, short-circuited to voltage.	No limitation.	Check cabling between control unit and component. Check the sensor.
94/5	PID94/5	Sensor fuel pressure, short-circuited to ground or open circuit.	No limitation.	Check cabling between control unit and component. Check the sensor.
94/7	PID94/7	Sensor fuel pressure, short-circuited to voltage, ground, or open circuit.	No limitation.	Change fuel filter. Change fuel pre-filter. Check if pressure can be built up with the hand pump.
97/0	PID97/0	Water in fuel.	No limitation.	Drain water separator. Clean metal filter in the fuel feed's hose connection on the engine. Check fuel filter and fuel pre-filter.
97/4	PID97/4	Sensor water in fuel short-circuited to ground or open circuit.	No limitation.	Check cabling between control unit and component. Check the sensor.
100/0	PID100/0	Low engine oil pressure.	Engine will shut down.	Check oil level. Change oil filter. Check the system pressure valves and the safety valve in the lubrication system. Check the sensor.
100/3	PID100/3	Sensor oil pressure, short-circuited to voltage.	No limitation.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
100/5	PID100/5	Sensor, oil pressure, open circuit.	No limitation.	Check cabling between control unit and component. Check the sensor.
105/0	PID105/0	High charge-air temperature.	Engine will shut down.	Check that the charge-air cooler is clean. Check the sensor.
105/4	PID105/4	Sensor charge-air temperature, cable short-circuited to ground.	No limitation.	Check cabling between control unit and component. Check the sensor.
105/5	PID105/5	Sensor charge-air temperature, cable open circuit.	No limitation.	Check cabling between control unit and component. Check the sensor.
106/0	PID106/0	Boost pressure too high.	Reduced engine power.	Check the turbocharger. Check the sensor. Check fuel quality and injectors.
106/3	PID106/3	Sensor boost pressure, cable short-circuited to voltage.	Reduced engine power.	Check cabling between control unit and component. Check the sensor.
106/5	PID106/5	Sensor boost pressure, cable open circuit.	Reduced engine power.	Check cabling between control unit and component. Check the sensor.
108/2	PID108/2	Faulty signal from charge air pressure sensor.	No limitation.	Check cabling between control unit and component. Check the sensor.
108/3	PID108/3	Sensor boost pressure, short-circuited to voltage.	No limitation.	Check cabling between control unit and component. Check the sensor.
108/4	PID108/4	Sensor boost pressure, short-circuited to frame ground or open circuit.	No limitation.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
110/0	PID110/0	High coolant temperature.	No limitation.	Check coolant level. Check that radiator is clean. Check thermostat. Check the cap on the expansion tank. Check if there's air in coolant system. Check the sensor.
110/4	PID110/4	Sensor coolant temperature, short-circuited to ground.	Preheating is activated even if engine is warm.	Check cabling between control unit and component. Check the sensor.
110/5	PID110/5	Sensor coolant temperature, cable open circuit.	Preheating is activated even if engine is warm.	Check cabling between control unit and component. Check the sensor.
111/1	PID111/1	Low coolant level.	No limitation.	Check the coolant level, top up if needed. Check the sensor.
158/1	PID158/1	Low battery voltage.	Engine may be difficult to start.	Check and charge the batteries. Check the alternator. Check the battery cables.
164/0	PID164/0	High fuel pressure.	No limitation.	Check the fuel pump. Check the sensor.
164/2	PID164/2	Faulty signal from fuel pressure sensor.	Engine speed limited to 1100 rpm.	Check cabling between control unit and component. Check the sensor.
164/4	PID164/4	Sensor fuel pressure, short-circuited to ground.	Engine speed limited to 1100 rpm.	Check cabling between control unit and component. Check the sensor.
164/5	PID164/5	Sensor fuel pressure, open circuit.	Engine speed limited to 1100 rpm.	Check cabling between control unit and component. Check the sensor.
190/0	PID190/0	Engine rpm too high.	No limitation.	Ease off throttle or select higher gear.

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		Description	Limitation	Action
Code	**J1587**			
626/3	PID45/3	Preheating relay, short-circuited to voltage.	Preheating cannot be activated. White smoke at cold-start. Start problems in cold weather.	Check cabling between control unit and component. Check the relay.
626/4	PID45/4	Preheating relay, short-circuited to ground.	Preheating relay is activated constantly. Fuse for preheating may blow.	Check cabling between control unit and component. Check the relay.
626/5	PID45/5	Preheating relay, open circuit or defective component.	Preheating cannot be activated. White smoke at cold-start. Start problems in cold weather.	Check cabling between control unit and component. Check the relay.
629/3	SID254/3	Engine control unit (D794), internal fault.	The engine will not start.	Change the control unit.
629/8	SID254/8	Engine control unit (D794), internal fault.	The engine will not start.	Change the control unit.
629/12	SID254/12	Engine control unit (D794), internal fault.	The engine will not start.	Change the control unit.
636/2	SID21/3	Faulty signal from camshaft speed sensor.	Engine takes longer time to start than normal. Engine runs normally when it has started.	Check cabling between control unit and component. Check the sensor.
636/3	SID21/3	Sensor rpm camshaft, no signal.	Engine takes longer time to start than normal. Engine runs normally when it has started.	Check cabling between control unit and component. Check the sensor.
636/8	SID21/8	Sensor engine rpm, camshaft, abnormal frequency.	Engine takes longer time to start than normal. Engine runs normally when it has started.	Check cabling between control unit and component. Check the sensor.
637/2	SID22/2	Faulty signal from engine speed sensor, flywheel.	Engine is difficult to start and runs rough, if it starts.	Check cabling between control unit and component. Check the sensor.
637/3	SID22/3	Sensor engine rpm, flywheel, abnormal frequency.	Engine is difficult to start and runs rough, if it starts.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
637/8	SID22/8	Sensor engine rpm, flywheel, abnormal frequency.	Engine is difficult to start and runs rough, if it starts.	Check cabling between control unit and component. Check that the sensor is connected correctly.
639/2	SID231/2	Communication error with Engine control unit (D794), configuration error.	Engine off: engine cannot be started. Engine on: engine goes to idle and can only be stopped by using the emergency stop.	Use diagnostic menu to find incorrect segment. Check cabling between control unit and component. Check the control unit.
639/2	SID240/2	Communication error with Engine control unit (D794), configuration error.	It may not be possible to start the engine.	Re-program the control unit.
639/7	SID240/7	Communication error with Engine control unit (D794), configuration error.	It may not be possible to start the engine.	Re-program the control unit.
639/9 1675/9	PSID201/9	Communication error with Engine control unit (D794), configuration error.	Instruments and controls do not work.	Use diagnostic menu to find incorrect segment. Check cabling between control unit and component. Check the control unit.
639/11	SID240/11	Communication error with Engine control unit (D794), configuration error.	It may not be possible to start the engine.	Re-program the control unit.
639/14	SID240/14	Communication error with Engine control unit (D794), configuration error.	It may not be possible to start the engine.	Re-program the control unit.
651/3	SID1/3	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
651/4	SID1/4	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
651/5	SID1/5	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.

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		Description	Limitation	Action
Code	**J1587**			
651/7	SID1/7	Incorrect compression or defective injector cylinder 1.	Runs rough at low rpm and low load.	Check fuel pressure. Check valve clearance. Check cabling between control unit and component. Check the injector. Perform compression test and check cylinder 1.
651/12	SID1/12	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
652/3	SID2/3	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
652/4	SID2/4	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
652/5	SID2/5	Electric failure, injector cylinder 1.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
652/7	SID2/7	Incorrect compression or defective injector cylinder 2.	Runs rough at low rpm and low load.	Check fuel pressure. Check valve clearance. Check cabling between control unit and component. Check the injector. Perform compression test and check cylinder 2.
652/12	SID2/12	Electric failure, injector cylinder 2.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
653/3	SID3/3	Electric failure, injector cylinder 3.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
653/4	SID3/4	Electric failure, injector cylinder 3.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.

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		Description	Limitation	Action
Code	**J1587**			
653/5	SID3/5	Electric failure, injector cylinder 3.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
653/7	SID3/7	Incorrect compression or defective injector cylinder 3.	Runs rough at low rpm and low load.	Check fuel pressure. Check valve clearance. Check cabling between control unit and component. Check the injector. Perform compression test and check cylinder 3.
653/12	SID3/12	Electric failure, injector cylinder 3.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
654/3	SID4/3	Electric failure, injector cylinder 4.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
654/4	SID4/4	Electric failure, injector cylinder 4.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
654/5	SID4/5	Electric failure, injector cylinder 4.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
654/7	SID4/7	Incorrect compression or defective injector cylinder 4.	Runs rough at low rpm and low load.	Check fuel pressure. Check valve clearance. Check cabling between control unit and component. Check the injector. Perform compression test and check cylinder 4.
654/12	SID4/12	Electric failure, injector cylinder 4.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
655/3	SID5/3	Electric failure, injector cylinder 5.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.

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		Description	Limitation	Action
Code	**J1587**			
655/4	SID5/4	Electric failure, injector cylinder 5.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
655/5	SID5/5	Electric failure, injector cylinder 5.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
655/7	SID5/7	Incorrect compression or defective injector cylinder 5.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check that cabling to the injectors is not damaged. Check cabling between control unit and component. Check the injector. Perform compression test and check cylinder 5.
655/12	SID5/12	Electric failure, injector cylinder 5.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
656/3	SID6/3	Electric failure, injector cylinder 6.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
656/4	SID6/4	Electric failure, injector cylinder 6.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
656/5	SID6/5	Electric failure, injector cylinder 6.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.
656/7	SID6/7	Incorrect compression or defective injector cylinder 6.	Runs rough at low rpm and low load.	Check fuel pressure. Check valve clearance. Check cabling between control unit and component. Check the injector. Perform compression test and check cylinder 6.
656/12	SID6/12	Electric failure, injector cylinder 6.	Engine runs on 5 cylinders, sounds rough and has reduced power.	Check cabling between control unit and component. Check the injector.

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		Description	Limitation	Action
Code	**J1587**			
677/3 1675/3	SID39/3	Starter motor relay, short-circuited to voltage.	The engine will not start. Engine starts immediately when ignition is turned on.	Check cabling between control unit and component. Check the relay.
677/4 1675/4	SID39/4	Starter motor relay, short-circuited to ground.	The engine will not start.	Check cabling between control unit and component. Check the relay.
677/5 1675/5	SID39/5	Starter motor relay, open circuit.	The engine will not start.	Check cabling between control unit and component. Check the relay.
679/0	PSID97/0	Faulty signal from pressure relief valve.	Engine speed limited to 1100 rpm. Reduced engine power.	Check cabling between control unit and component. Check the component.
679/3	SID42/3	Pressure relief valve, short-circuited to voltage.	Engine speed limited to 1100 rpm.	Check cabling between control unit and component. Check the component.
679/4	SID43/4	Pressure relief valve, short-circuited to ground.	Engine speed limited to 1100 rpm.	Check cabling between control unit and component. Check the component.
679/5	SID43/5	Pressure relief valve, open circuit.	Engine speed limited to 1100 rpm.	Check cabling between control unit and component. Check the component.
679/7	PSID97/7	Pressure relief valve, mechanical defect.	Engine speed limited to 1100 rpm. Reduced engine power.	Check cabling between control unit and component. Check the component.
679/11	PSID97/11	Pressure relief valve, unidentified problem.	Engine speed limited to 1100 rpm. Reduced engine power.	Check cabling between control unit and component. Check the component.
679/14	PSID97/14	Pressure relief valve, defective component.	Engine speed limited to 1100 rpm. Reduced engine power.	Check cabling between control unit and component. Check the component.
729/3	SID70/3	Sensor preheating, short-circuited to voltage.	Fuse blows.	Check cabling between control unit and component. Check the component.
729/4	SID70/4	Sensor preheating, short-circuited to ground.	Engine difficult to start in cold weather.	Check cabling between control unit and component. Check the component.

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		Description	Limitation	Action
Code	**J1587**			
729/5	SID70/5	Sensor preheating, open circuit.	Engine difficult to start in cold weather.	Check cabling between control unit and component. Check the component.
1079/3	SID 232/3	Reference voltage 5 V no. 1 to sensor, short-circuited to voltage.	No limitation.	Check cabling between control unit and component. Check the sensor.
1079/4	SID 232/4	Reference voltage 5 V no. 1 to sensor, short-circuited to ground.	No limitation.	Check cabling between control unit and component. Check the sensor.
1080/3	SID 211/3	Reference voltage 5 V no. 2 to sensor, short-circuited to voltage.	No limitation.	Check cabling between control unit and component. Check the sensor.
1080/4	SID 211/4	Reference voltage 5 V no. 2 to sensor, short-circuited to ground.	No limitation.	Check cabling between control unit and component. Check the sensor.
1239/0	PSID 96/0	Too high fuel pressure.	Engine speed limited to 1100 rpm. High engine power. (Powerful engine)	Check fuel feed.
1239/1	PSID 96/1	Too low fuel pressure.	Engine speed limited to 1100 rpm. Reduced engine power.	Check fuel filter, replace if necessary. Check fuel feed. Make sure that it is proper flow and pressure of the fuel through prefilter -filter - feed pump- high-pressure-pump before any injectors are relased.
1239/4	PSID 96/4	Sensor fuel pressure, short-circuited to ground.	Engine speed limited to 1100 rpm. Reduced engine power. Engine starting difficulty.	Check cabling between control unit and component. Check the sensor.
1239/7	PSID 96/7	Sensor fuel pressure, mechanical defect.	Engine speed limited to 1100 rpm. Reduced engine power. Engine starting difficulty.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
1239/12	PSID 96/12	Sensor fuel pressure, defective component.	Engine speed limited to 1100 rpm. Reduced engine power. Engine starting difficulty.	Check the sensor.
2047/xx		Undetectable error code from the engine. Error codes above 2047 cannot be shown in the display. Possible error codes: 2791, 520195.	-	Contact the engine supplier for further information.
2791/3	PPID19/3	Internal EGR, short-circuited to voltage.	Internal EGR not working.	Check cabling between control unit and component. Check the component.
2791/4	PPID19/4	Internal EGR, short-circuited to ground.	Internal EGR not working.	Check cabling between control unit and component. Check the component.
2791/5	PPID19/5	Internal EGR, open circuit.	Internal EGR not working.	Check cabling between control unit and component. Check the component.
2791/7	PPID19/7	Internal EGR, mechanical defect.	Internal EGR not working.	Check sensor boost pressure. Check the component (IEGR) Contact Volvo Penta workshop for more information.
520195/3	PPID6	Abnormally high voltage or short-circuiting to higher voltage.	The engine can only be stopped with the auxiliary stop.	Check the connections and cables are not damaged. Check the stop button.
520195/4	PPID6	Abnormally low voltage or short-circuiting to lower voltage.	The engine can only be stopped with the auxiliary stop.	Check the connections and cables are not damaged.
520195/5	PPID6	Abnormally low power or open circuit.	Engine cannot be shut down.	Check the connections and cables are not damaged.

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Error codes engine alternative Cummins QSB6.7

		Description	Limitation	Action
Code	**J1587**			
84 / 2	P084 / 2	Machine Speed Sensor Circuit - Data Erratic, Intermittent or Incorrect. The ECU 794 lost the machine speed signal.	Engine speed limited to Maximum Engine Speed without VSS parameter value. Cruise control, Gear-Down Protection, and Road Speed Governor will not work.	Check cabling between control unit and component. Check the sensor.
84 / 10	P084 / 10	Machine Speed Sensor Circuit Tampering Has Been Detected - Abnormal Rate of Change. Invalid or inappropriate machine speed signal. Signal indicates an intermittent connection or VSS tampering.	Engine speed limited to Maximum Engine Speed without VSS parameter value. Cruise control, Gear-Down Protection, and Road Speed Governor will not work.	Check cabling between control unit and component. Check the sensor.
91 / 0	P91 / 0	Accelerator Pedal or Lever Position Sensor 1 - Data Valid but Above Normal Operational Range - Most Severe Level. A frequency of more than 1500 Hz has been detected at the frequency throttle input to the ECU 794.	Severe derate in power output of the engine. Limp home power only.	-
91 / 1	P91 / 1	Accelerator Pedal or Lever Position 1 Sensor Circuit Frequency - Data Valid but Below Normal Operational Range - Most Severe Level. A frequency of less than 100 HZ has been detected at the frequency throttle input to the ECU 794.	Severe derate in power output of the engine. Limp home power only.	-
91 / 19	P91	SAE J1939 Multiplexing Accelerator Pedal or Lever Sensor System Error - Received Network Data Error. The OEM machine electronic control unit (VECU) detected a fault with its accelerator pedal.	Engine may only idle or engine will not accelerate to full speed.	Use diagnostic menu to find incorrect segment.
91 / 2	P31 / 2	Position sensor accelerator pedal		-
91 / 3	P091 / 3	Accelerator Pedal or Lever Position Sensor Circuit - Shorted High. High voltage detected at accelerator pedal or lever position circuit.	Severe derate in power output of the engine. Limp home capability only.	Check cabling between control unit and component. Check the component.

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		Description	Limitation	Action
Code	**J1587**			
91 / 4	P091 / 4	Accelerator Pedal or Lever Position Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected at accelerator pedal or lever position signal circuit.	Severe derate in power output of the engine. Limp home capability only.	Check cabling between control unit and component. Check the component.
94 / 1	P94 / 1	Fuel pump delivery pressure - data valid but below normal operational range - moderately severe level. The ECU 794 has detected the fuel pressure in the fuel rail is lower than the commanded performance.	Possibly hard to start; low power; possible engine smoke. Engine can possibly not start.	-
94 / 2	P094 / 2	Injector Metering Rail 1 Pressure - Data Erratic, Intermittent, or Incorrect. The ECU 794 has detected that the fuel pressure signal is not changing.	The ECU 794 will estimate fuel pressure, and power is reduced.	-
94 / 18	P94 / 0	Fuel pump delivery pressure - data valid but above normal operational range - moderately severe level. The ECU 794 has detected fuel pressure in the fuel rail that is higher than the commanded pressure.	None or possible engine noise associated with higher injection pressures (especially at idle or light load). Engine power is reduced.	-
97 / 3	P097 / 3	Water-in-fuel indicator sensor circuit - Voltage above normal or short circuited to high source. High voltage detected at the water-in-fuel circuit.	None on performance. No water-in-fuel warning available.	Check cabling between control unit and component. Check the sensor.
97 / 4	P097 / 4	Water-in-fuel indicator sensor circuit - Voltage below normal or short circuited to low source. Low voltage detected at the water-in-fuel circuit.	None on performance. No water-in-fuel warning available.	Check cabling between control unit and component. Check the sensor.
97 / 15	P097 / 0	Water-in-fuel indicator - Data valid but above normal operational range - least severe level. Water has been detected in the fuel filter.	Possible white smoke, loss of power, or hard starting	Drain water from the fuel.
100 / 1	P100 / 1	Engine Oil Rifle Pressure - Data Valid but Below Normal Operational Range - Most Severe Level. Oil pressure signal indicates oil pressure is below the engine protection critical limit.	Progressive power derate increasing in severity from time after alert. If the Engine Protection Shutdown feature is enabled, engine will shut down 30 seconds after the red STOP lamp starts flashing.	Check oil level in the engine, top up as needed.

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		Description	Limitation	Action
Code	**J1587**			
100 / 2	P100 / 2	Oil Pressure Switch Sensor Circuit - Data Erratic, Intermittent or Incorrect. An error in the engine oil pressure switch signal was detected by the ECU 794.	None on performance. No engine protection for oil pressure.	Check cabling between control unit and component. Check the sensor.
100 / 3	P100 / 3	Oil Pressure Sensor Circuit - Voltage Above Normal, or Shorted to High Source. High signal voltage detected at the engine oil pressure circuit.	None on performance. No engine protection for oil pressure.	Check cabling between control unit and component. Check the sensor.
100 / 4	P100 / 4	Oil Pressure Sensor Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at the engine oil pressure circuit.	None on performance. No engine protection for oil pressure.	Check cabling between control unit and component. Check the sensor.
100 / 18	P100 / 1	Engine Oil Rifle Pressure - Data Valid but Below Normal Operational Range - Moderately Severe Level. Engine oil pressure signal indicates engine oil pressure is below the engine protection warning limit.	None on performance.	Check oil level in the engine, top up as needed.
102 / 2	P102 /2	Intake Manifold Pressure Sensor Circuit - Data Erratic, Intermittent or Incorrect. The ECU 794 has detected an intake manifold pressure signal that is too high or low for current engine operating conditions.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
102 / 2	P102 /2	Intake manifold pressure sensor circuit - data incorrect. An error in the intake manifold pressure sensor signal was detected by the ECU 794.	Derate in power output of the engine.	Check cabling between control unit and component. Check the sensor.
102 / 3	P102 / 3	Intake Manifold Pressure Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage detected at the intake manifold pressure circuit.	Derate in power output of the engine.	Check cabling between control unit and component. Check the sensor.
102 / 4	P102 / 4	Intake Manifold Pressure Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the intake manifold pressure circuit.	Derate in power output of the engine.	Check cabling between control unit and component. Check the sensor.
103 / 10	P103 / 10	Turbocharger speed - invalid rate of change detected. The turbocharger speed sensor has detected an erroneous speed value.	Possible-low-power estimated turbocharger speed will be used.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
103 / 16	P103 / 0	Turbocharger Number 1 speed high - warning level. High turbocharger speed has been detected.	Engine power derate. The ECU 794 uses an estimated turbocharger speed.	Check the component
103 / 18	P103 / 1	Turbocharger number 1 speed low - warning level. Low turbocharger speed detected by the ECU 794.	Engine power derate. The ECU 794 uses an estimated turbocharger speed.	Check the component
105 / 0	P105 / 0	Intake Manifold 1 Temperature - Data Valid but Above Normal Operational Range - Most Severe Level. Intake manifold air temperature signal indicates intake manifold air temperature above engine protection critical limit.	Progressive power derate increasing in severity from time after alert. If the Engine Protection Shutdown feature is enabled, engine will shut down 30 seconds after the red STOP lamp starts flashing.	Check the coolant level in the engine, top up as needed. Check that the charge-air cooler is clean, clean as needed. Check that fan belts are intact. Check the sensor.
105 / 3	P105 / 3	Intake Manifold Air Temperature Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage detected at intake manifold air temperature circuit.	Possible white smoke. Fan will stay ON if controlled by the ECU 794. No engine protection for intake manifold air temperature	Check cabling between control unit and component. Check the sensor.
105 / 4	P105 / 4	Intake Manifold Air Temperature Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at intake manifold air temperature circuit.	Possible white smoke. Fan will stay ON if controlled by the ECU 794. No engine protection for intake manifold air temperature	Check cabling between control unit and component. Check the sensor.
105 / 15	P105 / 0	Intake Manifold Temperature High - Data Valid but Above Normal Operational Range - Least Severe Level. Intake manifold air temperature signal indicates intake manifold air temperature above engine protection warning limit.	Progressive power derate increasing in severity from time of alert.	Check the coolant level in the engine, top up as needed. Check that the charge-air cooler is clean, clean as needed. Check that fan belts are intact. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
108 / 2	P108 / 2	Barometric pressure: Data erratic, intermittent, or incorrect. The ambient air pressure sensor reads an erratic value upon activation.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
108 / 3	P108 / 3	Barometric Pressure Sensor Circuit - Voltage Above Normal, or Shorted to High Source. High signal voltage detected at barometric pressure circuit.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
108 / 4	P108 / 4	Barometric Pressure Sensor Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at barometric pressure circuit.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
110 / 0	P110 / 0	Engine Coolant Temperature - Data Valid but Above Normal Operational Range - Most Severe Level. Engine coolant temperature signal indicates engine coolant temperature above engine protection critical limit.	Progressive power derate increasing in severity from time after alert. If the Engine Protection Shutdown feature is enabled, engine will shut down 30 seconds after the red STOP lamp starts flashing.	Check coolant level. Check that radiator is clean. Check if there's air in coolant system. Check the cap on the expansion tank. Check the sensor. Check thermostat.
110 / 2	P110 / 2	Engine Coolant Temperature - Data Erratic, Intermittent, or Incorrect. The engine coolant temperature reading is not changed with engine operating conditions.	The ECU 794 will estimate engine coolant temperature.	Check cabling between control unit and component. Check the sensor.
110 / 3	P110 / 3	Engine Coolant Temperature 1 Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage or open circuit detected at engine coolant temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECU 794. No engine protection for engine coolant temperature.	Check cabling between control unit and component. Check the sensor.
110 / 4	P110 / 4	Engine Coolant Temperature 1 Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at engine coolant temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECU 794. No engine protection for engine coolant temperature.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
110 / 15	P110 / 0	Engine Coolant Temperature High - Data Valid but Above Normal Operational Range - Least Severe Level. Engine coolant temperature signal indicates coolant temperature is above the engine coolant temperature engine protection warning limit.	Progressive power derate increasing in severity from time of alert.	Check coolant level. Check that radiator is clean. Check if there's air in coolant system. Check the cap on the expansion tank. Check the sensor. Check thermostat.
110 / 16	P110 / 0	Engine Coolant Temperature - Data Valid but Above Normal Operational Range - Moderately Severe Level. Engine coolant temperature signal indicates engine coolant temperature is above engine protection warning limit.	Progressive power derate increasing in severity from time of alert.	Check coolant level. Check that radiator is clean. Check if there's air in coolant system. Check the cap on the expansion tank. Check the sensor. Check thermostat.
111 / 1	P111 / 1	Coolant Level - Data Valid but Below Normal Operational Range - Most Severe Level. Low engine coolant level detected.	Progressive power derate increasing in severity from time after alert. If the engine protection shutdown feature is enabled, engine will shut down 30 seconds after the red STOP lamp starts flashing.	Check the coolant level, top up if needed. Check the sensor.
111 / 3	P111 / 3	Coolant Level Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage detected at engine coolant level circuit.	None on performance.	Check cabling between control unit and component. Check the sensor.
111 / 4	P111 / 4	Coolant Level Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the engine coolant level circuit.	None on performance.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
157 / 0	P94 / 0	Injector Metering Rail Number 1 Pressure - Data Valid But Above Normal Operating Range - Most Severe Level. The ECU 794 has detected that fuel pressure in the rail fuel is higher than the commanded pressure.	None or possible engine noise associated with higher injection pressures (especially at idle or light load). Engine power is reduced.	-
157 / 2	P157 / 2	Injector Metering Rail 1 Pressure - Data Erratic, Intermittent, or Incorrect. the ECU 794 has detected that the fuel pressure signal is not changing.	The ECU 794 will estimate fuel pressure, and power is reduced.	-
157 / 3	P157 / 3	Injector Metering Rail Number 1 Pressure Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage detected at rail fuel pressure sensor circuit.	Power and or speed derate.	-
157 / 4	P157 / 4	Injector Metering Rail Number 1 Pressure Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the rail fuel pressure sensor circuit.	Power and or speed derate.	-
157 / 16	P157 / 0	Injector Metering Rail 1 Pressure - Data Valid but Above Normal Operational Range - Moderately Severe Level. The ECU 794 has detected that fuel pressure is higher than commanded pressure.	None or possible engine noise associated with higher injection pressures (especially at idle or light load). Engine power is reduced.	-
157 / 18	P157 / 1	Fuel Pump Delivery Pressure Low - Data Valid but Below Normal Operational Range - Moderately Severe Level. The ECU 794 has detected that fuel pressure is lower than commanded pressure.	Possibly hard to start, low power, or engine smoke. Engine can possibly not start.	-
167 / 1	P167 / 1	Electrical Charging System Voltage Low - Data Valid but Below Normal Operational Range - Most Severe Level. Very low battery voltage detected by the battery voltage monitor feature.	Warning lamp illuminated until very low battery voltage condition is corrected.	Check batteries and alternator.
167 / 16	P167 / 0	Electrical Charging System Voltage High - Data Valid but Above Normal Operational Range - Moderately Severe Level. High battery voltage detected by the battery voltage monitor feature.	Amber warning lamp illuminated until high battery voltage condition is corrected.	Check fuses. Check batteries and alternator.

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		Description	Limitation	Action
Code	**J1587**			
167 / 18	P167 / 1	Electrical Charging System Voltage Low - Data Valid but Below Normal Operational Range - Moderately Severe Level. Low battery voltage detected by the battery voltage monitor feature.	Amber lamp will light until low battery voltage condition is corrected.	Check batteries and alternator.
168 / 16	P168 / 0	Battery 1 Voltage - Data Valid but Above Normal Operational Range - Moderately Severe Level. ECU 794 supply voltage is above the maximum system voltage level.	Possible electrical damage to all electrical components.	Check fuses. Check batteries and alternator.
168 / 18	S168 / 1	Battery 1 Voltage - Data Valid but Below Normal Operational Range - Moderately Severe Level. ECU 794 supply voltage is below the minimum system voltage level.	Engine may stop running or be difficult to start.	Check fuses. Check batteries and alternator.
171 / 3	P171 / 3	Ambient temperature sensor, circuit fault- Abnormally high voltage or short-circuit to higher voltage.		-
171 / 4	P171 / 4	Ambient temperature sensor, circuit fault - Abnormally low voltage or short-circuit to lower voltage.		-
190 / 0	P190 / 0	Engine Crankshaft Speed/Position - Data Valid but Above Normal Operational Range - Most Severe Level. Engine speed signal indicates engine speed above engine protection limit.	Fuel injection disabled until engine speed fails below the overspeed limit.	Ease off throttle or select higher gear.
190 / 2	P190 / 2	Engine Crankshaft Speed/Position - Data Erratic, Intermittent, or Incorrect. Crankshaft engine speed sensor intermittent synchronization.	Engine can exhibit misfire as control switches from the primary to the backup speed sensor. Engine power is reduced while the engine operates on the backup speed sensor.	Check cabling between control unit and component. Check the sensor.
190 / 2	P190 / 2	Engine Crankshaft Speed/Position - Data Erratic, Intermittent, or Incorrect. Loss of signal from crankshaft sensor.	Engine can run rough. Possibly poor starting capability. Engine runs using backup speed sensor. Engine power is reduced.	Check cabling between control unit and component. Check the sensor.
251 / 2	P251 / 2	Real-Time Clock Power Interrupt - Data Erratic, Intermittent or Incorrect. Real-time clock lost power.	None on performance. Data in the ECU 794 will not have accurate time and date information.	-

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		Description	Limitation	Action
Code	**J1587**			
441 / 3	P441 / 3	Auxiliary Temperature Sensor Input 1 - Voltage Above Normal, or Shorted to High Source. High signal voltage or open circuit detected at the OEM auxiliary temperature circuit.	None on performance.	Check cabling between control unit and component. Check the sensor.
441 / 4	P441 / 4	Auxiliary Temperature Sensor Input 1 Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at OEM auxiliary temperature circuit.	None on performance.	Check cabling between control unit and component. Check the sensor.
558 / 2	S230 / 2	Accelerator Pedal or Lever Idle Validation Circuit - Data Erratic, Intermittent or Incorrect. Voltage detected simultaneously on both idle validation and off-idle validation switches.	Engine will only idle.	Check cabling between control unit and component. Check component.
558 / 4	S230 / 4	Accelerator Pedal or Lever Idle Validation Circuit - Voltage Below Normal or Shorted to Low Source. No voltage detected simultaneously on both the idle validation off-idle and on-idle circuits.	Engine will only idle.	Check cabling between control unit and component. Check component.
558 / 13	S230 / 13	Accelerator Pedal or Lever Idle Validation Circuit - Out of Calibration. Voltage at idle validation on-idle and off-idle circuit does not match accelerator pedal position.	Engine will only idle.	Check cabling between control unit and component. Check component.
611 / 2	P089 / 2	Auxiliary Intermediate (PTO) Speed Switch Validation - Data Erratic, Intermittent, or Incorrect. The position of the intermediate speed control switch 1 does not match the position of the intermediate speed control validation switch.	Intermediate speed control switch may not operate correctly.	-
611 / 3	S232 / 3	Sensor Supply Voltage 4 Circuit - Voltage Above Normal or Shorted to High Source. High voltage detected at +5 volt sensor supply circuit to the accelerator pedal position sensor.	Engine will only idle.	-
611 / 4	S232 / 4	Sensor Supply 3 Circuit - Voltage Below Normal, or Shorted to Low Source. Low voltage detected on the +5 volt sensor supply circuit to the engine speed sensor.	Possible hard starting and rough running.	-

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		Description	Limitation	Action
Code	**J1587**			
611 / 4	S232 / 4	Sensor Supply Voltage 4 Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected at +5 VDC sensor supply circuit to the accelerator pedal position sensor.	Engine will only die.	-
611 / 15	S151 / 0	Turbocharger compressor outlet temperature - data above normal. High turbocharger compressor outlet temperature has been calculated by the ECU 794.	Fuel is limited in an attempt to decrease the calculated turbocharger compressor outlet temperature.	-
612 / 2	P190 / 2	Engine Magnetic Crankshaft Speed/Position lost both of two signals - Data Erratic, Intermittent, or Incorrect. The ECU 794 has detected that the primary engine speed sensor and the backup engine speed sensor signals are reversed.	Fueling to the injectors is disabled, and the engine can not be started.	-
627 / 2	S251 / 2	Power Lost without Ignition Off - Data Erratic, Intermittent or Incorrect. Supply voltage to the ECU 794 fell below 6.2 volts momentarily, or the ECU 794 was not allowed to power down correctly (retain battery voltage for 30 seconds after key OFF).	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data can be inaccurate.	Check fuses. Check batteries and alternator.
627 / 2	S251 / 2	Power Supply Lost With Ignition On - Data Erratic, Intermittent or Incorrect. Supply voltage to the ECU 794 fell below 6.2 VDC momentarily, or the ECU 794 was not allowed to power down correctly (retain battery voltage for 30 seconds after key OFF).	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data can be inaccurate.	Check fuses. Check batteries and alternator.
627 / 2	S254 / 12	Injector Power Supply - Bad Intelligent Device or Component. The ECU 794 measured injector boost voltage is low.	Possible smoke, low power, engine misfire, and/or engine will not start.	Check fuses. Check batteries and alternator.
629 / 12	S254 / 12	Engine Control Module - critical internal failure. Error internal to the ECU 794 related to memory hardware failures or internal ECU 794 voltage supply circuits.	Engine may not start.	Check the control unit
629 / 12	S254 / 12	Engine Control Module Warning Internal Hardware Failure - Bad Intelligent Device or Component.	No performance effects or possible severe power derate.	Check the control unit

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		Description	Limitation	Action
Code	**J1587**			
630 / 2	S253 / 2	Engine Control Module Data Lost - Data Erratic, Intermittent or Incorrect. Severe loss of data from the ECU 794.	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data can be inaccurate.	Re-program the software in Control unit engine (D794).
630 / 31	S240 / 11	Engine Control Module Calibration Program Memory (RAM) Corruption - Condition Exists. Severe loss of data from the ECU 794.	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data can be inaccurate.	-
633 / 31	S018 / 11	Fueling Actuator Number 1 Circuit Error Conditions Exists. Fuel pump actuator circuit resistance too high or too low.	Possible low power.	-
639 / 9	S231 / 9	SAE J1939 Multiplexing PGN Timeout Error - Abnormal Update Rate. The Cummins ECU 794 did not receive a multiplexed message from an OEM VECU within the time limit or did not receive it at all.	One or more multiplexed devices will not operate properly. One or more symptoms will occur	Use diagnostic menu to find incorrect segment.
639 / 13	S231 / 13	SAE J1939 Multiplexing Configuration Error - Out of Calibration. The ECU 794 expected information from a multiplexed device but only received a portion of the necessary information.	At least one multiplexed devices will not operate properly.	Use diagnostic menu to find incorrect segment.
641 / 3	S027 / 3	VGT actuator driver circuit - voltage above normal or shorted to high source.	Possible low power. Power removed from the turbocharger actuator motor.	-
641 / 4	S027 / 4	VGT actuator driver circuit - voltage below normal, or shorted to low source.	Possible low power. Power removed from the turbocharger actuator motor.	-
644 / 2	S030 / 2	External Speed Command Input (Multiple Unit Synchronization) - Data Erratic, Intermittent, or Incorrect. The throttle input signal to the primary or secondary engine for multiple unit synchronization is less than 3 percent or more than 97 percent.	Primary or secondary engines may be shut down	Check cabling between control unit and component. Check component.

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		Description	Limitation	Action
Code	**J1587**			
647 / 3	S033 / 3	Fan Control Circuit - Voltage Above Normal or Shorted to High Source. Open circuit or high voltage detected at the fan control circuit.	The fan may stay on continuously or not run at all.	Check cabling between control unit and component. Check component.
647 / 4	S033 / 4	Fan Control Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the fan control circuit when commanded on.	The fan may stay on continuously or not run at all.	Check cabling between control unit and component. Check component.
651 / 5	S001 / 5	Injector Solenoid Driver Cylinder 1 Circuit - Current Below Normal, or Open Circuit. High resistance or no current detected at Number 1 injector DRIVER or RETURN pin.	Engine can misfire or possibly run rough.	Check cabling between control unit and component. Check the injector.
651 / 7	S001 / 7	Injector Solenoid Driver Cylinder 1 - Mechanical System Not Responding Properly or Out of Adjustment. Unintended fueling detected in cylinder number 1.	Engine will shut down.	Check cabling between control unit and component. Check the injector.
652 / 5	S002 / 5	Injector Solenoid Driver Cylinder 2 Circuit - Current Below Normal, or Open Circuit. High resistance or no current detected at Number 2 injector driver or return pin.	Engine can misfire or possibly run rough.	Check cabling between control unit and component. Check the injector.
652 / 7	S002 / 7	Injector Solenoid Driver Cylinder 2 - Mechanical System Not Responding Properly or Out of Adjustment. Unintended fueling detected in cylinder number 2.	Engine will shut down.	Check cabling between control unit and component. Check the injector.
653 / 5	S003 / 5	Injector Solenoid Driver Cylinder 3 Circuit - Current Below Normal, or Open Circuit. High resistance or no current detected at Number 3 injector or return pin.	Engine can misfire or possibly run rough.	Check cabling between control unit and component. Check the injector.
653 / 7	S003 / 7	Injector Solenoid Driver Cylinder 3 - Mechanical System Not Responding Properly or Out of Adjustment. Unintended fueling detected in cylinder number 3.	Engine will shut down.	Check cabling between control unit and component. Check the injector.

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		Description	Limitation	Action
Code	**J1587**			
654 / 5	S004 / 5	Injector Solenoid Driver Cylinder 4 Circuit - Current Below Normal or Open Circuit. High resistance or no current detected at Number 1 injector driver or return pin.	Engine can misfire or possibly run rough.	Check cabling between control unit and component. Check the injector.
654 / 7	S004 / 7	Injector Solenoid Driver Cylinder 4 - Mechanical System Not Responding Properly or Out of Adjustment. Unintended fueling detected in cylinder number 4.	Engine will shut down.	Check cabling between control unit and component. Check the injector.
655 / 5	S005 / 5	Injector Solenoid Driver Cylinder 5 Circuit - Current Below Normal, or Open Circuit. High resistance or no current detected at Number 5 injector DRIVER or RETURN pin.	Engine can misfire or possibly run rough.	Check cabling between control unit and component. Check the injector.
655 / 7	S005 / 7	Injector Solenoid Driver Cylinder 5 - Mechanical System Not Responding Properly or Out of Adjustment. Unintended fueling detected in cylinder Number 5.	Engine will shut down.	Check cabling between control unit and component. Check the injector.
656 / 5	S006 / 5	Injector Solenoid Driver Cylinder 6 Circuit - Current Below Normal, or Open Circuit. High resistance or no current detected at Number 6 injector driver or return pin.	Engine can misfire or possibly run rough.	Check cabling between control unit and component. Check the injector.
656 / 7	S006 / 7	Injector Solenoid Driver Cylinder 6 - Mechanical System Not Responding Properly or Out of Adjustment. Unintended fueling detected in cylinder Number 6.	Engine will shut down.	Check cabling between control unit and component. Check the injector.
677 / 3	S39 / 3	Starter Relay Circuit - Voltage Above Normal or Shorted to High Source. Open circuit or high voltage detected at starter lockout circuit.	Either the engine will not start or the engine will not have starter lockout protection.	Check cabling between control unit and component. Check the relay.
677 / 4	S39 / 4	Starter Relay Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected at starter lockout circuit.	The engine will not have starter lockout protection.	Check cabling between control unit and component. Check the relay.

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		Description	Limitation	Action
Code	**J1587**			
697 / 3	S057 / 3	Auxiliary PWM Driver #1 - Voltage Above Normal or Shorted to High Source. High signal voltage detected at the analog torque circuit.	Can not control transmission.	-
697 / 4	S057 / 4	Auxiliary PWM Driver #1 - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the analog torque circuit.	Can not control transmission.	-
703 / 11	S051 / 11	Auxiliary Equipment Sensor Input #3 (OEM Switch) - Root Cause Not Known.	Possible engine power derate.	Check cabling between control unit and component. Check the component.
723 / 2	S064 / 2	Backup Engine Speed/Position Sensor Number 2 - Data Erratic, Intermittent, or Incorrect. Camshaft engine speed sensor intermittent synchronization.	Possible low power.	Check cabling between control unit and component. Check the sensor.
723 / 2	S064 / 2	Engine Speed Sensor (Camshaft) Error - Data Erratic, Intermittent, or Incorrect. The ECU 794 has detected an error in the camshaft position sensor signal.	Possible poor starting. Engine power derate.	Check cabling between control unit and component. Check the sensor.
723 / 7	S064 / 7	Engine Speed Sensor/Position Camshaft and Crankshaft Misalignment - Mechanical System Not Responding Properly or Out of Adjustment. Mechanical misalignment between the crankshaft and camshaft engine speed sensors.	Engine will run derated. Excessive smoke, hard start, and rough idle possible.	Check cabling between control unit and component. Check the sensor.
729 / 3	S070 / 3	Intake Air Heater #1 Circuit - Voltage Above Normal or Shorted to High Source. High voltage detected at the intake air heater signal circuit.	The intake air heaters may be ON or OFF all the time.	Check cabling between control unit and component. Check component.
729 / 4	S070 / 4	Intake Air Heater #1 Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected at the intake air heater signal circuit.	The intake air heaters may be ON or OFF all the time.	Check cabling between control unit and component. Check component.

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		Description	Limitation	Action
Code	**J1587**			
974 / 3	P974 / 3	Remote Accelerator Pedal or Lever Position Sensor 1 Circuit - Voltage Above Normal, or shorted to High Source. High voltage detected at remote accelerator pedal position circuit.	Remote accelerator will not operate. Remote accelerator position will be set to zero percent.	Check cabling between control unit and component. Check component.
974 / 4	P974 / 4	Remote Accelerator Pedal or Lever Position Sensor 1 Circuit - Voltage Below Normal, or Shorted to Low Source. Low voltage detected at remote accelerator pedal position signal.	Remote accelerator will not operate. Remote accelerator position will be set to zero percent.	Check cabling between control unit and component. Check component.
974 / 19	P29	SAE J1939 Multiplexing Remote Accelerator Pedal or Lever Data Error - Received Network Data Error. The OEM machine electronic control unit (VECU) detected a fault with the remote accelerator.	The engine will not respond to the remote throttle. Engine may only idle. The primary or cab accelerator may be able to be used.	Use diagnostic menu to find incorrect segment.
1043 / 3	S221 / 3	Accelerator Pedal or Lever Position Sensor Supply Voltage Circuit - Voltage Above Normal or Shorted to High Source. High voltage detected at sensor supply circuit for the accelerator pedal or lever position sensor.	Engine will only idle.	Check cabling between control unit and component. Check component.
1043 / 4	S221 / 4	Accelerator Pedal or Lever Position Sensor Supply Voltage Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected at sensor supply circuit to the accelerator pedal or lever position sensor.	Engine will only die.	Check cabling between control unit and component. Check component.
1043 / 4	S221 / 4	Engine Speed/Position Sensor (Crankshaft) Supply Voltage Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected on the ECU 794 voltage supply line to engine speed sensor.	Possible hard starting and rough running.	Check cabling between control unit and component. Check component.
1072 / 3	S028 / 3	Engine Brake Actuator Circuit #1 - Voltage Above Normal or Shorted to High Source. Open circuit or high voltage detected at the engine brake solenoid number 1 signal circuit.	Engine brake on cylinders 1, 2, and 3 can not be activated or exhaust brake will not operate.	Check cabling between control unit and component. Check component.

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		Description	Limitation	Action
Code	**J1587**			
1072 / 4	S028 / 4	Engine Brake Actuator Circuit #1 - Voltage Below Normal or Shorted to Low Source. Low voltage detected at the engine brake solenoid number 1 signal circuit.	Engine brake on cylinders 1, 2, and 3 can not be activated or exhaust brake will not operate.	Check cabling between control unit and component. Check component.
1073 / 3	S029 / 3	Engine Brake Actuator Circuit #2 - Voltage Above Normal or Shorted to High Source. Open circuit or high voltage detected at the engine brake solenoid number 2 signal circuit.	Engine brake on cylinders 4, 5, and 6 can not be activated.	Check cabling between control unit and component. Check component.
1073 / 4	S029 / 4	Engine Brake Actuator Circuit #2 - Voltage Below Normal or Shorted to Low Source. Low voltage detected at the engine brake solenoid number 2 signal circuit.	Engine brake on cylinders 4, 5, and 6 can not be activated.	Check cabling between control unit and component. Check component.
1075 / 3	S126 / 3	Electric Lift Pump for Engine Fuel Supply Circuit - Voltage Above Normal, or Shorted to High Source. High voltage or open detected at the fuel lift pump signal circuit.	Engine can be difficult to start.	-
1075 / 4	S126 / 4	Electric Lift Pump for Engine Fuel Supply Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at the fuel lift pump circuit.	Engine can be difficult to start.	-
1079 / 3	S212 / 3	Sensor Supply Voltage number 1 Circuit - Voltage Above Normal or Shorted to High Source. High voltage detected at sensor supply number 1 circuit.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
1079 / 4	S212 / 4	Sensor Supply Voltage Number 1 Circuit - Voltage Below Normal or Shorted to Low Source. Low voltage detected at sensor supply number 1 circuit.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
1080 / 3	S232 / 3	Sensor Supply 2 Circuit - Voltage Above Normal or Shorted to High Source. High voltage detected at sensor supply number 2 circuit.	Engine power derate.	Check cabling between control unit and component. Check the sensor.
1080 / 4	S232 / 4	Sensor Supply Voltage Number 2 Circuit - Voltage Below Normal, or Shorted to Low Source. Low voltage detected at the sensor supply number 2 circuit.	Engine power derate.	Check cabling between control unit and component. Check the sensor.

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		Description	Limitation	Action
Code	**J1587**			
1137 / 2	S114 / 2	Multiple Unit Synchronization Switch - Data Erratic, Intermittent, or Incorrect. Multi-Unit synchronous ON/OFF switch and Multi-Unit synchronous complimentary ON/OFF switch have different values in the ECU 794.	Multi-Unit synchronization feature is disabled.	-
1172 / 3	/ 3	Turbocharger Number 1 Compressor Inlet Temperature Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage detected at the turbocharger compressor inlet air temperature circuit.	Engine power derate.	-
1172 / 4	/ 4	Turbocharger Number 1 Compressor Inlet Temperature Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the turbocharger compressor inlet air temperature sensor circuit.	Engine power derate.	-
1347 / 3	S126 / 3	High Fuel Pressure Solenoid Valve Circuit - Voltage Above Normal or Shorted to High Source. Electronic fuel control actuator shorted high.	Engine will run poorly but will be severely derated. Rail pressure will be higher than commanded.	-
1347 / 4	S126 / 4	High Fuel Pressure Solenoid Valve Circuit - Voltage Below Normal or Shorted to Low Source. Electronic fuel control actuator shorted low.	Engine will run poorly at idle. Engine will have low power. Fuel pressure will be higher than commanded.	-
1347 / 7	S126 / 7	Fuel Pump Pressurizing Assembly 1 - Mechanical System Not Responding Properly or Out of Adjustment. A pumping imbalance between the front and rear pumping plungers has been detected.	Engine will not run or possible low power	-
1347 / 7	S126 / 7	Fuel Pumping Element Number 1 (Front) - Mechanical System Not Responding Properly or Out of Adjustment.	Engine will not run or possible low power	-
1378 / 31	S153 / 11	Change Lubricating Oil and Filter - Condition Exists. Change engine oil and filter.	None on performance; maintenance reminder only.	-
1388 / 3	P223 / 3	Auxiliary Pressure Sensor Input 1 Circuit - Voltage Above Normal, or Shorted to High Source. High signal voltage detected at the OEM pressure circuit.	None on performance.	-

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		**Description**	**Limitation**	**Action**
Code	**J1587**			
1388 / 4	P223 / 4	Auxiliary Pressure Sensor Input 1 Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage or open circuit detected at the OEM pressure circuit.	None on performance.	-
2789 / 15	/ 0	Exhaust gas temperature - data above normal. High exhaust temperature has been calculated by the electronic control system.	Derate in power output of the engine in attempt to decrease the calculated exhaust gas temperature value.	-

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Error codes engine alternative Caterpillar C6.6

		Description	Limitation	Action
SPN/FMI	CID/EID			
91/2	91/2	ECU794 has detected an invalid combination of positions for the multi-position switches. If the engine is equipped with an analog throttle positon sensor then the signal from the throttle idle validation switch is invalid.	The engine speed defaults to low idle or a predetermined safe speed. The engine will remain at this speed while the diagnostic code remains active. The reduction of speed is determined by the current speed of the engine. When a fault is detected and the engine is above the predetermined safe speed, the engine will reduce speed to the safe speed. When a fault is detected and the engine is below the predetermined safe speed, the engine will match the correct speed. All throttle switch inputs are ignored byt ECU794 until the fault is repaired. All throttle switch inputs will also be ignored by ECU794 until the keyswitch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. If a second throttle is installed, the engine will use the second throttle until the fault is repaired.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
91/2	774/2	ECU794 detects a position for the throttle switch that has not been defined.	The engine speed defaults to low idle or a predetermined safe speed. The engine will remain at this speed while the diagnostic code remains active. The reduction of speed is determined by the current speed of the engine. When a fault is detected and the engine above the predetermined safe speed, the engine will reduce speed to the safe speed. When a fault is detected and the engine is below the predetermined safe speed, the engine will match the correct speed. Throttle inputs are ignored by ECU794 until the fault is repaired. Throttle inputs will also be ignored by ECU794 until the key-switch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. The engine will use the primary throttle only until the fault is repaired. Perform the following diagnostic procedure: “Throttle Switch Circuit - Test”.	*
91/3	91/3	ECU794 detects the following conditions: • ECU794 has been powered for at least 3 seconds. • A signal voltage for the throttle position is above the diagnostic upper limit that is set for the application. • The power supply for the throttle sensor is within the expected range.	Throttle inputs are ignored by ECU794 until the fault is repaired. Throttle inputs will also be ignored by ECU794 until the key-switch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. If a second throttle is installed, the engine will use the second throttle until the fault is repaired.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
91/3	774/3	ECU794 detects the following conditions: • ECU794 has been powered for 3 seconds. • Diagnostic code 168-1 is not active. • No 1079 diagnostic codes are active. • The setting for the upper diagnostic limit has been exceeded for 1 second.	Throttle inputs are ignored by ECU794 until the fault is repaired. Throttle inputs will also be ignored by ECU794 until the key-switch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. If a second throttle is installed, the engine will use the second throttle until the fault is repaired.	*
91/4	91/4	ECU794 detects all of the following conditions: • ECU794 has been powered for at least 3 seconds. • A signal voltage for the throttle position is below the diagnostic lower limit that is set for the application. • The power supply for the throttle sensor is within the expected range.	ECU794 will return the engine to low idle.	*
91/4	774/4	ECU794 detects one of the following conditions: • ECU794 has been powered for 3 seconds. • Diagnostic code 168-1 is not active. • No 1079 diagnostic codes are active. • The setting for the lower diagnostic limit has been exceeded for 1 second.	Throttle inputs are ignored by ECU794 until the fault is repaired. Throttle inputs will also be ignored by ECU794 until the key-switch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. If a second throttle is installed, the engine will use the second throttle until the fault is repaired.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
91/8	91/8	ECU794 detects the following conditions: • The signal frequency from the accelerator pedal position sensor is less than 150 Hz or the signal frequency is greater than 1050 Hz for more than two seconds. • ECU794 has been powered for at least three seconds. • Diagnostic code 91-3 is not active. • Diagnostic code 91-4 is not active. • Diagnostic codes for the 8 volt sensor supplies are not active.	The engine will remain at low idle while the diagnostic code is active. Throttle inputs are ignored by ECU794 until the fault is repaired. Throttle inputs will also be ignored by ECU794 until the key-switch has been turned to the OFF position and then back to the ON position. If a second throttle is installed, the engine will use the second throttle until the fault is repaired.	*
91/8	774/8	ECU794 detects one of the following conditions: • ECU794 has been powered for 3 seconds. • Diagnostic code 168-1 is not active. • No 1079 codes are active for the analog sensors. • No 678 codes are active for the digital (PWM) sensors. • Diagnostic codes 91-3 (774-3) and 91-4 (774-4) are not active. • The frequency of the signal from the digital (PWM) sensor is less than 150 Hz for more than one second. • The frequency of the signal from the digital (PWM) sensor is greater than 1050 Hz for more than one second.	ECU794 will return the engine to low idle or to a safe speed while the diagnostic code is active.	*
91/12	91/12	Throttle position sensor, Bad device or component.	ECU794 will return the engine to low idle speed.	*
91/12	774/12	Secondary throttle position sensor, Bad device or component.	ECU794 will return the engine to low idle speed.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
100/1	360/3	The following conditions occur: • The engine has been running for at least ten seconds. • There are no active diagnostic codes for the oil pressure sensor or for the atmospheric pressure sensor.	The engine will shut down.	*
100/3	100/3	ECU794 detects the following conditions: • The signal voltage from the engine oil pressure sensor is greater than 4.95 VDC for more than eight seconds. • ECU794 has been powered for at least two seconds. • The engine is not running or the engine coolant temperature is greater than 38 °C (100 °F).	-	*
100/4	100/4	ECU794 detects the following conditions: • The signal voltage from the engine oil pressure sensor is less than 0.1 VDC for more than eight seconds. • ECU794 has been powered for at least two seconds. • The engine is running .	-	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
100/10	0100/10	ECU794 detects the following conditions: • No other codes for the oil pressure sensor are active. • No 1079 diagnostic codes are active for the 5 volt supply. • The engine speed is greater than 600 rpm. • The engine oil pressure signal is within the limits of 410 kPa (59 psi) to 520 kPa (75 psi) with a pressure variation of less than 1.68 kPa (0.25 psi) for more than 30 seconds. • The engine oil pressure signal remains constant for 30 seconds.	-	*
100/17	360/1	The following conditions occur: • The engine has been running for at least ten seconds. • There are no active diagnostic codes for the oil pressure sensor or for the atmospheric pressure sensor. Note: The warning will be cancelled if the oil pressure rises 21 kPa (3psi) above the set point for 20 seconds.	Engine operation is not affected.	*
100/18	360/2	The following conditions occur: • The engine has been running for at least ten seconds. • There are no active diagnostic codes for the oil pressure sensor or for the atmospheric pressure sensor. Note: The derate will be cancelled if the oil pressure rises 21 kPa (3psi) above the set point for 20 seconds.	ECU794 will derate power by 17.0 percent per second up to a maximum of 100 percent while the derate is active.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
102/10	1785/10	The diagnostic code is designed to detect the loss of the 5 volt supply at the sensor connector. ECU794 detects the following conditions: • The engine speed is more than 1000 rpm. • The intake manifold pressure i within the acceptable range. • No 1079 codes for the 5 volt supply are active. • Diagnostic code 168-1 is not active.	The engine will be derated.	*
102/16	1044/XX	Intake manifold pressure sensor, High intake manifold pressure.	ECU794 will derate the engine 20%.	*
102/18	1045/XX	Intake manifold pressure sensor, Low intake manifold pressure	ECU794 will derate the engine 100%.	*
105/3	172/3	ECU794 detects the following conditions: • The signal voltage from the intake manifold air temperature sensor is greater than 4.95 VDC for more than eight seconds. • Engine coolant temperature is above -10 °C (15.0 °F). • ECU794 has been powered for at least two seconds. • Diagnostic code 168-1 is not active.	Poor stability Poor cold running White smoke Black smoke Poor acceleration under load	*
105/4	172/4	ECU794 detects the following conditions: • The signal voltage from the intake manifold air temperature sensor is less than 0.2 VDC for more than eight seconds. • ECU794 has been powered for at least two seconds. • Diagnostic code 168-1 is not active.	Poor stability Poor cold running White smoke Black smoke Poor acceleration under load	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
105/15	539/1	ECU794 detects a problem with the engine´s intake manifold air temperature. ECU794 detects the following conditions: • The engine has been running for more than 3 minutes. • The temperature of the coolant is more than 99 °C (210 °F) and the intake manifold pressure is more than 30 kPa (4.35 psi). • The intake manifold air temperature trip level for the event code is reached. • Diagnostic code 105-3 intake manifold air temperature voltage above normal is not active. • Diagnostic code 105-4 intake manifold air temperature voltage below normal is not active.	No limitation.	*
105/16	539/2	ECU794 detects a problem with the engine´s intake manifold air temperature. ECU794 detects the following conditions: • The engine has been running for more than 3 minutes. • The temperature of the coolant is more than 99 °C (210 °F) and the intake manifold pressure is more than 30 kPa (4.35 psi). • The intake manifold air temperature trip level for the event code is reached. • Diagnostic code 105-3 intake manifold air temperature voltage above normal is not active. • Diagnostic code 105-4 intake manifold air temperature voltage below normal is not active.	ECU794 will derate the power. The power will be derated at one percent per second. The derate of the engine will only occur if the “enable derate” customer programmable parameter has been enabled.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
106/3	1785/3	ECU794 detects the following conditions: • ECU794 has been powered for two seconds. • The signal voltage from the intake manifold pressure sensor is above 4.95 VDC for at least two seconds. • The diagnostic code can be caused by an open circuit or a short to another power source.	-	*
106/4	1785/4	ECU794 detects the following conditions: • The signal voltage from the intake manifold pressure sensor is less than 0.2 VDC for at least two seconds. • ECU794 has been powered for at least two seconds. • This code can be caused by a short to ground or at shorted sensor. • The keyswitch is in the “ON” position so that ECU794 is energized.	-	*
106/10	1785/10	The diagnostic code is designed to detect the loss of the 5 volt supply at the sensor connector. ECU794 detects the following conditions: • The engine speed is more than 1000 rpm. • The intake manifold pressure is within the acceptable range. • No 1079 codes for the 5 volt supply are active. • Diagnostic code 168-1 is not active.	The engine will be derated.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
110/0	361/3	ECU794 detects a problem with the engine's coolant temperature. ECU794 detects the following problem: • The engine has been running for more than 185 seconds. • The trip level for the event code for the temperature of the engine coolant is reached. • Diagnostic code 110-3 Engine Coolant Temperature open/short to +batt is not active. • Diagnostic code 110-4 Engine Coolant Temperature short to ground is not active.	ECU794 will shut down the engine after two seconds when the Engine Coolant Temperature Trip Level has been reached. The shutdown of the engine will only occur if the "Enable Shutdown" customer programmable parameter has been enabled.	*
110/3	110/3	ECU794 detects the following conditions: • The signal voltage from the engine coolant temperature sensor is greater than 4.95 VDC for more than eight seconds. • ECU794 has been powered for at least two seconds.	Poor stability Poor cold running White smoke	*
110/4	110/4	ECU794 detects the following conditions: • The signal voltage from the engine coolant temperature sensor is less than 0,2 VDC for more than eight seconds. • ECU794 has been powered for at least two seconds. • Diagnostic code 168-1 is not active.	Poor stability Poor cold running White smoke	*

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		Description	Limitation	Action
SPN/FMI	**CID/EID**			
110/15	361/1	ECU794 detects a problem with the engine's coolant temperature. ECU794 detects the following problem: • The engine has been running for more than 185 seconds. • The trip level for the event code for the temperature of the engine coolant is reached. • Diagnostic code 110-3 Engine Coolant Temperature open/short to +batt is not active. • Diagnostic code 110-4 Engine Coolant Temperature short to ground is not active.	Warning, no limitation.	*
110/16	361/2	ECU794 detects a problem with the engine's coolant temperature. ECU794 detects the following problem: • The engine has been running for more than 185 seconds. • The trip level for the event code for the temperature of the engine coolant is reached. • Diagnostic code 110-3 Engine Coolant Temperature open/short to +batt is not active. • Diagnostic code 110-4 Engine Coolant Temperature short to ground is not active.	ECU794 will derate the power will derate the power from 25 to 100% with increasing temp. The power will be derated at one percent per second. The derate of the engine will only occur if the "Enable Derate" customer programmable parameter has been enabled.	*
157/3	1797/3	ECU794 detects the following conditions: • The signal voltage for the pressure in the fuel rail is more than 4.8 VDC for 0.6 seconds.	The engine will be derated	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
157/4	1797/4	ECU794 detects the following conditions: • No 1079 codes for the 5 volt supply are active. • Diagnostic code 168-1 is not active. • The signal voltage for the pressure in the fuel rail is less than 0.2 V for 0.6 seconds.	The engine will be derated	*
157/16	396/1	ECU794 detects excessive fuel rail pressure. ECU794 detects the following probelms: • ECU794 detects fuel rail pressure that is more than the pressure that is required for the operating conditions. • Diagnostic code 1079-3 5 Volt Sensor DC Power Supply voltage above normal is not active. • Diagnostic code 1079-4 5 Volt Sensor DC Power Supply voltage below normal is not active. • Diagnostic code 157-3 Fuel Rail Pressure Sensor voltage above normal is not active. • Diagnostic code 157-4 Fuel Rail Pressure Sensor voltage below normal is not active. • No diagnostic codes are active for the fuel rail pump. • No diagnostic codes are active for the fuel injectors.	The engine will be derated 100% until the keyswitch is turned to OFF.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
157/18	398/1	ECU794 detects a problem with low fuel rail pressure. ECU794 detects the following problem: • ECU794 determines that the expected fuel rail pressure is lower than the pressure that is requested by the electronic control system. • Diagnostic code 1079-3 5 Volt Sensor DC Power Supply voltage above normal is not active. • Diagnostic code 1079-4 5 Volt Sensor DC Power Supply voltage below normal is not active. • Diagnostic code 157-3 Fuel Rail Pressure Sensor voltage above normal is not active. • Diagnostic code 157-4 Fuel Rail Pressure Sensor voltage below normal is not active. • No diagnostic codes are active for the fuel rail pump. • No diagnostic codes are active for the fuel injectors.	The engine will be derated 100% until the keyswitch is turned to OFF.	*
158/2	1834/2	ECU794 detects the following conditions: The signal from the keyswitch was erratic because the keyswitch was cycled at least three times within the last second.	Engine shutdown.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
168/00	168/0	This condition indicates the battery circuit to ECU794 has excessive voltage while the engine is running. ECU794 detects the following conditions: • For 24 VDC systems, the battery voltage to ECU794 exceeds 16 V for more than 0.5 seconds. • For 12 VDC systems, the battery voltage to ECU794 exceeds 16 V for more than 0.5 seconds. • The keyswitch is in the ON mode. • The engine is not cranking. • The engine is running for more than 30 seconds.	-	*
168/1	0168/1	This code indicates that the battery circuit for ECU794 has low voltage while the engine is running. If battery voltage disappears without returning, ECU794 will not log this diagnostic code and the engine will shut down. ECU794 detects the following conditions: • The keyswitch is in the ON mode. • The engine is not cranking. • The engine is running for more than three seconds. • For 24 VDC systems, the battery voltage to ECU794 is below 18 V for more than 0.5 seconds. • For 12 VDC systems, the battery voltage to ECU794 is below 9 V for more than 0.5 seconds.	The engine may experience changes in the engine rpm, and intermittent engine shutdowns or complete engine shutdowns while the conditions that cause this diagnostic code are present.	*

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		Description	Limitation	Action
SPN/FMI	**CID/EID**			
168/2	168/2	This condition indicates the battery circuit for ECU794 is intermittent while the engine is running. If the battery voltage disappears without returning, ECU794 will not log this diagnostic code and the engine will shut down. ECU794 detects the following conditions: • Three voltage readings that are below 6 VDC in a period of 7 seconds will be detected by ECU794. The voltage must subsequently increase to more than 9 VDC. • The keyswitch is in the ON mode. • The engine is running . • The engine is not cranking.	The engine may experience changes in the engine rpm, and intermittent engine shutdowns or complete engine shutdowns while the conditions that cause this diagnostic code are present.	*
190/8	190/8	ECU794 detects the following conditions: • ECU794 detected an intermittent loss of signal or a complete loss of signal from the primary speed/timing sensor for 2 seconds. • The engine has been running for more than three seconds.	The engine will be derated. If the signal from the secondary speed/timing sensor is also lost, the engine will shut down.	*
190/15	362/1	The engine speed is above 3000 rpm for more than 0.6 seconds. Note: This event code represents an event. This does not represent an electronic system fault.	-	*

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		Description	Limitation	Action
SPN/FMI	**CID/EID**			
558/2	91/2	ECU794 has detected an invalid combination of positions for the multi-position switches. If the engine is equipped with an analog throttle positon sensor then the signal from the throttle idle validation switch is invalid.	The engine speed defaults to low idle or a predetermined safe speed. The engine will remain at this speed while the diagnostic code remains active. The reduction of speed is determined by the current speed of the engine. When a fault is detected and the engine is above the predetermined safe speed, the engine will reduce speed to the safe speed. When a fault is detected and the engine is below the predetermined safe speed, the engine will match the correct speed. All throttle switch inputs are ignored byt ECU794 until the fault is repaired. All throttle switch inputs will also be ignored by ECU794 until the keyswitch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. If a second throttle is installed, the engine will use the second throttle until the fault is repaired.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
558/2	774/2	ECU794 detects a position for the throttle switch that has not been defined.	The engine speed defaults to low idle or a predetermined safe speed. The engine will remain at this speed while the diagnostic code remains active. The reduction of speed is determined by the current speed of the engine. When a fault is detected and the engine above the predetermined safe speed, the engine will reduce speed to the safe speed. When a fault is detected and the engine is below the predetermined safe speed, the engine will match the correct speed. Throttle inputs are ignored by ECU794 until the fault is repaired. Throttle inputs will also be ignored by ECU794 until the key-switch has been turned to the OFF position and then back to the ON position. The engine will default to the limp home mode. The engine will use the primary throttle only until the fault is repaired. Perform the following diagnostic procedure: “Throttle Switch Circuit - Test”.	*
630/2	268/2	ECU794 detects one or more of the following conditions: • One or more of the following configuration parameters are not programmed. The effect on ECU794 depends on the parameter. • FLS or FTS. • Injector trim codes. • Engine serial number. • All of the injector trim files are not loaded into ECU794. Engine performance and emissions are affected.	ECU794 may limit the engine to low idle and/or ECU794 may derate the power. Engine performance and emissions are affected.	*
631/2	253/2	ECU794 detects incorrect engine software.	The engine will not start.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
637/11	261/11	ECU794 detects the following conditions: • The primary speed/timing and the secondary speed/timing sensor are off by more than 8 crankshaft degrees. • The engine has been running for more than five seconds. • Diagnostic code 190-8 is not active. • No 0041 diagnostic codes are active.	The pressure in the fuel rail may be unstable and the engine may not run smoothly.	*
637/13	261/13	Primary to secondary speed signal, calibration required.	-	*
639/9	247/9	ECU794 detects the following conditions: • Another controller has stopped transmitting a J1939 speed request (TSC1) incorrectly or another controller has started transmitting a J1939 speed request incorrectly.	-	*
639/9	247/12	ECU794 detects the following conditions: • There is an unexpected loss of a continuous J1939 Torque Speed Controller (TSC1) signal on the J1939 data link. • The expected continuous TSC1 signal has never been received on the J1939 data link.	-	*
646/5	526/5	ECU794 detects the following conditions: • A low current condition in the output from ECU794 to the solenoid for the wastegate regulator. • No 168 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
646/6	526/6	ECU794 detects the following conditions: • A high current condition in the output from ECU794 to the solenoid for the wastegate regulator. • No 168 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*
651/2	1/2	ECU794 detects the following conditions: • Data from the electronic unit injector for the No. 1 cylinder is out of limits. • Diagnostic code 168-1 is not active. • Diagnostic codes 651-5 and 651-6 are not active. • No 678 diagnostic codes are active. • No 1079 diagnostic codes are active. • Diagnostic code 190-8 is not active. • No 110 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*
651/5	1/5	This diagnostic code is designed to indicate an open circuit (low current) in either the solenoid or the wiring for the electronic unit injector for No. 1 cylinder. ECU794 detects the following conditions: • A low current condition (open circuit) for each of five consecutive attempts to operate. • Battery voltage is higher than 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
651/6	1/6	This diagnostic code is designed to indicate a short circuit (high current) in either the solenoid or the wiring for the electronic unit injector for No. 1 cylinder. ECU794 detects the following conditions: • A high current condition (short circuit) for each of five consecutive attempts to operate. • Battery voltage above 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
651/7	1/7	The electronic unit injector is no longer capable of delivering the correct amount of fuel.	The engine will be derated.	*
652/2	2/2	ECU794 detects the following condition: • Data from the electronic unit injector for the No. 2 cylinder is out of limits. • Diagnostic code 168-1 is not active. • Diagnostic codes 651-5 and 651-6 are not active. • No 678 diagnostic codes are active. • No 1079 diagnostic codes are active. • Diagnostic code 190-8 is not active. • No 110 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*

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		Description	Limitation	Action
SPN/FMI	**CID/EID**			
652/5	2/5	This diagnostic code is designed to indicate an open circuit (low current) in either the solenoid or the wiring for the electronic unit injector for No. 2 cylinder. ECU794 detects the following condition: • A low current condition (open circuit) for each of five consecutive attempts to operate. • Battery voltage is higher than 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
652/6	2/6	This diagnostic code is designed to indicate a short circuit (high current) in either the solenoid or the wiring for the electronic unit injector for No. 2 cylinder. ECU794 detects the following conditions: • A high current condition (short circuit) for each of five consecutive attempts to operate. • Battery voltage above 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
652/7	2/7	The electronic unit injector is no longer capable of delivering the correct amount of fuel.	The engine will be derated.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
653/2	3/2	ECU794 detects the following condition: • Data from the electronic unit injector for the No. 3 cylinder is out of limits. • Diagnostic code 168-1 is not active. • Diagnostic codes 651-5 and 651-6 are not active. • No 678 diagnostic codes are active. • No 1079 diagnostic codes are active. • Diagnostic code 190-8 is not active. • No 110 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*
653/5	3/5	This diagnostic code is designed to indicate an open circuit (low current) in either the solenoid or the wiring for the electronic unit injector for No. 3 cylinder. ECU794 detects the following conditions: • A low current condition (open circuit) for each of five consecutive attempts to operate. • Battery voltage is higher than 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
653/6	3/6	This diagnostic code is designed to indicate a short circuit (high current) in either the solenoid or the wiring for the electronic unit injector for No. 3 cylinder. ECU794 detects the following conditions: • A high current condition (short circuit) for each of five consecutive attempts to operate. • Battery voltage above 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
653/7	3/7	The electronic unit injector is no longer capable of delivering the correct amount of fuel.	The engine will be derated.	*
654/2	4/2	ECU794 detects the following condition: • Data from the electronic unit injector for the No. 4 cylinder is out of limits. • Diagnostic code 168-1 is not active. • Diagnostic codes 651-5 and 651-6 are not active. • No 678 diagnostic codes are active. • No 1079 diagnostic codes are active. • Diagnostic code 190-8 is not active. • No 110 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*
654/5	4/5	This diagnostic code is designed to indicate an open circuit (low current) in either the solenoid or the wiring for the electronic unit injector for No. 4 cylinder. ECU794 detects the following conditions: • A low current condition (open circuit) for each of five consecutive attempts to operate. • Battery voltage is higher than 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
654/6	4/6	This diagnostic code is designed to indicate a short circuit (high current) in either the solenoid or the wiring for the electronic unit injector for No. 4 cylinder. ECU794 detects the following conditions: • A high current condition (short circuit) for each of five consecutive attempts to operate. • Battery voltage above 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
654/7	4/7	The electronic unit injector is no longer capable of delivering the correct amount of fuel.	The engine will be derated.	*
655/2	5/2	This diagnostic code is applicable to six cylinder engines only. ECU794 detects the following condition: • Data from the electronic unit injector for the No. 5 cylinder is out of limits. • Diagnostic code 168-1 is not active. • Diagnostic codes 651-5 and 651-6 are not active. • No 678 diagnostic codes are active. • No 1079 diagnostic codes are active. • Diagnostic code 190-8 is not active. • No 110 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
655/5	5/5	This diagnostic code is applicable to six cylinder engines only. This diagnostic code is designed to indicate an open circuit (low current) in either the solenoid or the wiring for the electronic unit injector for No. 5 cylinder. ECU794 detects the following conditions: • A low current condition (open circuit) for each of five consecutive attempts to operate. • Battery voltage is higher than 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
655/6	5/6	This diagnostic code is applicable to six cylinder engines only This diagnostic code is designed to indicate a short circuit (high current) in either the solenoid or the wiring for the electronic unit injector for No. 5 cylinder. ECU794 detects the following conditions: • A high current condition (short circuit) for each of five consecutive attempts to operate. • Battery voltage above 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
655/7	5/7	This diagnostic code is applicable to six cylinder engines only. The electronic unit injector is no longer capable of delivering the correct amount of fuel.	The engine will be derated.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
656/2	6/2	This diagnostic code is applicable to six cylinder engines only. ECU794 detects the following condition: • Data from the electronic unit injector for the No. 6 cylinder is out of limits. • Diagnostic code 168-1 is not active. • Diagnostic codes 651-5 and 651-6 are not active. • No 678 diagnostic codes are active. • No 1079 diagnostic codes are active. • Diagnostic code 190-8 is not active. • No 110 diagnostic codes are active.	The engine will be derated while this diagnostic code is active.	*
656/5	6/5	This diagnostic code is applicable to six cylinder engines only. This diagnostic code is designed to indicate an open circuit (low current) in either the solenoid or the wiring for the electronic unit injector for No. 6 cylinder. ECU794 detects the following conditions: • A low current condition (open circuit) for each of five consecutive attempts to operate. • Battery voltage is higher than 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
656/6	6/6	This diagnostic code is applicable to six cylinder engines only This diagnostic code is designed to indicate a short circuit (high current) in either the solenoid or the wiring for the electronic unit injector for No. 6 cylinder. ECU794 detects the following conditions: • A high current condition (short circuit) for each of five consecutive attempts to operate. • Battery voltage above 9 volts for 2 seconds.	The engine will have low power and/or rough running.	*
656/7	6/7	This diagnostic code is applicable to six cylinder engines only. The electronic unit injector is no longer capable of delivering the correct amount of fuel.	The engine will be derated.	*
676/5	2246/5	Glow plug start aid relay, current low.	The engine may be difficult to start in cold temperatures and the exhaust may emit white smoke.	*
676/6	2246/6	ECU794 has detected a high current condition (short circuit) after attempting to activate the glow plug starting aid ECU794 detects the following conditions: • The engine is not cranking. • ECU794 has been powered for at least one second. • There is a high current condition (short circuit) for more than two seconds.	The engine may be difficult to start in cold temperatures and the exhaust may emit white smoke.	*
678/3	41/3	ECU794 detects the following conditions: • The 8 volt supply is more than 8.8 VDC for more than one second. • ECU794 has been powered for more than three seconds.	The engine may be limited to low idle. Note: The 8 volt supply may provide power to the digital throttle position sensor. Note: The 8 volt supply provides power to the two speed/timing sensors.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
678/4	41/4	ECU794 detects the following conditions: • The 8 volt supply is less than 7.2 VDC for more than one second. • ECU794 has been powered for more than three seconds. • Diagnostic code 168-1 is not active.	The engine may be limited to low idle. Note: The 8 volt supply may provide power to the digital throttle position sensor. Note: The 8 volt supply provides power to the two speed/timing sensors.	*
723/8	342/8	ECU794 detects the following conditions: • The signal from the secondary speed/timing sensor is lost and/or intermittent. • The signal from the secondary speed/timing sensor was lost for at least 2 seconds while the signal from the primary speed/timing sensor remained valid and the engine was running. • Diagnostic code 168-1 is not active. • The engine has been running for more than 3 seconds. • No 678 diagnostic codes are active.	The performance will not be affected unless both speed signals are lost. The loss of the signals from both speed/timing will cause ECU794 to shut down the engine. The engine will not restart if the signal from the secondary speed/timing sensor is lost.	*
1079/3	262/3	ECU794 detects the following conditions: • The 5 volt supply is greater than 5.16 VDC for more than one second. • ECU794 has been powered for at least three seconds. • Diagnostic code 168-1 is not active.	The engine will be derated.	*

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		Description	Limitation	Action
SPN/FMI	CID/EID			
1079/4	262/4	ECU794 detects the following conditions: • The 5 volt supply is less than 4.84 VDC for more than one second. • ECU794 has been powered for at least three seconds. • Diagnostic code 168-1 is not active.	The engine will be derated.	*
1188/7	526/7	This diagnostic code indicates that the intake manifold pressure is not being controlled correctly. ECU794 detects the following conditions: • ECU794 has been powered for more than 4 seconds. • Diagnostic code 168 is not active. • No 102 diagnostic codes are active. • Diagnostic codes 646-5 and 646-6 are not active.	The engine may not reach top rpm. The engine produces excessive black smoke. The engine has low power.	*
1347/5	1779/5	This diagnostic code indicates that ECU794 has detected an open circuit or low current condition in the solenoid for the fuel rail.	An electrical fault may prevent the provision of pressure to the fuel rail. This may result in the loss of fuel injection. If the solenoid for the fuel rail pump fails, it is likely that fuel will not be pumped into the fuel rail. The engine will stop or the engine will not start.	*
1347/6	1779/6	This diagnostic code indicates that ECU794 has detected a short circuit or high current condition in the solenoid for the fuel rail.	An electrical fault may prevent the provision of pressure to the fuel rail. This may result in the loss of fuel injection. If the solenoid for the fuel rail pump fails, it is likely that fuel will not be pumped into the fuel rail. The engine will stop or the engine will not start.	*
1347/7	1779/7	Fuel rail pump, Not responding.	An electrical fault may prevent the provision of pressure to the fuel rail. This may result in the loss of fuel injection. If the solenoid for the fuel rail pump fails, it is likely that fuel will not be pumped into the fuel rail. The engine will stop or the engine will not start.	*

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		**Description**	**Limitation**	**Action**
SPN/FMI	**CID/EID**			
2789/15	194/1	ECU794 monitors the following parameters in order to estimate the exhaust temperature: • Intake manifold air temperature • Barometric pressure • Engine speed High intake manifold air temperature, high altitude operation and high engine loads can cause the exhaust temperature to increase to a level that may damage the components of the exhaust system. When this occurs, ECU794 derates the engine in order to reduce the exhaust temperature. This protects the components of the exhaust system from damage.	Engine power is reduced	*

*) See component supplier documentation.

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2 Transmission

Error codes transmission alternative Dana TE13000 and TE17000

In case of serious transmission malfunctions the control unit uses two modes with reduced functionality to protect the transmission against damage, Limp-home mode and Shut-down mode.

For more detailed description see section *2 Transmission*, group *2.8 Control system transmission*.

 Code	Description	Limitation	Action
00/50	Memory error in control unit transmission.	Transmission locked in neutral (shutdown).	-
00/51	Memory error in control unit transmission.	Transmission locked in neutral (shutdown).	-
00/52	Memory error in control unit transmission.	Transmission locked in neutral (shutdown).	-
00/53	Memory error in control unit transmission.	Transmission locked in neutral (shutdown).	-
20/60	Sensor oil pressure (B253) indicates low oil pressure when there should be pressure.	Transmission locked in neutral (shutdown).	Check cabling between control unit and component. Check the solenoid valve.
20/61	The oil pressure sensor (B253) indicates oil pressure when there should not be pressure.	Transmission locked in neutral (shutdown).	Check cabling between control unit and component. Check the solenoid valve.
21/02	Solenoid valves VFS short-circuiting to voltage, ground, or open circuit.	Transmission locked in neutral (shutdown).	Check cabling between the control unit and the component with diagnostic menu. Check the solenoid valve.
30/04	Low battery voltage.	Control unit saves stored information to flash memory and restarts to clear memory.	Check cabling to control unit. Check alternator, battery and cabling between battery and alternator.
30/05	High battery voltage.	Control unit receives reduced proportional control precision depending on reduced PWM work cycle.	Check voltage feed. If auxiliary start equipment is connected, disconnect it.
31/00	Reference voltage sensor 8 V, too low.	Control unit receives reduced sensor signals.	Check voltage feed. Check the control unit.

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Code	Description	Limitation	Action
31/01	Reference voltage sensor 8 V, too high.	Control unit receives reduced sensor signals.	Check voltage feed. Check the control unit.
40/06	Incorrect direction from gear selector.	Control unit locks transmission in neutral.	Check cabling to gear selector with regards to forward and reverse signal.
41/06	Incorrect gear selection from gear selector.	Control unit doesn't allow change of range, however, operation of machine is possible.	Check cabling to gear selector with regards to signal range.
42/04	Actual gear ratio too low.	Control unit indicates that one or several clutches are slipping.	Check transmission with purpose to understand if and, if that is the case, which clutch is slipping. Check the set gear ratio for the control unit.
42/05	Actual gear ratio too high.	Control unit indicates that one or several clutches are slipping.	Check transmission with purpose to understand if and, if that is the case, which clutch is slipping. Check the set gear ratio for the control unit.
43/03	Signal from Sensor engine rpm and oil temperature transmission (B758/766) outside valid interval.	Control unit indicates the error.	Check cabling between control unit and component. Check the sensor.
43/07	Torque converter temperature exceeds 100 °C.	Control unit indicates the error to make operator aware of the warning's level.	Check transmission oil cooler, clean as needed. Check the thermostat in the transmission oil cooler.
43/08	Torque converter temperature exceeds 125 °C.	The control unit protects the transmission and does not allow the temperature in the torque converter to exceed the limit value. The control unit locks the transmission in neutral position, the engine is restricted to 50% of max. rpm.	Check transmission oil cooler, clean as needed. Check the thermostat in the transmission oil cooler.
44/10	Faulty signal for accelerator pedal position from engine control unit (D794)	-	Use diagnostic menu to find incorrect segment.
46/05	Max. torque for inching has been exceeded.	-	-

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 Code	Description	Limitation	Action
50/00	Sensor oil pressure (B253), short-circuited to ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the sensor.
50/01	Sensor oil pressure (B253), not connected or open circuit.	Transmission in limp-home.	Check cabling between control unit and component. Check the sensor.
51/00	Sensor engine rpm and oil temperature transmission (B758/766) short-circuited to ground.	The control unit limits the transmission's temperature measurement to the lowest value in its settings, which results in poor temperature compensation.	Check cabling between control unit and component. Check the sensor.
51/01	Sensor engine rpm and oil temperature transmission (B758/766) not connected or open circuit.	The control unit limits the transmission's temperature measurement to the highest value in its settings, which results in poor temperature compensation.	Check cabling between control unit and component. Check the sensor.
52/00	Sensor oil temperature (S221) short-circuited to ground.	The control unit limits the transmission's temperature measurement to the highest value in its settings, which results in poor temperature compensation.	Check cabling between control unit and component. Check the sensor.
52/01	Sensor oil temperature (S221) open circuit.	The control unit limits the transmission's temperature measurement to the highest value in its settings, which results in poor temperature compensation.	Check cabling between control unit and component. Check the sensor.
54/00	Reference voltage sensor 5 V short-circuiting to frame ground.	-	Check cabling between control unit and component. Check the sensor.
54/01	Reference voltage sensor 5 V open circuit.	-	Check cabling between control unit and component. Check the sensor.

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 Code	Description	Limitation	Action
60/00	Sensor rpm drum (B752) short-circuited to ground.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
60/01	Sensor rpm drum (B752) not connected.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
61/00	Sensor rpm output shaft (B758) short-circuited to ground.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
61/01	Sensor rpm output shaft (B758) not connected.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.

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 Code	Description	Limitation	Action
62/00	Sensor engine rpm (B758/766), short-circuited to ground.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
62/01	Sensor engine rpm (B758/766), not connected or has open circuit.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
63/00	Sensor rpm turbine (B751) short-circuited to ground.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
63/01	Sensor rpm turbine (B751) not connected.	When only one rpm signal that is not the engine rpm signal is incorrect, the control unit calculates the missing rpm. If several rpm signals or if the engine rpm signal are defective, the control unit activates Limp-home.	Check cable between control unit and component. Check component.
70/00	Solenoid valve VFS front (Y630), short-circuited to each other, signal cable short-circuited to voltage, or plus-cable short-circuited to frame ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.

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 Code	Description	Limitation	Action
70/01	Solenoid valve VFS forward (Y630) open circuit or short-circuited voltage.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
70/02	Solenoid valve VFS forward (Y630), control current higher than 1400 mA.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
70/03	Solenoid valve VFS forward (Y630), control current outside approved interval. Incorrect impedance.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
71/00	Solenoid valve VFS 2/4 (Y6069), short-circuited to each other, signal cable short-circuited to voltage, or plus-cable short-circuited to frame ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
71/01	Solenoid valve VFS 2/4 (Y6069) open circuit or short-circuited voltage.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
71/02	Solenoid valve VFS 2/4 (Y6069), control current higher than 1400 mA.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
71/03	Solenoid valve VFS 2/4 (Y6069), control current outside approved interval (incorrect impedance).	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
72/00	Solenoid valve VFS reverse (Y631), cables short-circuited to each other, signal cable short-circuited to voltage, or plus-cable short-circuited to frame ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
72/01	Solenoid valve VFS reverse (Y631) open circuit or short-circuited voltage.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
72/02	Solenoid valve VFS reverse (Y631), control current higher than 1400 mA.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.

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 Code	Description	Limitation	Action
72/03	Solenoid valve VFS reverse (Y631), control current outside approved interval (incorrect impedance).	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
73/00	Solenoid valve VFS 1/3 (Y6067), cables short-circuited to each other, signal cable short-circuited to voltage, or plus-cable short-circuited to frame ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
73/01	Solenoid valve VFS 1/3 (Y6067) open circuit or short-circuited voltage.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
73/02	Solenoid valve VFS 1/3 (Y6067), control current higher than 1400 mA.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
73/03	Solenoid valve VFS 1/3 (Y6067), control current outside approved interval (incorrect impedance).	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
77/02	All gear packs disengaged.	Transmission locked in neutral (shutdown).	-
80/00	Solenoid valve RSP Drive (Y6066), cable short-circuited to frame ground.	Transmission locked in neutral (shutdown).	Check cabling between control unit and component. Check the solenoid valve.
80/01	Solenoid valve RSP Drive (Y6066), cable is not connected or short-circuited to voltage.	Transmission locked in neutral (shutdown).	Check cabling between control unit and component. Check the solenoid valve.
81/00	Solenoid valve VFS 2/4 (Y6074), cable short-circuited to frame ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
81/01	Solenoid valve VSF 2/4 (Y6074), cable is not connected or short-circuited to voltage.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
82/00	Solenoid valve VFS 1/3 (Y6075), cable short-circuited to frame ground.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.

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 Code	Description	Limitation	Action
82/01	Solenoid valve VSF 1/3 (Y6075), cable is not connected or short-circuited to voltage.	Transmission in limp-home.	Check cabling between control unit and component. Check the solenoid valve.
83/00	Solenoid valve RSP Drive (Y6066), cable short-circuited to frame ground.	Transmission locked in neutral (shutdown).	Check cabling to solenoid valve drive Check solenoid valve drive.
83/01	Solenoid valve RSP Drive (Y6066), cable is not connected or short-circuited to voltage.	Transmission locked in neutral (shutdown).	Check cabling to solenoid valve drive Check solenoid valve drive.
90/xx - 99/xx	System error.	Transmission locked in neutral (shutdown).	-
95/71	Control unit cannot interpret input data.	-	-
99/90	Incorrect software in control unit transmission.	-	-

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Error codes transmission alternative ZF 3WG161

For serious transmission errors, the control unit uses four modes with reduced functionality to protect the transmission from damage. These are:

- “Substitute clutch control”.

  In this state the driver can use the machine as normal. However, gear shifting and change of travel direction does not take place under the control of normal modulation. The control unit uses standard values for modulating clutches.

- “Limp home”.

  In this state the driver can use one of the transmission gears in each direction, and in some cases only in one direction. To continue driving with a fault and the limitation “Limp home” active, the machine must be stopped, coming to a standstill, the gear selector moved to neutral before a gear can be selected again.

- “Transmission shut down”.

  In this state the transmission is permanently in neutral as the solenoid valves for the clutches and parts of the power supply to the transmission are shutoff. Park the machine and switch off the engine.

- “TCU shut down”.

  In this state the transmission is permanently in neutral as all the solenoid valves and all power supplies to the transmission are shutoff. Park the machine and switch off the engine.

		**Description**	**Limitation**	**Action**
SPN/FMI	**ZF code (hex)**			
5000/12	11	Logical error at gear range signal. ECU793 detected a wrong signal combination for the gear range. Possible reasons: • Cable from shift lever to ECU793 is broken. • Cable is defective and is contacted to battery voltage or vehicle ground. • Shift lever is defective.	Transmission locked in neutral (“transmission shut down”).	Check the cables from ECU793 to shift lever. Check signal combinations of shift lever positions for gear range.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5010/12	12	Logical error at direction select signal. ECU793 detected a wrong signal combination for the direction. Possible reasons: • Cable from shift lever to ECU793 is broken. • Cable is defective and is contacted to battery voltage or vehicle ground. • Shift lever is defective.	Transmission locked in neutral (“transmission shut down”).	Check the cables from ECU793 to shift lever. Check signal combinations of shift lever positions F-N-R.
5020/12	13	Logical error at engine derating device. TCU detected no reaction of engine while derating device activ.	After selecting neutral, ECU793 changes to “limp home”.	Restart ECU 793 by switching the ignition on and off. Check engine derating device.
5040/12	15	Logical error at direction select signal 2. shift lever. ECU793 detected a wrong signal combination for the direction Possible reasons: • Cable from shift lever 2 to ECU793 is broken • Cable is defective and is contacted to battery voltage or vehicle ground. • Shift lever is defective.	Transmission locked in neutral (“transmission shut down”) when extra direction selector is used.	Check the cables from ECU793 to shift lever 2. Check signal combinations of shift lever positions F-N-R.
5050/12	16	LOGICAL ERROR AT AXLE CONNECTION Feedback axle connection measured by ECU793 and output signal axle connection don't fit. Possible reasons: • Axle can’t be connected or disconnected due to mechanical problem • one of the cables from feedback axle connection switch to ECU793 is broken.	-	Check the cable from ECU793 to feedback axle connection switch. Check signals of the feedback connection switch.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5110/3	25	S.C. to battery voltage or O.C. at transmission sump temperature sensor input. The measured voltage is too high. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Temperature sensor has an internal defect. • Connector pin is contacted to battery voltage or is broken.	ECU793 uses default temperature.	Check the cable from ECU793 to the sensor. Check the connectors. Check the temperature sensor.
5110/4	26	S.C. to ground at transmission sump temperature sensor input. The measured voltage is too low. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Temperature sensor has an internal defect. • Connector pin is contacted to vehicle ground.	ECU793 uses default temperature.	Check the cable from ECU793 to the sensor. Check the connectors. Check the temperature sensor.
5120/3	27	S.C. to battery voltage or O.C. at retarder/torque converter temperature sensor input. The measured voltage is too high. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Temperature sensor has an internal defect. • Connector pin is contacted to battery voltage or is broken.	ECU793 uses default temperature.	Check the cable from ECU793 to the sensor. Check the connectors. Check the temperature sensor.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5120/4	28	S.C. to ground at retarder/torque converter temperature sensor input The measured voltage is too low. Possible reasons: • cable is defective and is contacted to vehicle ground. • temperature sensor has an internal defect. • connector pin is contacted to vehicle ground.	ECU793 uses default temperature.	Check the cable from ECU793 to the sensor. Check the connectors. Check the temperature sensor.
5130/3	29	S.C. to battery voltage or O.C. at parking brake sensor input. The measured voltage is too high. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Sensor has an internal defect. • Connector pin is contacted to battery voltage or is broken.	ECU793 uses default value.	Check the cable from ECU793 to the sensor. Check the connectors. Check the parking brake sensor.
5130/4	2A	S.C. to ground parking brake sensor input. The measured voltage is too low. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Sensor has an internal defect. • Connector pin is contacted to vehicle ground.	ECU793 uses default value.	Check the cable from ECU793 to the sensor. Check the connectors. Check the parking brake sensor.

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5135/3	2C	Short circuit to battery voltage or open circuit in DLM TRACTION ADJUST DASHBOARD DEVICE INPUT. The measured voltage is too high. Possible reasons: 1. Cable is defective and is contacted to battery voltage. 2. Cable has no connection to ECU793. 3. Sensor has an internal defect. 4. Connector pin is contacted to battery voltage or is broken.	ECU793 uses default value.	Check the cable from ECU793 to the sensor. Check the connectors. Check the DLM Traction Adjust dashboard device.
5135/4	2D	S.C. to ground DLM traction adjust dashboard device input. The measured voltage is too low. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Sensor has an internal defect • Connector pin is contacted to vehicle ground.	ECU793 uses default value.	Check the cable from ECU793 to the sensor. Check the connectors. Check the DLM Traction Adjust dashboard device.
5137/3	2E	S.C. to battery voltage or O.C. at DLM steering angle sensor input. The measured voltage is too high. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Sensor has an internal defect. • Connector pin is contacted to battery voltage or is broken.	ECU793 uses default value.	Check the cable from ECU793 to the sensor. Check the connectors. Check the DLM steering angle sensor.

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5137/4	2F	S.C. to ground DLM steering angle sensor input. The measured voltage is too low. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Sensor has an internal defect. • Connector pin is contacted to vehicle ground.	ECU793 uses default value.	Check the cable from ECU793 to the sensor. Check the connectors. Check the DLM steering angle sensor.
5313/12	2B	Inchsensor-signal mismatch. The measured voltage from CCO and CCO2 signal don't match. Possible reasons: • Cable is defective. • Sensor has an internal defect.	During inching mode: ECU793 shifts to neutral. While not inching: no change	Check the cable from ECU793 to the sensor. Check the connectors. Check the sensor.
5140/3	31	S.C. to battery voltage or O.C. at engine speed input. ECU793 measures a voltage higher than 7.00 V at speed input pin. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Speed sensor has an internal defect. • Connector pin is contacted to battery voltage or has no contact.	Transmission limited according to "Substitute clutch control".	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5140/4	32	S.C. to ground at engine speed input. ECU793 measures a voltage less than 0.45V at speed input pin. Possible reasons: • Cable / connector is defective and is contacted to vehicle ground. • Speed sensor has an internal defect.	Transmission limited according to “Substitute clutch control”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.
5140/12	33	Logical error at engine speed input. ECU793 measures a engine speed over a threshold and the next moment the measured speed is zero. Possible reasons: • Cable / connector is defective and has bad contact. • Speed sensor has an internal defect. • Sensor gap has the wrong size.	Transmission limited according to “Substitute clutch control”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor. Check the sensor gap. Restart ECU 793 by switching the ignition on and off.
5150/3	34	S.C. to battery voltage or O.C. at turbine speed input. ECU793 measures a voltage higher than 7.00 V at speed input pin. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Speed sensor has an internal defect. • Connector pin is contacted to battery voltage or has no contact.	Transmission limited according to “Substitute clutch control”, on output tachometer sensor error, the transmission control unit activates “limp home”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5150/4	35	S.C. to ground at turbine speed input. ECU793 measures a voltage less than 0.45V at speed input pin. Possible reasons: • Cable / connector is defective and is contacted to vehicle ground. • Speed sensor has an internal defect.	Transmission limited according to “Substitute clutch control”, on output tachometer sensor error, the transmission control unit activates “limp home”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.
5150/12	36	Logical error att turbine speed input. ECU793 measures a turbine speed over a threshold and at the next moment the measured speed is zero. Possible reasons: • Cable / connector is defective and has bad contact • Speed sensor has an internal defect. • Sensor gap has the wrong size.	Transmission limited according to “Substitute clutch control”, on output tachometer sensor error, the transmission control unit activates “limp home”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor. Check the sensor gap. Restart ECU 793 by switching the ignition on and off.
5160/3	37	S.C. to battery voltage or O.C. at internal speed input. ECU793 measures a voltage higher than 7.00 V at speed input pin. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Speed sensor has an internal defect. • Connector pin is contacted to battery voltage or has no contact.	Transmission limited according to “Substitute clutch control”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5160/4	38	S.C. to ground at internal speed input. ECU793 measures a voltage less than 0.45V at speed input pin. Possible reasons: • Cable / connector is defective and is contacted to vehicle ground. • Speed sensor has an internal defect.	Transmission limited according to “Substitute clutch control”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.
5160/12	39	Logical error at internal speed input. ECU793 measures a internal speed over a threshold and at the next moment the measured speed is zero. Possible reasons: 1. Cable / connector is defective and has bad contact. 2. Speed sensor has an internal defect. 3. Sensor gap has the wrong size.	Transmission limited according to “Substitute clutch control”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor. Check the sensor gap. Restart ECU 793 by switching the ignition on and off.
5170/3	3A	S.C. to battery voltage or O.C. at output speed input. ECU793 measures a voltage higher than 12.5 V at speed input pin. Possible reasons: • Cable is defective and is contacted to battery voltage. • Cable has no connection to ECU793. • Speed sensor has an internal defect. • Connector pin is contacted to battery voltage or has no contact.	Transmission limited according to “Substitute clutch control”, on turbine speed sensor error, the transmission control unit activates “limp home”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5170/4	3B	S.C. to ground at output speed input. ECU793 measures a voltage less than 1.00V at speed input pin. Possible reasons: • Cable / connector is defective and is contacted to vehicle ground. • Speed sensor has an internal defect.	Transmission limited according to “Substitute clutch control”, on turbine speed sensor error, the transmission control unit activates “limp home”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor.
5170/12	3C	Logical error at output speed input. ECU793 measures a output speed over a threshold and at the next moment the measured speed is zero. Possible reasons: • Cable / connector is defective and has bad contact. • Speed sensor has an internal defect. • Sensor gap has the wrong size.	Transmission limited according to “Substitute clutch control”, on turbine speed sensor error, the transmission control unit activates “limp home”.	Check the cable from ECU793 to the sensor. Check the connectors. Check the speed sensor. Check the sensor gap. Restart ECU 793 by switching the ignition on and off.
5180/2	3E	Output speed zero doesn’t fit to other speed signals. If transmission is not neutral and the shifting has finished, ECU793 measures outputspeed zero and turbine speed or internal speed not equal to zero. Possible reasons: • Speed sensor has an internal defect. • Sensor gap has the wrong size.	Transmission limited according to “Substitute clutch control”, on turbine speed sensor error, the transmission control unit activates “limp home”..	Check the sensor signal of output speed sensor. Check the sensor gap of output speed sensor. Check the cable from ECU793 to the sensor. Restart ECU 793 by switching the ignition on and off.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5260/9	54	DCT1 timeout Timeout of CAN-message DCT1 from display computer. Possible reasons: • Interference on CAN-Bus. • CAN wire/connector is broken. • CAN wire/connector is defective and has contact to vehicle ground or battery voltage.		Check display computer. Check wire of CAN-Bus. Check cable to display computer.
5270/9	E5	DISPID1_timeout Timeout of CAN-message DISPID1 from display controller. Possible reasons: 1. Interference on CAN-Bus. 2. CAN wire/connector is broken. 3. CAN wire/connector is defective and has contact to vehicle ground or battery voltage.	ECU793 select parameter set with ID0. Control unit transmission activates “limp home”.	Check display controller. Check wire of CAN-Bus. Check cable to display controller.
5390/2	61	AEB Request signal. CAN signal for AEB request is defective. Possible reasons: • I/O controller is defective. • Interference on CAN-Bus.	Last selection is kept.	Check I/O controller. Check wire of CAN-Bus. Check cable to I/O controller.
5480/3	71	S.C. to battery voltage at clutch K1. The measured resistance value of the valve is out of limit, the voltage at K1 valve is too high. Possible reasons: • Cable / connector is defective and has contact to battery voltage. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5480/4	72	S.C. to ground at clutch K1. The measured resistance value of the valve is out of limit, the voltage at K1 valve is too low. Possible reasons: • Cable / connector is defective and has contact to vehicle ground. • Cable / connector is defective and has contact to another regulator output of the ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5480/5	73	O.C. at clutch K1 The measured resistance value of the valve is out of limit. Possible reasons: • Cable / connector is defective and has no contact to ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5490/3	74	S.C. to battery voltage at clutch K2. The measured resistance value of the valve is out of limit, the voltage at K2 valve is too high. Possible reasons: • Cable / connector is defective and has contact to battery voltage. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5490/4	75	S.C. to ground at clutch K2. The measured resistance value of the valve is out of limit, the voltage at K2 valve is too low. Possible reasons: • Cable / connector is defective and has contact to vehicle ground. • Cable / connector is defective and has contact to another regulator output of the ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5490/5	76	O.C. at clutch K2 The measured resistance value of the valve is out of limit. Possible reasons: • Cable / connector is defective and has no contact to ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5500/3	77	S.C. to battery voltage at clutch K3. The measured resistance value of the valve is out of limit, the voltage at K3 valve is too high. Possible reasons: • Cable / connector is defective and has contact to battery voltage. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5500/4	78	S.C. to ground at clutch K3. The measured resistance value of the valve is out of limit, the voltage at K3 valve is too low. Possible reasons: • Cable / connector is defective and has contact to vehicle ground. • Cable / connector is defective and has contact to another regulator output of the ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5500/5	79	O.C. at clutch K3 The measured resistance value of the valve is out of limit. Possible reasons: • Cable / connector is defective and has no contact to ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5510/3	81	S.C. to battery voltage at clutch K4. The measured resistance value of the valve is out of limit, the voltage at K4 valve is too high. Possible reasons: • Cable / connector is defective and has contact to battery voltage. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5510/4	82	S.C. to ground at clutch K4. The measured resistance value of the valve is out of limit, the voltage at K4 valve is too low. Possible reasons: • Cable / connector is defective and has contact to vehicle ground. • Cable / connector is defective and has contact to another regulator output of the ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5510/5	83	O.C. at clutch K4. The measured resistance value of the valve is out of limit. Possible reasons: • Cable / connector is defective and has no contact to ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5520/3	84	S.C. to battery voltage at clutch KV, forward clutch. The measured resistance value of the valve is out of limit, the voltage at KV valve is too high. Possible reasons: • Cable / connector is defective and has contact to battery voltage. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5520/4	85	S.C. to ground at clutch KV, forward clutch. The measured resistance value of the valve is out of limit, the voltage at KV valve is too low. Possible reasons: • Cable / connector is defective and has contact to vehicle ground. • Cable / connector is defective and has contact to another regulator output of the ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5520/5	86	O.C. at clutch KV, forward clutch. The measured resistance value of the valve is out of limit. Possible reasons: • Cable / connector is defective and has no contact to ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5530/3	87	S.C. to battery voltage at clutch KR, reverse clutch. The measured resistance value of the valve is out of limit, the voltage at KR valve is too high. Possible reasons: • Cable / connector is defective and has contact to battery voltage. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5530/4	88	S.C. to ground at clutch KR, reverse clutch. The measured resistance value of the valve is out of limit, the voltage at KR valve is too low. Possible reasons: • Cable / connector is defective and has contact to vehicle ground. • Cable / connector is defective and has contact to another regulator output of the ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5530/5	89	O.C. at clutch KR, reverse clutch The measured resistance value of the valve is out of limit. Possible reasons: • Cable / connector is defective and has no contact to ECU793. • Regulator has an internal defect.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check the cable from ECU793 to the gearbox. Check the connectors from ECU793 to the gearbox. Check the regulator resistance. Check internal wire harness of the gearbox.
5535/3	8B	S.C. to battery voltage at DLM transversal output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to battery voltage. Possible seasons: • Cable is defective and is contacted to battery voltage. • Device has an internal defect. • Connector pin is contacted to battery voltage.	-	Check the cable from ECU793 to the valve. Check the connectors from ECU793 to the gearbox. Check the resistance of valve.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5535/4	8A	S.C. to ground at DLM transversal output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to vehicle ground. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Device has an internal defect. • Connector pin is contacted to vehicle.	Output will be on until ECU793 power down even if error vanishes (loose connection).	Check the cable from ECU793 to the valve. Check the connectors from ECU793 to the gearbox. Check the resistance of valve.
5536/3	8E	S.C. to battery voltage at DLM indicator lamp output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to battery voltage. Possible reasons: • Cable is defective and is contacted to battery voltage. • Device has an internal defect. • Connector pin is contacted to battery voltage.	-	Check the cable from ECU793 to the device. Check the connectors from ECU793 to the gearbox. Check the resistance of device.
5536/5	8F	O.C. DLM indicator lamp output. ECU793 detected a wrong voltage at the output pin, that looks like a o.c. for this output pin. Possible reasons: • Cable is defective and has no connection to ECU793. • Device has an internal defect. • Connector has no connection to ECU793.	-	Check the cable from ECU793 to the device. Check the connectors from ECU793 to the gearbox. Check the resistance of device.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5545/3	D8	S.C. to battery voltage at DLM longitudinal output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to battery voltage. Possible reasons: • Cable is defective and is contacted to battery voltage. • Device has an internal defect. • Connector pin is contacted to battery voltage.	-	Check the cable from ECU793 to the valve. Check the connectors from ECU793 to the gearbox. Check the resistance of valve.
5545/4	D7	S.C. to ground at DLM longitudinal output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to vehicle ground. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Device has an internal defect. • Connector pin is contacted to vehicle ground.	Output will be on until ECU793 power down even if error vanishes (loose connection).	Check the cable from ECU793 to the valve. Check the connectors from ECU793 to the gearbox. Check the resistance of valve.
5560/5	93	O.C. at relay reverse warning alarm. ECU793 detected a wrong voltage at the output pin, that looks like a o.c. for this output pin. Possible reasons: • Cable is defective and has no connection to ECU793. • Backup alarm device has an internal defect. • Connector has no connection to ECU793.	-	Check the cable from ECU793 to the backup alarm device. Check the connectors from backup alarm device to ECU793. Check the resistance of backup alarm device.

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5570/3	95	S.C. to battery voltage at relay starter interlock. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to battery voltage. Possible reasons: • Cable is defective and is contacted to battery voltage. • Starter interlock relay has an internal defect. • Connector pin is contacted to battery voltage.	-	Check the cable from ECU793 to the starter interlock relay. Check the connectors from starter interlock relay to ECU793. Check the resistance of starter interlock relay.
5570/4	94	S.C. to ground at relay starter interlock. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to vehicle ground. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Starter interlock relay has an internal defect. • Connector pin is contacted to vehicle ground.	-	Check the cable from ECU793 to the starter interlock relay. Check the connectors from starter interlock relay to ECU793. Check the resistance of starter interlock relay.
5570/5	96	O.C. at relay starter interlock. ECU793 detected a wrong voltage at the output pin, that looks like a o.c. for this output pin. Possible reasons: • Cable is defective and has no connection to ECU793. • Starter interlock relay has an internal defect. • Connector has no connection to ECU793.	-	Check the cable from ECU793 to the starter interlock relay. Check the connectors from starter interlock relay to ECU793. Check the resistance of starter interlock relay.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5620/3	A6	S.C. to battery voltage at warning signal output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to battery voltage. Possible reasons: • Cable is defective and is contacted to battery voltage. • Warning device has an internal defect. • Connector pin is contacted to battery voltage.	-	Check the cable from ECU793 to the warning device. Check the connectors from warning device to ECU793. Check the resistance of warning device.
5620/4	A4	S.C. to ground at warning signal output. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to vehicle ground. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Warning device has an internal defect. • Connector pin is contacted to vehicle ground.	-	Check the cable from ECU793 to the warning device. Check the connectors from warning device to ECU793. Check the resistance of warning device.
5620/5	A5	O.C. at warning signal output. ECU793 detected a wrong voltage at the output pin, that looks like a o.c. for this output pin. Possible reasons: • Cable is defective and has no connection to ECU793. • Warning device has an internal defect. • Connector has no connection to ECU793.	-	Check the cable from ECU793 to the warning device. Check the connectors from warning device to ECU793. Check the resistance of warning device.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5660/2	B1	Slippage at clutch K1. ECU793 calculates a differential speed at closed clutch K1. If this calculated value is out of range, ECU793 interprets this as slipping clutch. Possible reasons: • Low pressure at clutch K1. • Low main pressure. • Wrong signal at internal speed sensor. • Wrong signal at output speed sensor. • Wrong size of the sensor gap. • Clutch is defective.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check pressure at clutch K1. Check main pressure in the system. Check sensor gap at internal speed sensor. Check sensor gap at output speed sensor. Check signal at internal speed sensor. Check signal at output speed sensor. Replace clutch.
5665/2	B2	Slippage at clutch K2. ECU793 calculates a differential speed at closed clutch K2. If this calculated value is out of range, ECU793 interprets this as slipping clutch. Possible reasons: • Low pressure at clutch K2. • Low main pressure. • Wrong signal at internal speed sensor. • Wrong signal at output speed sensor. • Wrong size of the sensor gap. • Clutch is defective.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check pressure at clutch K2. Check main pressure in the system. Check sensor gap at internal speed sensor. Check sensor gap at output speed sensor. Check signal at internal speed sensor. Check signal at output speed sensor. Replace clutch.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5670/2	B3	Slippage at clutch K3. ECU793 calculates a differential speed at closed clutch K3. If this calculated value is out of range, ECU793 interprets this as slipping clutch. Possible reasons: • Low pressure at clutch K3. • Low main pressure. • Wrong signal at internal speed sensor. • Wrong signal at output speed sensor. • Wrong size of the sensor gap. • Clutch is defective.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check pressure at clutch K3. Check main pressure in the system. Check sensor gap at internal speed sensor. Check sensor gap at output speed sensor. Check signal at internal speed sensor. Check signal at output speed sensor. Replace clutch.
5675/2	B4	Slippage at clutch K4. ECU793 calculates a differential speed at closed clutch K4. If this calculated value is out of range, ECU793 interprets this as slipping clutch. Possible reasons: • Low pressure at clutch K4. • Low main pressure. • Wrong signal at internal speed sensor. • Wrong signal at turbine speed sensor. • Wrong size of the sensor gap. • Clutch is defective.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check pressure at clutch K4. Check main pressure in the system. Check sensor gap at internal speed sensor. Check sensor gap at output speed sensor. Check signal at internal speed sensor. Check signal at output speed sensor. Replace clutch.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5680/2	B5	Slippage at clutch KV, forward clutch. ECU793 calculates a differential speed at closed clutch KV. If this calculated value is out of range, ECU793 interprets this as slipping clutch. Possible reasons: • Low pressure at clutch KV. • Low main pressure. • Wrong signal at internal speed sensor. • Wrong signal at turbine speed sensor. • Wrong size of the sensor gap. • Clutch is defective.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check pressure at clutch KV. Check main pressure in the system. Check sensor gap at internal speed sensor. Check sensor gap at output speed sensor. Check signal at internal speed sensor. Check signal at output speed sensor. Replace clutch.
5685/2	B6	Slippage at clutch KR, reverse clutch. ECU793 calculates a differential speed at closed clutch KR. If this calculated value is out of range, ECU793 interprets this as slipping clutch. Possible reasons: • Low pressure at clutch KR. • Low main pressure. • Wrong signal at internal speed sensor. • Wrong signal at turbine speed sensor. • Wrong size of the sensor gap. • Clutch is defective.	Control unit transmission activates “limp home”. With an ongoing error on another gear, the transmission control unit activates “TCU shutdown”.	Check pressure at clutch KR. Check main pressure in the system. Check sensor gap at internal speed sensor. Check sensor gap at output speed sensor. Check signal at internal speed sensor. Check signal at output speed sensor. Replace clutch.
5700/0	B7	Overtemp sump. ECU793 measured a temperature in the oil sump that is over the allowed threshold.	-	Cool down machine. Check oil level. Check temperature sensor.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5730/0	BA	Differential oil pressure filter. ECU793 measured a voltage at differential pressure switch out of the allowed range. Possible reasons: • Oil filter is contaminated. • Cable/connector is broken or cable/connector is contacted to battery voltage or vehicle ground. • Differential pressure switch is defective.	-	Check oil filter. Check wiring from ECU793 to differential pressure switch. Check differential pressure switch (measure resistance) which should be around 510 Ohms normally and open circuit when contaminated filter.
5745/15	BC	Overspeed output. ECU793 messures an transmission output speed above the defined threshold.	-	
5751/0	C0	Engine torque or engine power overload. ECU793 calculates an engine torque or engine power above the defined thresholds.	-	
5752/0	C1	Transmission output torque overload. ECU793 calculates an transmission output torque above the defined threshold.	-	
5755/15	C2	Transmission input torque overload ECU793 calculates an transmission input torque above the defined threshold.	Programmable: No reaction or shift to neautral.	VARNING!
5760/0	C3	Overtemp converter output. ECU793 measured a oil temperature at the converter ouput that is over the allowed threshold.	-	Cool down machine. Check oil level. Check temperature sensor.

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 SPN/FMI	ZF code (hex)	Description	Limitation	Action
5770/3	C4	S.C. to ground at joystick status indicator. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to vehicle ground. Possible reasons: • Cable is defective and is contacted to vehicle ground. • Joystick status indicator has an internal defect. • Connector pin is contacted to vehicle ground.	-	Check the cable from ECU793 to joystick status indicator. Check the connectors from joystick status indicator to ECU793. Check the resistance of joystick status indicator.
5770/4	C5	S.C. to battery voltage at joystick status indicator. ECU793 detected a wrong voltage at the output pin, that looks like a s.c. to battery voltage. Possible reasons: • Cable is defective and is contacted to battery voltage. • Joystick status indicator has an internal defect. • Connector pin is contacted to battery voltage.	-	Check the cable from ECU793 to joystick status indicator. Check the connectors from joystick status indicator to ECU793. Check the resistance of joystick status indicator.
5770/5	C6	O.C. at joystick status indicator. ECU793 detected a wrong voltage at the output pin, that looks like a o.c. for this output pin. Possible reasons: • Cable is defective and has no connection to ECU793. • Joystick status indicator has an internal defect. • Connector has no connection to ECU793.	-	Check the cable from ECU793 to joystick status indicator. Check the connectors from joystick status indicator to ECU793. Check the resistance of joystick status indicator.

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5810/3	D1	S.C. to battery voltage at power supply for sensors. ECU793 measures more than 6V at the pin AU1 (5V sensor supply).	See error codes no. 25 to 2C.	Check cables and connectors to sensors, which are supplied from AU1 Check the power supply at the pin AU1 (should be appx. 5V). Error codes no. 25 to no. 2C may be a reaction of this fault.
5810/4	D2	S.C. to ground at power supply for sensors. ECU793 measures less than 4V at the pin AU1 (5V sensor supply).	See error codes no. 25 to 2C.	Check cables and connectors to sensors, which are supplied from AU1 Check the power supply at the pin AU1 (should be appx. 5V). Error codes no. 25 to no. 2C may be a reaction of this fault.
5820/3	D4	High voltage at battery. Measured voltage at power supply is higher than: • 18 V (12V device) • 32.5 V (24V device).	Transmission control unit activates “TCU shutdown”	Check power supply battery. Check cables from batteries to ECU793. Check connectors from batteries to ECU793.
5820/4	D3	Low voltage at battery measured voltage at power supply is lower than: • 10 V (12V device) • 18 V (24V device).	Transmission control unit activates “TCU shutdown”	Check power supply battery. Check cables from batteries to ECU793. Check connectors from batteries to ECU793.

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5830/2	D5	Error at value power supply VPS1. ECU793 switched on VPS1 and measured VPS1 is off or ECU793 switched off VPS1 and measured VPS1 is still on. Possible reasons: • Cable or connectors are defect and are contacted to battery voltage. • Cable or connectors are defect and are contacted to vehicle ground. • Permanent power supply KL30 missing. • ECU793 has an internal defect.	Transmission control unit activates “TCU shutdown”.	Check fuse. Check cables from gearbox to ECU793. Check connectors from gearbox to TECU793. Replace ECU793.
5840/2	D6	Error valve power supply VPS2. ECU793 switched on VPS2 and measured VPS2 is off or ECU793 switched off VPS2 and measured VPS2 is still on. Possible reasons: • Cable or connectors are defect and are contacted to battery voltage. • Cable or connectors are defect and are contacted to vehicle ground. • Permanent power supply KL30 missing. • ECU793 has an internal defect.	Transmission control unit activates “TCU shutdown”.	Check fuse. Check cables from gearbox to ECU793. Check connectors from gearbox to ECU793. Replace ECU793.

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		Description	Limitation	Action
SPN/FMI	ZF code (hex)			
5860/3	E3	S.C. to battery voltage at display output. ECU793 sends data to the display and measures allways a high voltage level on the connector. Possible reasons: • Cable or connectors are defective and are contacted to battery voltage. • Display has an internal defect.	-	Check the cable from ECU793 to the display. Check the connectors at the display. Change display.
5860/4	E4	S.C. to ground at display output. ECU793 sends data to the display and measures allways a high voltage level on the connector. Possible reasons: • Cable or connectors are defective and are contacted to vehicle ground. • Display has an internal defect.	-	Check the cable from ECU793 to the display. Check the connectors at the display. Change display.
5880/2	E6	Illegal ID request via CAN.	Transmission in neutral. Transmission control unit activates “TCU shutdown”.	
5890/2	F1	General EEPROM fault. ECU793 can't read non volantile memory. Possible reason: • ECU793 is defective.	-	Replace ECU793. Often shown together with error code F2.
5900/13	F2	Configuration lost. ECU793 has lost the correct configuration and can't control the transmission. Possible reasons: • Interference during saving data on non volatile memory. • ECU793 is brand new or from another vehicle.	Transmission control unit activates “TCU shutdown”.	Reprogramm the correct configuration for the machine (e.g. with cluster controller,...).

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		Description	Limitation	Action
SPN/FMI	**ZF code (hex)**			
5910/13	F3	Application error. Something of this application is wrong.	Transmission control unit activates “TCU shutdown”.	Replace ECU793. This fault occurs only if an test engineer did something wrong in the application of the machine.
5930/7	F5	Clutch failure. AEB was not able to adjust clutch filling parameters. Possible reason: • One of the AEB-Values is out of limit.	Transmission control unit activates “TCU shutdown”.	ECU793 shows also the affected clutch on the Display.
5930/13	F6	Clutch adjustment data lost or inchpedal calibration data lost. ECU793 was not able to read correct clutch adjustment parameters. Possible reason: • Interference during saving data on non volatile memory. • ECU793 is brand new.	Default values = 0 for AEB offsets used. No Inchmode available.	Execute AEB.

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8 Control system

Error codes machine

Code	Description	Limitation	Action
1	Time for service interval has been exceeded.		Make maintenance according to service schedule. Activate new service interval with service interval code.
10	Communication fault ECU 790.	Operation not possible.	Check the power supply to the ECU 790. Check the CAN bus for breaks.
11	Communication, defective cable ECU 790 - EDU 795. Short-circuit or open circuit.	Operation not possible.	Check the cable between ECU 790 and EDU 795.
12	Communication fault ECU 793. Short-circuit or open circuit.		Check the cable between ECU 793 and EDU 795.
13	Communication fault ECU 794. Short-circuit or open circuit.		Check the cable between ECU 794 and EDU 795.
14	Communication ECU 796, not responding.		Check the power supply to the ECU 796. Check the CAN bus for breaks.
15	Communication, defective cable ECU 795 - ECU 796. Short-circuit or open circuit.		Check cable.
16	Communication, defective cable ECU 796 - ECU 790. Short-circuit or open circuit.		Check cable.
17	Memory error, check sum EDU 795.	Operation not possible. Display not in function.	Re-start ECU 795. Load programs. If that does not help, replace ECU 795.
18	Communication ECU 792, not responding. Short-circuit or open circuit.		Check the power supply to the ECU 792. Check the CAN bus for breaks.
301	Voltage supply error ECU 790. Supply voltage below 14 or above 33 V for 5 s.	Reduction of engine speed.	Check fuse according to manual. Measure battery voltage or check acid level.
303	Reference voltage error, 5V, ECU 790. Reference voltage below 4,5 or above 5,5 V for 50 ms.	Reduction of engine speed.	Measure 5 V reference. Possible sensor fault or short-circuit to battery minus.
304	Defective sensor for electric scales. Signal below 0.20V for 5s.		Possible cable open circuit. Check cable from chassi to mast.

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Code	Description	Limitation	Action
305	Defective speed sensor. Machine speed above 40 km/h for one second or too fast change of speed (2 km/h at 20ms).	Reduction of engine speed.	Investigate fitting of sensor and cable to it. Search for open circuit or open conductor. Important that the distance between sensor and cam disc is correct, contact Kalmar Industries. Measure output signal with oscilloscope.
306	Defective engine rev sensor. Engine speed above 3500 rpm for 1s or too fast change of speed (150 rpm at 20 ms).	Reduction of engine speed.	Check that the sensor is properly screwed in the flywheel cover so that correct distance to the ring gear is obtained. On the front edge of the sensor is a flange which must rest against the flywheel cover. Also check the cable to the sensor if there is open circuit or open conductors. Measure output signal with oscilloscope.
307	Defective gear selector. Logical fault or unexpected input from lever.	Reduction of engine speed.	Check for physical damage or cable open circuit.
320	Defective sensor for hydrostatic drive pressure (forward). Signal below 0.20V or above 4.80V for 2s.	Reduction of engine speed.	Check connector on pressure sensor mounted on hydraulic pump.
321	Defective sensor for hydrostatic drive pressure (reverse). Signal below 0.20V or above 4.80V for 2s.	Reduction of engine speed.	Check connector on pressure sensor mounted on hydraulic pump.
322	Defective hydraulic pressure sensor for lift lever. Signal below 0.20V or above 4.80V for 2s.	Engine speed does not increase when using lift lever.	Check connector on pressure sensor.
323	Short-circuit or open circuit on output signal EDC valve pump (forward).	Reduction of engine speed.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
324	Short-circuit or open circuit on output signal EDC valve pump (reverse).	Reduction of engine speed.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
325	Short-circuit or open circuit on output signal PDC valve hydraulic motor.	Reduction of engine speed.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.

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Code	Description	Limitation	Action
350	Battery voltage low. Battery voltage below 23 V if engine is running for 12 s.		Check the alternator and the charging circuit. Measure acid level and if needed charge battery. If that doesn't help replace battery/batteries
351	Battery voltage high. Battery voltage above 30 V for 10 s.		Check the alternator's 24V output. Check cabling.
352	Fuel level low. Less than 15 % for 40 s.	Activity can be continued.	Fill with fuel.
353	Defective sensor fuel level.	Activity can be continued.	Check the sensor's resistance. It should be between 0 and 73 Ohm.
354	Coolant level low. Low level for 40 s.	Reduction of engine speed.	Fill with refrigerant.
355	Hydraulic oil temperature high. Hydraulic oil temperature over 100 °C for 40 seconds.		Do not use hydraulic functions before the temperature has fallen below 70 °C. Hydraulic fluid may catch fire if above 100 °C.
356	Defective sensor hydraulic oil temperature. If value above 138 °C or below -30 °C.	Activity can be continued.	Check sensor resistance. It should be 8.5 kohm at 0 °C and 290 ohm at 100 °C.
357	Brake system, accumulator pressure low. Brake pressure low for 10s. The pressure can be low for 60s at start-up.	Reduction of engine speed.	Stop machine. Check accumulator.
370	Engine particulate filter. Time to regenerate particulate filter in 30 minutes.		Regenerate particulate filter in 30 minutes.
371	Engine particle filter. Time to regenerate.	Reduction of engine speed.	Regenerate particulate filter.
372	High pressure in the particulate filter. Pressure high for 1 minute.	Reduction of engine speed.	Regenerate particulate filter.
380	Defective accelerator LF (Left Front). Accelerator pedal signal below 0,2 V or above 4,8 V or 0,3 V out of calibrated values for 500 ms.	Reduction of engine speed.	Check cable and physical installation of pedal. Calibrate pedal.
381	Defective accelerator RF (Right Front). Accelerator pedal signal below 0,2 V or above 4,8 V or 0,3 V out of calibrated values for 500 ms.	Reduction of engine speed.	Check cable and physical installation of pedal. Calibrate pedal.

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Code	Description	Limitation	Action
382	Defective accelerator LR (Left Rear). Accelerator pedal signal below 0,2 V or above 4,8 V or 0,3 V out of calibrated values for 500 ms.	Reduction of engine speed.	Check cable and physical installation of pedal. Calibrate pedal.
383	Defective accelerator RR (Right Rear). Accelerator pedal signal below 0,2 V or above 4,8 V or 0,3 V out of calibrated values for 500 ms.	Reduction of engine speed.	Check cable and physical installation of pedal. Calibrate pedal.
384	Defective servo motor for injector pump engine. Servo feedback above 4,8 V or 0,5 V out of calibrated values for 500 ms or too fast change of feedback.	Reduction of engine speed.	Check cable and physical installation of servo motor. Calibrate servo.
390	Defective valve to variable pump for Optimum Speed/Optimum Rev, short circuit or open circuit at terminal K2:28.		Measure the valve's resistance. Should not be under 10 Ohm. Check with data sheet from valve manufacturer.
400	Fault in sensor for reversible driver's seat. Sensor faulty or open circuit in signal wire. Signal below 0,3V or above 4,7V for 200ms. Mechanical sensor fault.	Only driving with operator's seat in forward direction is possible.	Measure the signal with a multimeter or use the built-in diagnostic system in the KCS to check whether the signal is within the permissible limits. Use the diagnostic menus (KCS, monitoring) to investigate K1:37.
401	Overload lift and tilt according to calibrate table. Machine capacity exceeded.	Speed limitation.	Put down and lift lighter loads.
402	Parking brake error. Parking brake valve or parking brake switch out of order.	Parking brake doesn't release.	Check parking brake pressure after valve. Check parking brake switch.
404	Coolant level sensor error. Signal from sensor below 0.2V or above 4.8V.		Check cable from sensor and make sure coolant level is ok.
405	Seat turning sensing logic error. Signal from sensor below 0.2V or above 4.8V.	Possible to turn seat but with limitations.	Check cables and connections to seat sensing logic.
406	Tiltaxle force sensor error. Sensor signal below 0.1V or above 4.8V for 10s.	Overload protection disabled.	Overload protection is disabled. Do not overload machine. Replace sensor.
601	Voltage supply error, ECU 796. Supply voltage below 14 or above 33 V.		Measure battery voltage. Check fuse 58-4 no. 6 (5 A).

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Code	Description	Limitation	Action
602	Memory error, check sum ECU 796.		Re-start ECU 796. Load program. If that does not help, replace ECU 796.
603	Reference voltage 10V error, ECU 796. Reference voltage below 9 or above 11 V for 50 ms.		Measure 10V reference between X46.7 (0 V) and X46.6 (10V).
604	Voltage supply error PWM outputs, ECU 796. Supply voltage below 14 or above 33 V for 5s.	Hydraulics not working.	Switch off the hydraulic functions. Check if emergency stop is de-pressed at the electrical servo. Measure battery voltage. Check fuse 58-4 no. 7 (10 A).
605	Communication error XA-PWM, K2.	Hydraulic functions not working.	Re-start ECU 796. If that does not help, replace ECU 796.
606	Communication error XA-PWM, K3.	Hydraulic functions not working.	Re-start ECU 796. If that does not help, replace ECU 796.
610	Error, input signal from lever for hydraulic function 1. Signal from sensor below 0.6 V or above 9.4 V for 100 ms.	Hydraulic function 1 not working.	Check the potentiometer fitting and cable. The signal voltage should be between 0-10 V.
611	Error, input signal from lever for hydraulic function 2. Signal from sensor below 0.6 V or above 9.4 V for 100 ms.	Hydraulic function 2 not working.	Check the potentiometer fitting and cable. The signal voltage should be between 0-10 V.
612	Error, input signal from lever for hydraulic function 3. Signal from sensor below 0.6 V or above 9.4 V for 100 ms.	Hydraulic function 3 not working.	Check the potentiometer fitting and cable. The signal voltage should be between 0-10 V.
613	Error, input signal from lever for hydraulic function 4. Signal from sensor below 0.6 V or above 9.4 V for 100 ms.	Hydraulic function 4 not working.	Check the potentiometer fitting and cable. The signal voltage should be between 0-10 V.
614	Error, input signal from lever for hydraulic function 5. Signal from sensor below 0.6 V or above 9.4 V for 100 ms.	Hydraulic function 5 not working.	Check the potentiometer fitting and cable. The signal voltage should be between 0-10 V.
615	Short-circuit or open circuit for main valve hydraulic function 1A at terminal K2:3.	Hydraulic function 1 not working.	Measure the valve’s resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
616	Short-circuit or open circuit for main valve hydraulic function 1B at terminal K2:4.	Hydraulic function 1 not working.	Measure the valve’s resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.

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Code	Description	Limitation	Action
617	Short-circuit or open circuit for main valve hydraulic function 2A at terminal K2:5.	Hydraulic function 2 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
618	Short-circuit or open circuit for main valve hydraulic function 2B at terminal K2:6.	Hydraulic function 2 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
619	Short-circuit or open circuit for main valve hydraulic function 3A at terminal K2:7.	Hydraulic function 3 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
620	Short-circuit or open circuit for main valve hydraulic function 3B at terminal K2:8.	Hydraulic function 3 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
621	Short-circuit or open circuit for main valve hydraulic function 4A at terminal K2:11.	Hydraulic function 4 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
622	Short-circuit or open circuit for main valve hydraulic function 4B at terminal K2:12.	Hydraulic function 4 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
623	Short-circuit or open circuit for main valve hydraulic function 5A at terminal K2:13.	Hydraulic function 5 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
624	Short-circuit or open circuit for main valve hydraulic function 5B at terminal K2:14.	Hydraulic function 5 not working.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
626	Defective sensor for vertical alignment. Signal below 0,5V or above 9,5V for 100ms.	Vertical alignment not working.	Switch off vertical alignment. Check the potentiometer fitting and cable.
627	Defective sensor for pre-selected lifting height. Signal below 0,5V or above 9,5V for 100ms.	Pre-selected lifting height not working.	Switch off pre-selected lifting height.
628	CTX communication error. Clamping control no reply.	Only manual clamping function is possible.	CTX clamping controller inoperative. Select manual clamping control. Check cable to clamping controller.
630	Fault in pressure sensor P1 for automatic clamping unit. Signal below 0.5V or above 10.5V for 2s.	Clamping pressure is estimated to be the set value. WARNING! There is no automatic increase in clamping pressure.	Check the cable for the pressure sensor on the clamping unit. Check the pressure sensor.
631	Fault in pressure sensor P2 for automatic clamping unit Signal below 0.5V or above 10.5V for 2s.	Clamping pressure is estimated to be the set value. WARNING! There is no automatic increase in clamping pressure.	Check the cable for the pressure sensor on the clamping unit. Check the pressure sensor.

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Code	Description	Limitation	Action
632	Short circuit or open circuit in hydraulic valve at terminal K3:3.	Clamping prevented.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
633	Short circuit or open circuit in clamping pressure valve, on/off.	Clamping prevented.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
634	Short circuit or open circuit in valve for left clamping arm, on/off.	Not possible to shut off left side.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
635	Short circuit or open circuit in valve for right clamping arm, on/off.	Not possible to shut off right side.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
636	Short circuit or open circuit in upper left clamping arm valve on/off.	Not possible to shut off upper left side.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
637	Short circuit or open circuit in middle right clamping arm valve on/off.	Not possible to shut off middle right side.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
638	Short circuit or open circuit in middle left clamping arm valve on/off.	Not possible to shut off middle left side.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
639	Short circuit or open circuit in upper right clamping arm valve on/off.	Not possible to shut off upper right side.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
642	Fault in pressure sensor for opening clamping unit. Signal below 0.5V or above 10.5V for 2s.	Clamping prevented.	Check the cable for the pressure sensor for opening the clamping unit. Check the pressure sensor.

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Code	Description	Limitation	Action
643	Fault in pressure sensor for closing clamping unit. Signal below 0.5V or above 10.5V for 2s.	Clamping prevented.	Check the cable for the pressure sensor for closing the clamping unit. Check the pressure sensor.
644	Switch for selecting left or right clamping unit.	Not possible to shut off left or right side.	Check the switch. Check the cable connected to the switch.
645	Overload	Speed reduction to max 1 km/h.	
646	Short circuit or open circuit in upper left bypass valve on clamp.	Clamping on left side not possible.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
647	Short circuit or open circuit in middle left bypass valve on clamp.	Clamping on left side not possible.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
648	Short circuit or open circuit in left sequence valve on clamp.	Clamping on left side not possible.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
650	Short circuit or open circuit in upper right bypass valve on clamp.	Clamping on right side not possible.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
651	Short circuit or open circuit in middle right bypass valve on clamp.	Clamping on right side not possible.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
652	Short circuit or open circuit in right sequence valve on clamp.	Clamping on right side not possible.	Measure the valve resistance. This should not be less than 15 Ohm. Use the manufacturer's data sheet to check. Check the cable connected to the valve.
654	Pressure sensor P3 left long arm fault, paper clamp.	Clamping on left side not possible.	Check the cable for the pressure sensor for P3 left long arm. Check the pressure sensor.
655	Pressure sensor P3 left short arm fault, paper clamp.	Clamping on left side not possible.	Check the cable for the pressure sensor for P3 left short arm. Check the pressure sensor.

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Code	Description	Limitation	Action
656	Pressure sensor P3 right long arm fault, paper clamp.	Clamping on right side not possible.	Check the cable for the pressure sensor for P3 right long arm. Check the pressure sensor.
657	Pressure sensor P3 right short arm fault, paper clamp.	Clamping on right side not possible.	Check the cable for the pressure sensor for P3 right short arm. Check the pressure sensor.
658	Pressure select switch fault.	Clamp pressure one is selected.	Check switch mounting and cable. Signal voltage should be between 0.2-9.8 V.
659	Pressure sensor P1 on left arm fault, paper clamp. Signal below 0.5V or above 10.5V for 2s.	Clamping pressure is estimated to be the set value. WARNING! There is no automatic increase in clamping pressure.	Check the cable for the pressure sensor. Check the pressure sensor.
660	Pressure sensor P2 on left arm fault, paper clamp. Signal below 0.5 V or above 10.5 V for two seconds.	Clamping pressure is estimated to be the set value. WARNING! There is no automatic increase in clamping pressure.	Check the cable for the pressure sensor. Check the pressure sensor.
661	Pressure sensor P1 on right arm fault, paper clamp. Signal below 0.5 V or above 10.5 V for two seconds.	Clamping pressure is estimated to be the set value. WARNING! There is no automatic increase in clamping pressure.	Check the cable for the pressure sensor. Check the pressure sensor.
662	Pressure sensor P2 on right arm fault, paper clamp. Signal below 0.5 V or above 10.5 V for two seconds.	Clamping pressure is estimated to be the set value. WARNING! There is no automatic increase in clamping pressure.	Check the cable for the pressure sensor. Check the pressure sensor.
900	Fault code from gearbox control unit. SPN and FMI code is shown if available.	Depending on type of fault.	See *Error codes transmission alternative Dana TE13000 and TE17000 page 69*. See *Error codes transmission alternative ZF 3WG161 page 77*.
1200	Error code from engine control unit. SPN and FMI code is shown if available.	Depending on type of fault.	See *Error codes engine alternative Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE page 10*. See *Error codes engine alternative Cummins QSB6.7 page 21*. See *Error codes engine alternative Caterpillar C6.6 page 39*.

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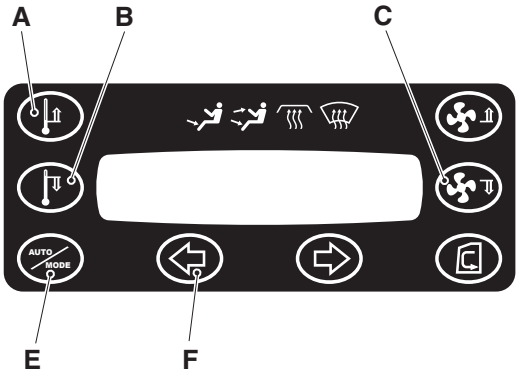
Code	Description	Limitation	Action
1501	Defective sensor for feedback steering. Signal below 0,3 V or above 4,7 V for 100ms or mechanical sensor fault.	Steering turns off automatically.	Check potentiometer and cabling from the steer sensor. The signal should be between 0.5 and 4.5V.
1502	Defective steer lever. Signal below 0,3 V or above 4,7 V for 100ms or mechanical sensor fault.	Steering turns off automatically.	Check potentiometer and cabling from the steer lever. The signal should be between 0.5 and 4.5V.
1503	Defective mini steering 2-channel potentiometer. Unexpected input from potentiometer. Signal value below 0,2V or above 4,8V	Steering turns off automatically.	Check cabling. Measure potentiometer channels 1 and 2 (oscilloscope required).
1504	Short-circuit or open circuit on output signal for right steering valve.	Steering turns off automatically.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
1505	Short-circuit or open circuit on output signal for left steering valve.	Steering turns off automatically.	Measure the valve's resistance. Must not be under 15 Ohm. Check with data sheet from valve manufacturer.
1506	Voltage supply error, ECU 792. Supply voltage below 14 or above 33 V for 5s.	Reduction of engine speed.	Check fuse according to manual. Measure battery voltage or check acid level.
1507	Reference voltage 5V error, ECU 792. Reference voltage below 4,5 or above 5,5 V for 50 ms.	Reduction of engine speed.	Measure 5 V reference. Possible sensor fault or short-circuit to battery minus.

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9 Frame, body, cab and accessories

9.4 Heating, ventilation and air conditioning

ECC: Reading out error code



003708

A. Scrolling between error messages
B. Scrolling between error messages
C. Resetting the pressure monitor
D. -
E. Auto mode
F. Fault cause

NOTE

In case of an error code, perform the recommended actions according to the error code table to find the problem.

If there is a fault in any sensor, or if the pressure monitor has tripped, “ERROR” will be flashed on the display.

Keep the auto button (position E) depressed for a few seconds to show the current fault(s) as text on the display.

Scroll between error messages, using the temperature buttons (positions A and B). The selected error message is indicated with an arrow on the display.

The fault cause is indicated with a left arrow (position F).

The pressure monitor is re-set with the button for reducing fan speed (position C). Keep the button depressed for several seconds to reset.

Return by briefly pressing the auto button (position E).

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ECC: Error code table



Error	Description	Limitation	Recommended action
Heatervalve Open	The heater valve has failed or become disconnected.	Pin 10 should have a voltage of approx. 5 V all the time. Pin 9 should have a voltage of approx. 0.9 V when fully closed and approx. 2.7 V when fully open. Pin 8 should have ground potential all the time. Pin 6, when valve is closing voltage should be approx. 12 V, when opening approx. 0 V, when stopped approx. 0 V. Pin 5, when valve is closing voltage should be approx. 0 V, when opening approx. 12 V, when stopped approx. 0 V.	Check wiring harness. Is the heater valve connected? Change heater valve.
Heatervalve Short	The heater valve has been shorted to ground.		
Heatervalve Stuck	Is the heater valve stuck?		
Inside sensor Open	The connection between ECC and sensor has been broken.	Resistance should be approx. 10 kohm at 25 °C.	Check wiring harness. Sensor connected? Measure resistance. Replace sensor.
Inside sensor Short	The connection between ECC and sensor has been shorted to ground.		
Outside sensor Open	The connection between ECC and sensor has been broken.	Resistance should be approx. 10 kohm at 25 °C.	Check wiring harness. Sensor connected? Measure resistance. Replace sensor.
Outside sensor Short	The connection between ECC and sensor has been shorted to ground.		
Deicing sensor Open	The connection between ECC and sensor has been broken.	Resistance should be approx. 10 kohm at 25 °C.	Check wiring harness. Sensor connected? Measure resistance. Replace sensor.
Deicing sensor Short	The connection between ECC and sensor has been shorted to ground.		
Aftercoil sensor Open	The connection between ECC and sensor has been broken.	Resistance should be approx. 10 kohm at 25 °C.	Check wiring harness. Sensor connected? Measure resistance. Replace sensor.
Aftercoil sensor Short	The connection between ECC and sensor has been shorted to ground.		

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Error	Description	Limitation	Recommended action
AC system failure	There is a problem with the ECC system. Either over pressure or not enough refrigerant. System can be reset. Shutdown, restart and from the error menu the fan down key resets the error.		Control refrigerant charge. Control pressure switch. Refrigerant leakage?

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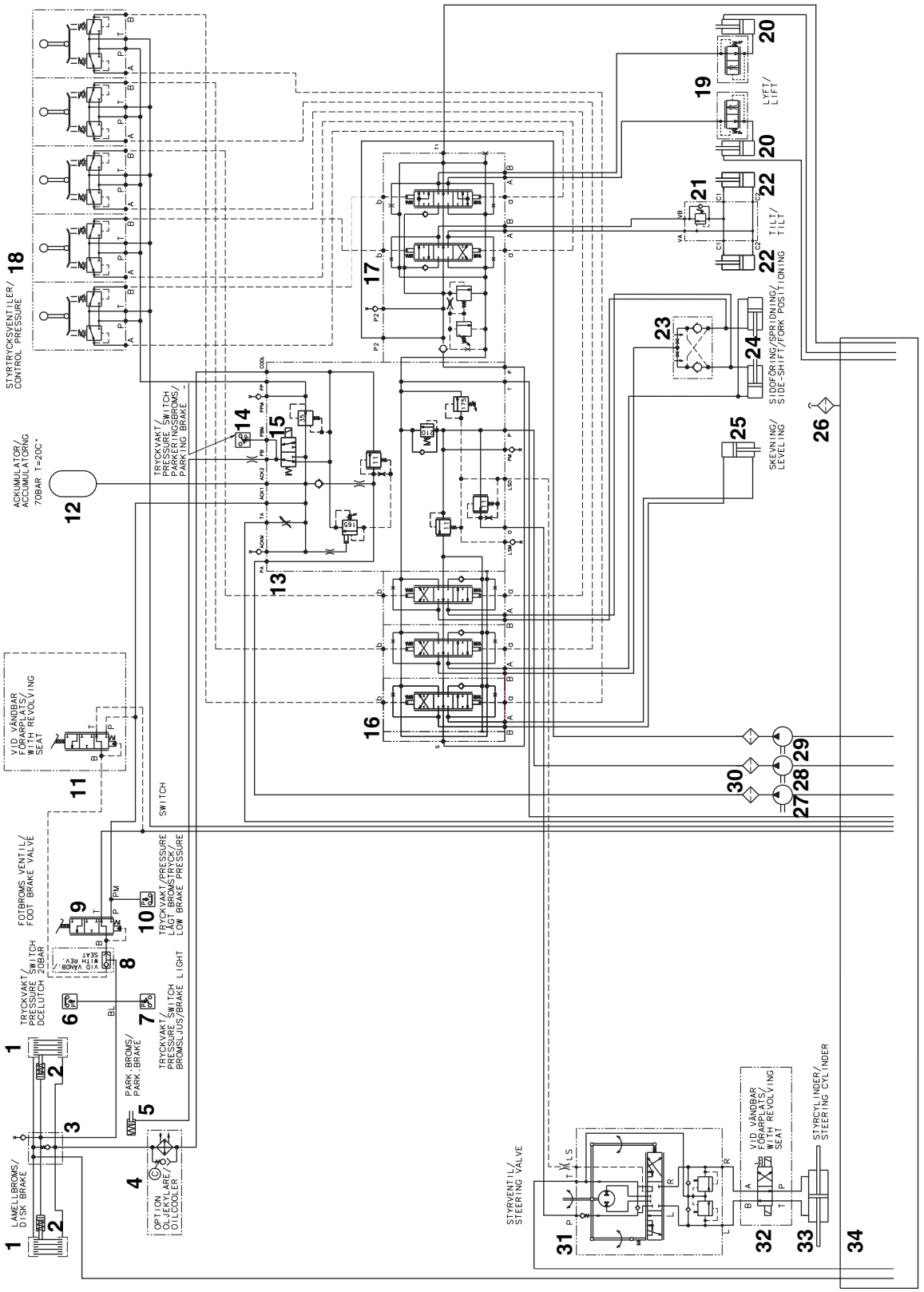
10 Common hydraulics

Hydraulic diagrams, compilation

Designation, drawing no., reference	Functions included
Hydraulic diagram A40750.1800 page 4	Brake, steering, load handling (hydraulic servo) and pumps
Hydraulic diagram A40750.1900 page 6	Brake, steering, load handling (container) and pumps
Hydraulic diagram A40750.2000 page 8	Brake, steering, load handling (electrical servo) and pumps
Hydraulic diagram A40750.2100 page 10	Brake, mini-wheel/lever steering, load handling (hydraulic servo) and pumps
Hydraulic diagram A40750.2200 page 12	Brake, mini-wheel/lever steering, load handling (electrical servo) and pumps
Hydraulic diagram A40750.3000 page 14	Brake, mini-wheel/lever steering, load handling (joy-stick) and pumps

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Hydraulic diagram A40750.1800

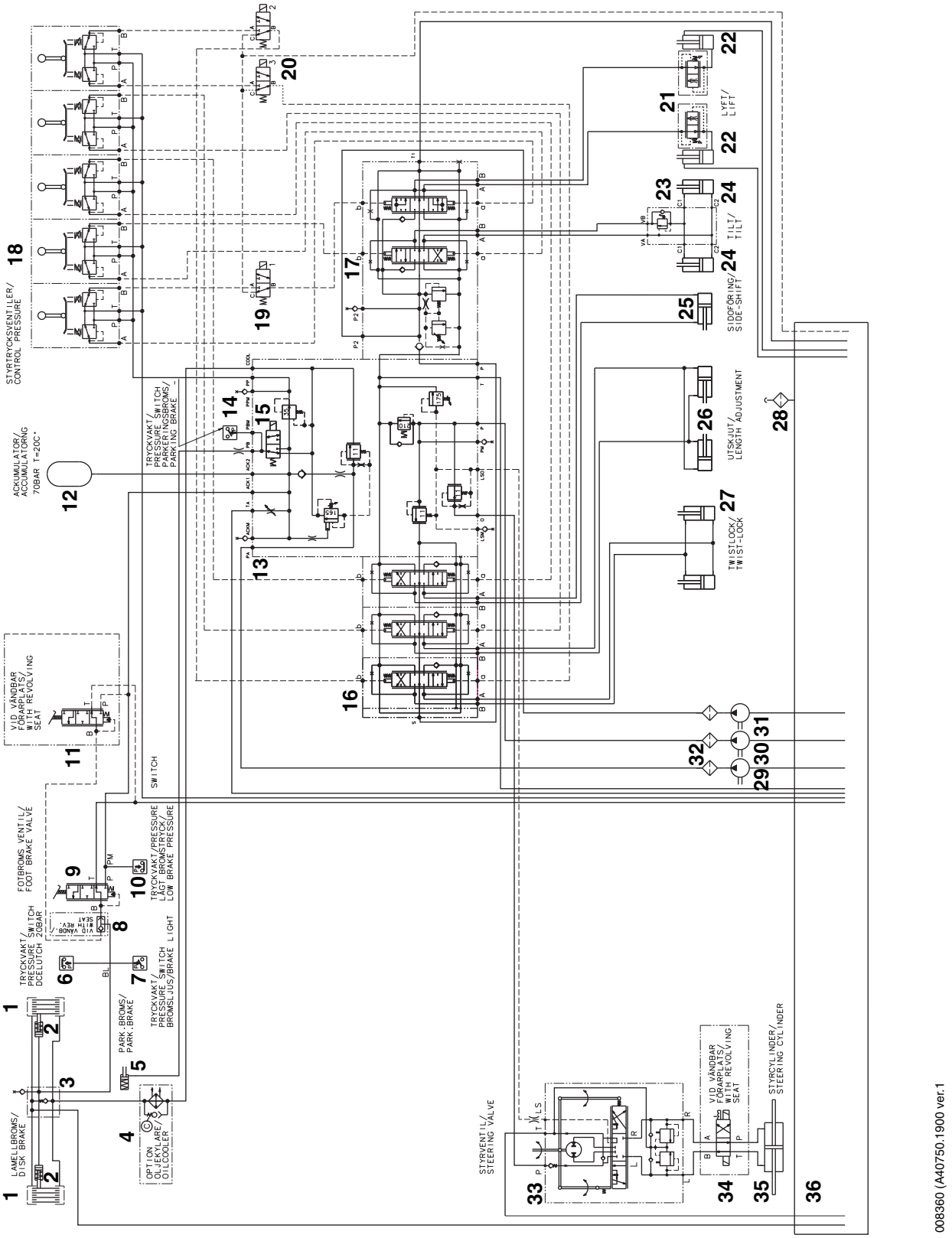


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1. Wheel brake
2. Brake cylinder
3. Drive axle block
4. Hydraulic oil cooler
5. Parking brake calliper
6. Switch normally closed (NC) disengagement (S220)
7. Switch normally open (NO) brake light (S216)
8. Shuttle valve, reversible operator’s seat
9. Brake valve
10. Switch normally closed (NC) low brake pressure (S204)
11. Extra brake valve, reversible operator’s seat
12. Accumulator
13. Main valve
14. Switch normally open (NO) parking brake (S200)
15. Solenoid valve parking brake (Y642)
16. Control valves for levelling, spreading and side shift
17. Control valves for tilt and lift
18. Control levers
19. Load control valve
20. Lift cylinder
21. Load holding valve
22. Tilt cylinder
23. Flow divider
24. Side shift and spreading cylinders
25. Levelling cylinder
26. Breather filter hydraulic oil tank
27. Hydraulic oil pump for brake system and servo circuit for load handling
28. Hydraulic oil pump for steering and load handling
29. Hydraulic oil pump for lifting and tilting
30. High-pressure filter
31. Steering valve
32. Directional valve with solenoid valve steering forward (Y636-1) and steering reverse (Y636-2), reversible driver´s seat
33. Steering cylinder
34. Hydraulic oil tank

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Hydraulic diagram A40750.1900

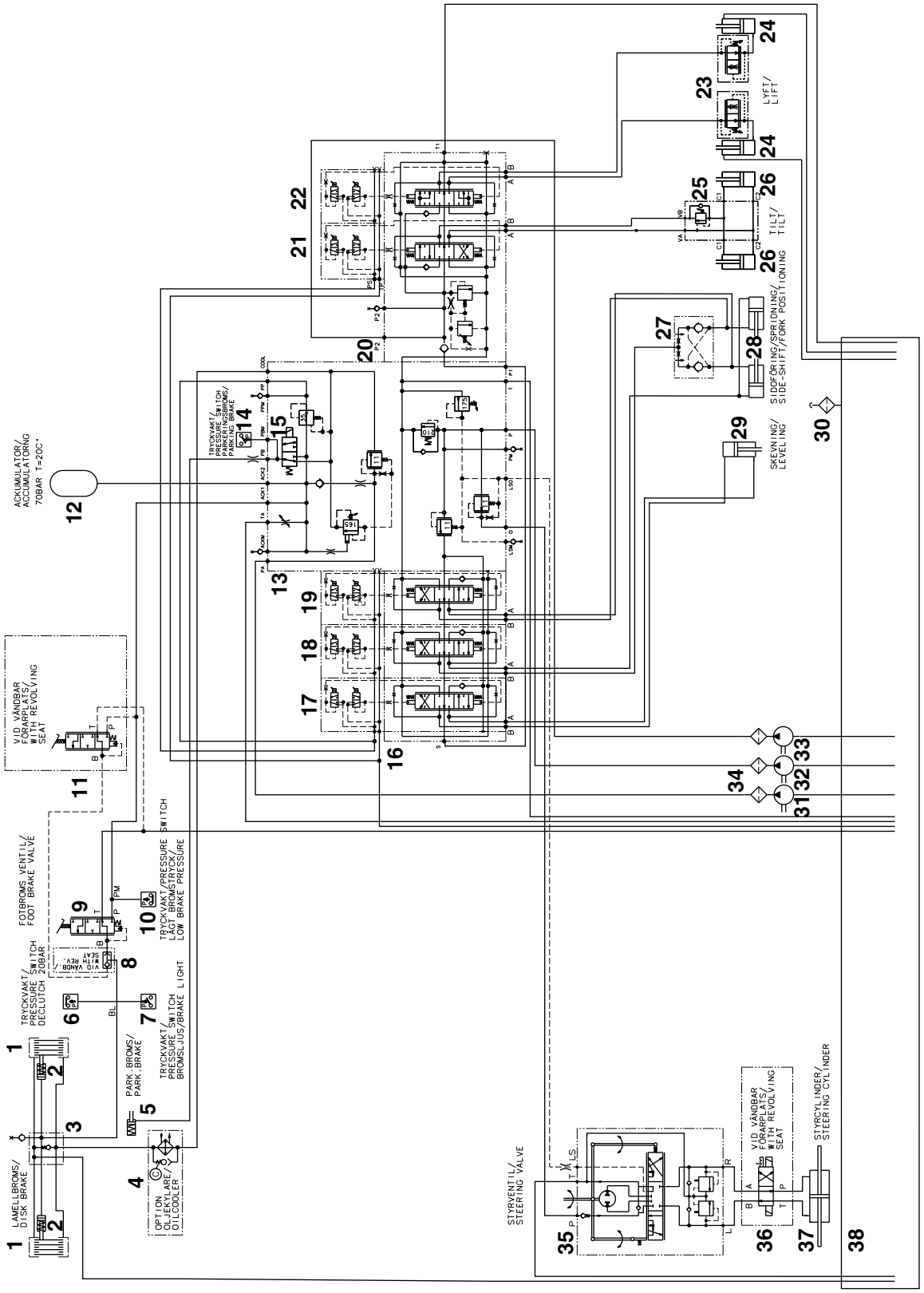


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1. Wheel brake
2. Brake cylinder
3. Drive axle block
4. Hydraulic oil cooler
5. Parking brake calliper
6. Switch normally closed (NC) disengagement (S220)
7. Switch normally open (NO) brake light (S216)
8. Shuttle valve, reversible operator’s seat
9. Brake valve
10. Switch normally closed (NC) low brake pressure (S204)
11. Extra brake valve, reversible operator’s seat
12. Accumulator
13. Main valve
14. Switch normally open (NO) parking brake (S200)
15. Solenoid valve parking brake (Y642)
16. Control valves for twistlock, spreading and side shift
17. Control valves for tilt and lift
18. Control levers
19. Solenoid valve blocking lift (Y6045)
20. Solenoid valve blocking twistlock (Y6044)
21. Load control valve
22. Lift cylinder
23. Load holding valve
24. Tilt cylinder
25. Side shift cylinder
26. Spreading cylinders
27. Twistlock cylinders
28. Breather filter hydraulic oil tank
29. Hydraulic oil pump for brake system and servo circuit for load handling
30. Hydraulic oil pump for steering and load handling
31. Hydraulic oil pump for lifting and tilting
32. High-pressure filter
33. Steering valve
34. Directional valve with solenoid valve steering forward (Y636-1) and steering reverse (Y636-2), reversible driver´s seat
35. Steering cylinder
36. Hydraulic oil tank

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Hydraulic diagram A40750.2000

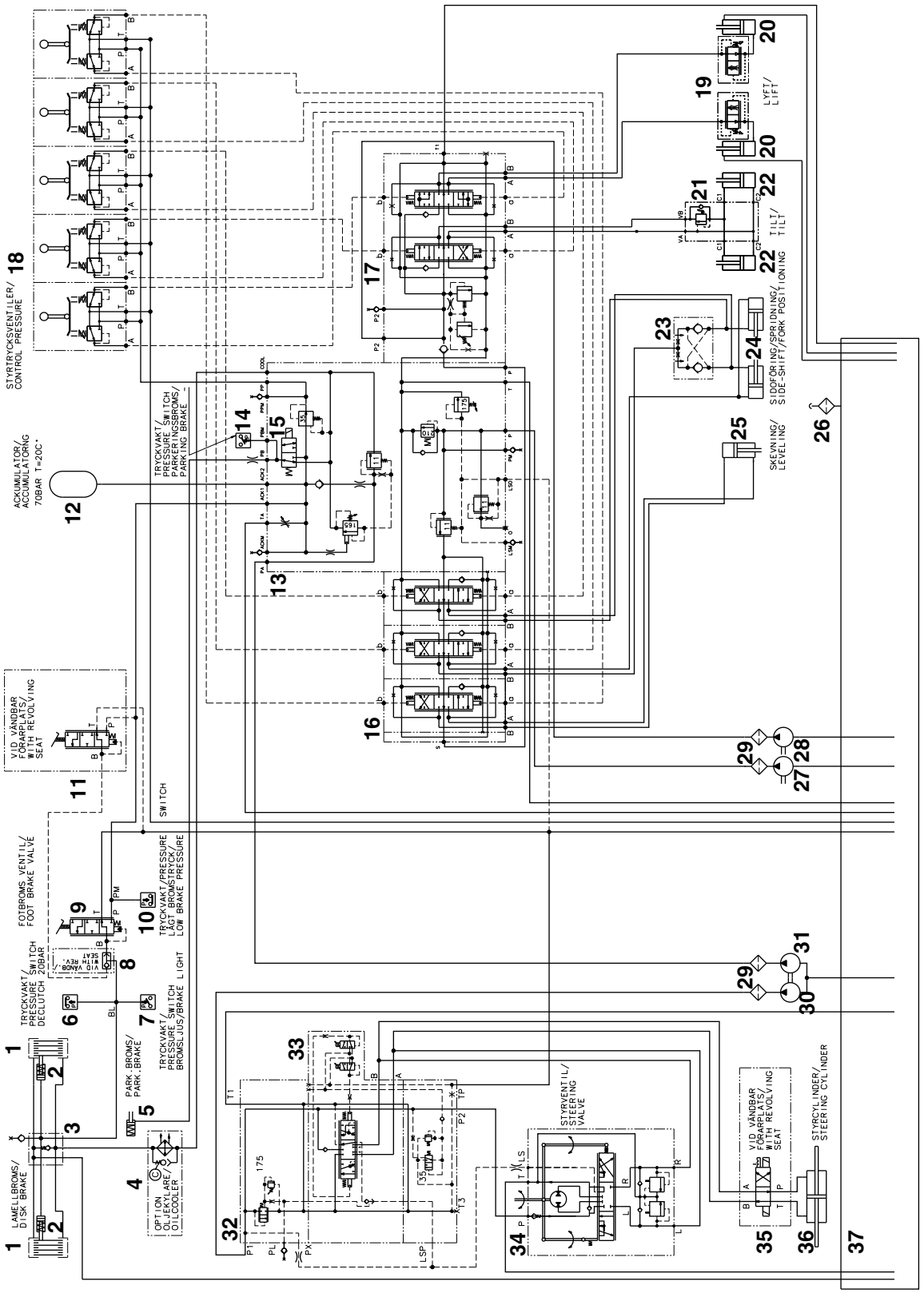


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1. Wheel brake
2. Brake cylinder
3. Drive axle block
4. Hydraulic oil cooler
5. Parking brake calliper
6. Switch normally closed (NC) disengagement (S220)
7. Switch normally open (NO) brake light (S216)
8. Shuttle valve, reversible operator’s seat
9. Brake valve
10. Switch normally closed (NC) low brake pressure (S204)
11. Extra brake valve, reversible operator’s seat
12. Accumulator
13. Main valve
14. Switch normally open (NO) parking brake (S200)
15. Solenoid valve parking brake (Y642)
16. Control valves for levelling, spreading and side shift
17. Solenoid valve levelling down (Y6022) or up (Y6023)
18. Solenoid valve spreading in (Y6019) or out (Y6018)
19. Solenoid valve side shift left (Y6020) or out (Y6021)
20. Control valves for tilt and lift
21. Solenoid valve lift (Y6005) or lower (Y6004)
22. Solenoid valve tilt in (Y6011) or out (Y6010)
23. Load control valve
24. Lift cylinder
25. Load holding valve
26. Tilt cylinder
27. Flow divider
28. Side shift and spreading cylinders
29. Levelling cylinder
30. Breather filter hydraulic oil tank
31. Hydraulic oil pump for brake system and servo circuit for load handling
32. Hydraulic oil pump for steering and load handling
33. Hydraulic oil pump for lifting and tilting
34. High-pressure filter
35. Steering valve
36. Directional valve with solenoid valve steering forward (Y636-1) and steering reverse (Y636-2), reversible driver´s seat
37. Steering cylinder
38. Hydraulic oil tank

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Hydraulic diagram A40750.2100

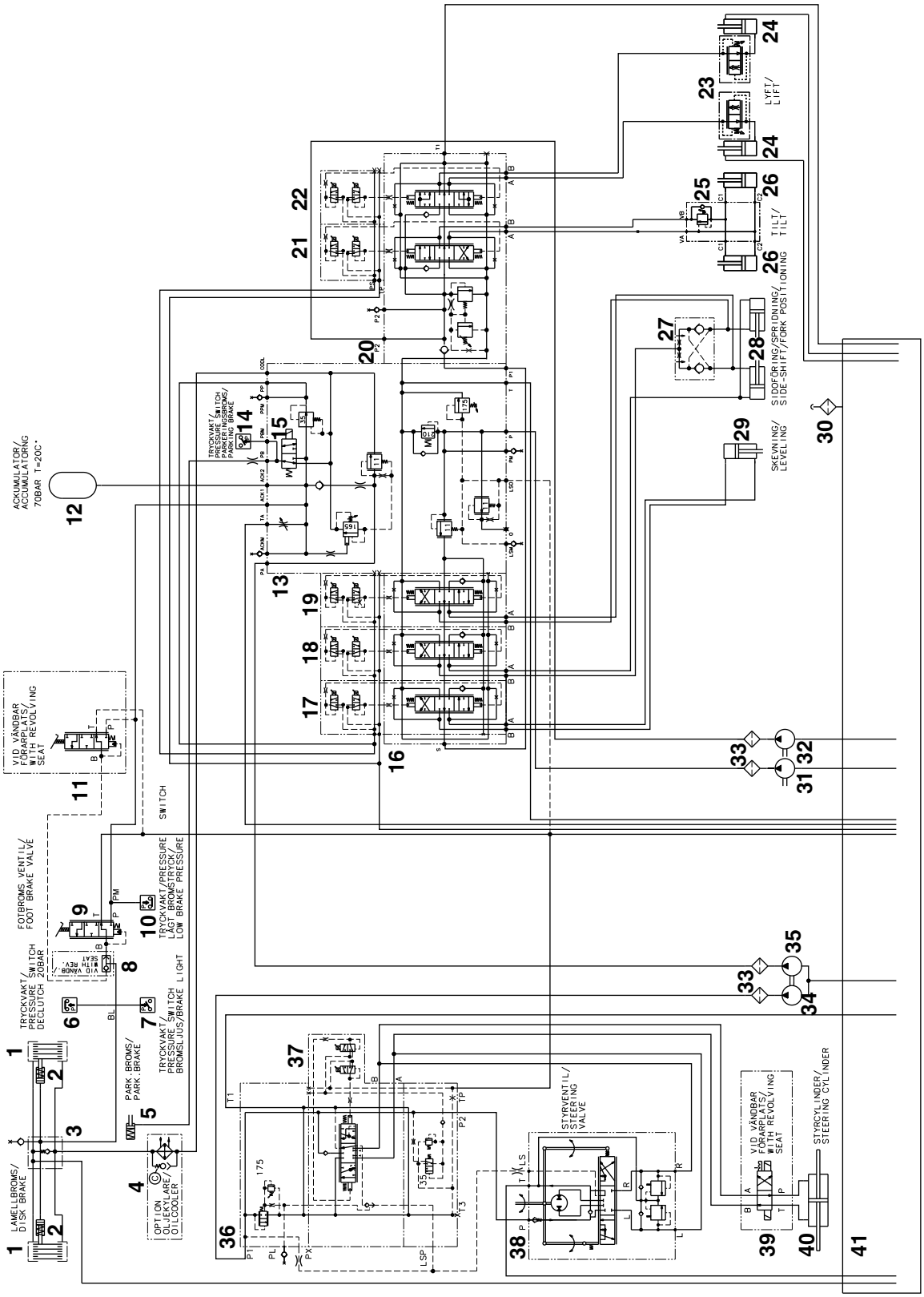


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1. Wheel brake
2. Brake cylinder
3. Drive axle block
4. Hydraulic oil cooler
5. Parking brake calliper
6. Switch normally closed (NC) disengagement (S220)
7. Switch normally open (NO) brake light (S216)
8. Shuttle valve, reversible operator’s seat
9. Brake valve
10. Switch normally closed (NC) low brake pressure (S204)
11. Extra brake valve, reversible operator’s seat
12. Accumulator
13. Main valve
14. Switch normally open (NO) parking brake (S200)
15. Solenoid valve parking brake (Y642)
16. Control valves for levelling, spreading and side shift
17. Control valves for tilt and lift
18. Control levers
19. Load control valve
20. Lift cylinder
21. Load holding valve
22. Tilt cylinder
23. Flow divider
24. Side shift and spreading cylinders
25. Levelling cylinder
26. Breather filter hydraulic oil tank
27. Hydraulic oil pump for steering and load handling
28. Hydraulic oil pump for lifting and tilting
29. High-pressure filter
30. Hydraulic oil pump mini-wheel/lever steering
31. Hydraulic oil pump for brake system and servo circuit for load handling
32. Control valve mini-wheel/lever steering
33. Solenoid valve steering right (Y615-1) and left (Y615-2)
34. Steering valve
35. Directional valve with solenoid valve steering forward (Y636-1) and steering reverse (Y636-2), reversible driver´s seat
36. Steering cylinder
37. Hydraulic oil tank

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Hydraulic diagram A40750.2200

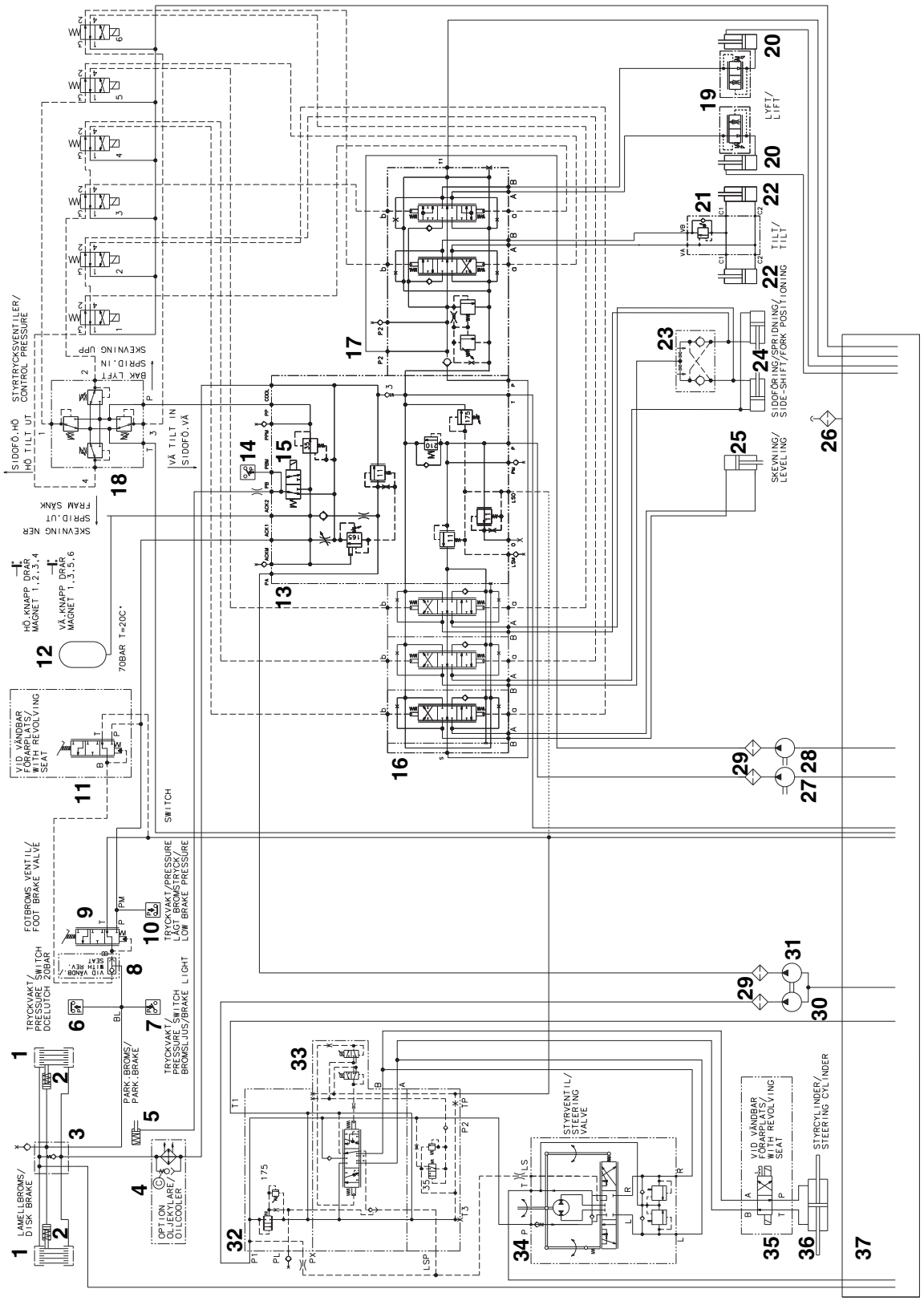


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1. Wheel brake
2. Brake cylinder
3. Drive axle block
4. Hydraulic oil cooler
5. Parking brake calliper
6. Switch normally closed (NC) disengagement (S220)
7. Switch normally open (NO) brake light (S216)
8. Shuttle valve, reversible operator’s seat
9. Brake valve
10. Switch normally closed (NC) low brake pressure (S204)
11. Extra brake valve, reversible operator’s seat
12. Accumulator
13. Main valve
14. Switch normally open (NO) parking brake (S200)
15. Solenoid valve parking brake (Y642)
16. Control valves for levelling, spreading and side shift
17. Solenoid valve levelling down (Y6022) or up (Y6023)
18. Solenoid valve spreading in (Y6019) or out (Y6018)
19. Solenoid valve side shift left (Y6020) or out (Y6021)
20. Control valves for tilt and lift
21. Solenoid valve lift (Y6005) or lower (Y6004)
22. Solenoid valve tilt in (Y6011) or out (Y6010)
23. Load control valve
24. Lift cylinder
25. Load holding valve
26. Tilt cylinder
27. Flow divider
28. Side shift and spreading cylinders
29. Levelling cylinder
30. Breather filter hydraulic oil tank
31. Hydraulic oil pump for steering and load handling
32. Hydraulic oil pump for lifting and tilting
33. High-pressure filter
34. Hydraulic oil pump mini-wheel/lever steering
35. Hydraulic oil pump for brake system and servo circuit for load handling
36. Control valve mini-wheel/lever steering
37. Solenoid valve steering right (Y615-1) and left (Y615-2)
38. Steering valve
39. Directional valve with solenoid valve steering forward (Y636-1) and steering reverse (Y636-2), reversible driver´s seat
40. Steering cylinder
41. Hydraulic oil tank

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Hydraulic diagram A40750.3000



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1. Wheel brake
2. Brake cylinder
3. Drive axle block
4. Hydraulic oil cooler
5. Parking brake calliper
6. Switch normally closed (NC) disengagement (S220)
7. Switch normally open (NO) brake light (S216)
8. Shuttle valve, reversible operator’s seat
9. Brake valve
10. Switch normally closed (NC) low brake pressure (S204)
11. Extra brake valve, reversible operator’s seat
12. Accumulator
13. Main valve
14. Switch normally open (NO) parking brake (S200)
15. Solenoid valve parking brake (Y642)
16. Control valves for levelling, spreading and side shift
17. Control valves for tilt and lift
18. Joy-stick
19. Load control valve
20. Lift cylinder
21. Load holding valve
22. Tilt cylinder
23. Flow divider
24. Side shift and spreading cylinders
25. Levelling cylinder
26. Breather filter hydraulic oil tank
27. Hydraulic oil pump for steering and load handling
28. Hydraulic oil pump for lifting and tilting
29. High-pressure filter
30. Hydraulic oil pump mini-wheel/lever steering
31. Hydraulic oil pump for brake system and servo circuit for load handling
32. Control valve mini-wheel/lever steering
33. Solenoid valve steering right (Y615-1) and left (Y615-2)
34. Steering valve
35. Directional valve with solenoid valve steering forward (Y636-1) and steering reverse (Y636-2), reversible driver´s seat
36. Steering cylinder
37. Hydraulic oil tank

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11 Common electrics

Circuit diagram, description

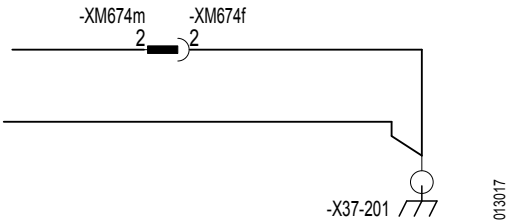
A circuit diagram is divided into circuit names (drawing numbers) and consists of a set of numbered pages.

The following is an explanation of symbols in circuit diagrams:

- 20015.0001 circuit drawings-post designations K-standard.
- K-standard 1: norms, rules
- K-standard 2: cables, general physical
- K-standard 5: Designation and marking system, item designations circuit drawings

The following is an explanation of symbols and texts in a circuit diagram:

Connectors



Connectors in the wiring start with an X followed by a number and end with f = female or m = male. If a connector is connected to a component then the component number is inherited into the connector's number, e.g. XB72002 Rm which is the connector for Sensor, alignment front right (B7202R).

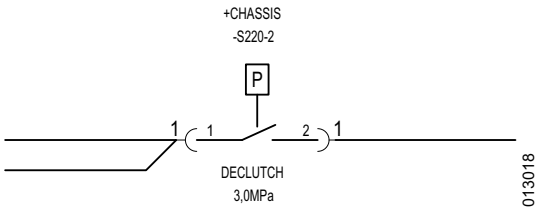
Under the connector's number the pin is specifie with numbers or letters depending on the connector.

- X37-: All grounding points start with X37, e.g. X37-201, which is a grounding point on the frame.

  X37-A: X37-B, X37-C and X37-D are grounding points in electronic box, cab.

  Zero references are in the control units.

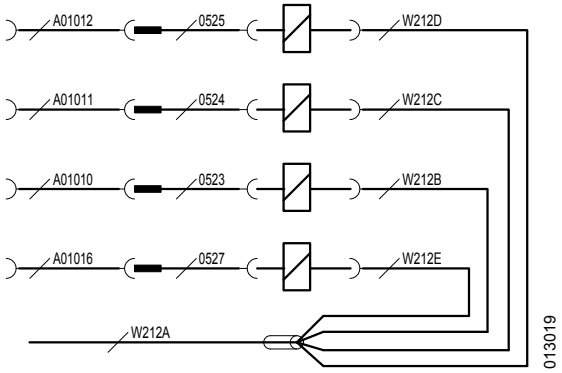
Components

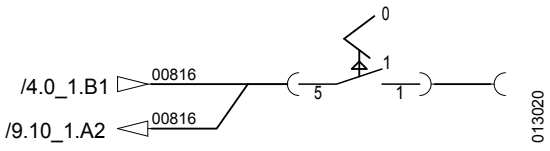


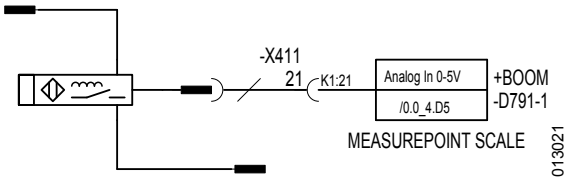
Components are described with component number (S220-2) and a short descriptive text. Components (sensors, switches, etc.) are shown in standby mode i.e. de-energized or mechanically relieved position.

- S indicates the type of component, see Component designations, page 18.
- 220 is component number and indicates the function the component has.
- - 2 indicates that it is the second component of this type for the specific diagram.

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Cable marking

All cables are either white (ground signal) or grey (other wiring) and labelled with numbers.

Cable numbering is interpreted as follows:

- 0525: the number on a cable can usually be traced to a pin in a connector, in this example, connector X052 pin 5.
- W212: cables that start with W and serial number cannot be traced directly to a connector.
- A01012: cables that start with A are in the electronic box in the cab.
- W212D: cables that end witha capital letter are jointed in the wiring from a main cable with the same number. Each joint will have its own letter.

References

A narrow symbo lmeans that the circuit continues on an other page in the circuit diagram at the specified coordinates. Sometimes there are also references for components that can then be part of a component whose other parts are on a different diagram. In some cases there is also a help text where the cable connects.

Example: /11.5_1.D3 means page 11.5_1 coordinate D3.

Connection to control unit

Connections to control units are described as a table with two fields the upper one shows the type of connection, the lower one has a reference to the compilation of the control unit's connections. Together with this there are descriptive texts that specify control unit and signal.

For more information about the different connection types on the control units, see section 11 Common electrics, group 11.5.5 Cables.

Fuses

Fuse boxes always start with F5. Example: F58-3 means fuse box 3 with 8 fuses.

For most fuse boxes there is also a table and an explanation of the circuits that the various fuses protect.

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Component designations

The components in circuit diagrams have a prefix and number, the prefix describes the type of component, the number which component.

Component list with component number, prefix and designation is provided as an appendix after the circuit diagrams.

Prefix	Description
B	Converter from non-electric to electric signals or vice versa. Example: inductive sensor.
D	Binary element, delay unit, memory. Example: control unit.
E	White light. Example: work lighting.
F	Protective device. Example: fuse.
G	Alternator, power supply device. Example: battery.
H	Signal device. Example: horn, brake lights.
K	Relay, contactor. Example: power relay ignition key lock.
M	Motor. Example: electric motor.
P	Measuring instrument, testing equipment. Example: operating hour gauge.
R	Resistor. Example: potentiometer.
S	Electric switch for control circuit, selector. Example: switch.
X	Outlet/socket, connecting device Example: connection terminal.
Y	Electrically controlled mechanical device. Example: solenoid valve, hydraulic valve.

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Circuit diagrams, compilation

Circuit diagrams for basic machine has drawing number A49842.0100, and are provided as an appendix in following order.

Sheet	Designation
0.0-1	Circuit cross-reference ECU 790
0.0-2	Circuit cross-reference ECU 793
0.0-3	Circuit cross-reference ECU 796
0.0-4	Circuit cross-reference ECU 796
0.0-5	Circuit cross-reference ECU 792
1.0-A	Circuit engine Volvo TAD650VE, TAD660VE, TAD750VE and TAD760VE
1.0-B	Circuit engine Cummins
1.0-C	Circuit engine Perkins/Caterpillar
2.0-A1	Circuit, gear changing ECU 790
2.0-A2	Circuit, extra forward/reverse selector
2.0-A3	Circuit, gear changing, aut/ECU 793
2.0-A4	Circuit, gear changing, ECU 793
2.0-B1	Circuit, hydrostatic transmission
2.0-B2	Circuit, hydrostatic transmission
2.0-B3	Circuit, hydrostatic transmission
2.0-C1	Circuit, gear changing ZF
2.0-C2	Circuit, gear changing ZF
3.3	Circuit, differential lock
4.0-1	Circuit, cab
4.0-2	Circuit, cab VBFS
4.0-3	Circuit, monitoring brake pressure
4.5	Circuit, parking brake
5.2-1A	Circuit, control function
5.2-1B	Circuit, control function, VBFS
5.2-2A	Circuit, control function
5.2-2B	Circuit, control function, VBFS
7.0-1	Circuit, servo and hydraulic functions
7.0-2	Circuit, servo and hydraulic functions
7.0-3	Circuit, servo and hydraulic functions, VBFS
7.0-4	Circuit, ECU 796, joystick

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Sheet	Designation
7.0-5A	Circuit, ECU 796, joystick 2
7.0-5B	Circuit, ECU 796, joystick 2 VBFS
7.0-6A	Circuit, hydraulic joystick
7.0-6B	Circuit, hydraulic joystick, VBFS
7.2-1	Circuit, paper functions
7.2-2A	Circuit, sensors attachment
7.2-2B	Circuit, valves attachment
7.2-3	Circuit, indication lamps
7.2-4	Circuit, switches paper functions
7.2-5A	Circuit, stop lower
7.2-6	Circuit, Optispeed/rev/lift
7.10	Circuit, electronic scale
8.2-1	Circuit, data com. RED CAN
8.2-2	Circuit monitoring
8.2-3	Circuit sensors speed and engine rev.
8.2-4	Circuit data com. J1939
8.2-5	Circuit data com.
9.1	Circuit sensors/instruments
9.2	Circuit, alcolocks
9.3-1	Circuit, seat rotation
9.3-2	Circuit, electric seat rotation
9.3-3	Circuit, seat up/down
9.3-4	Circuit, throttle application
9.4-1	Circuit, ECC
9.4-2A	Circuit heating/AC
9.4-2AB	Circuit heating/AC
9.4-3	Circuit heating/AC Flexcab
9.4-5	Circuit heating/AC
9.4-6	Circuit ECC fan
9.4-7	Circuit pause heater
9.5-1	Circuit, wipers
9.6-1	Circuit, headlights
9.6-2	Circuit, headlights
9.6-3A	Circuit, headlights

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Sheet	Designation
9.6-3B	Circuit, headlights, VBFS
9.6-4	Circuit, headlights, VBFS
9.6-5A	Circuit, rear headlights, DCE90-
9.6-5B	Circuit, rear headlights, DCE50-90
9.6-5C	Circuit, rear headlights
9.6-6	Circuit working light
9.6-7	Circuit working light
9.6-8A	Circuit working light
9.6-8B	Circuit, working lights VBFS
9.6-9	Circuit light, engine bay
9.8-1	Circuit, cab
9.8-2	Circuit, compressor horn
9.14-1	Circuit option
11.5-1	Circuit power supply
11.5-2	Circuit power supply, fuses
11.5-3	Circuit power supply, fuses
11.5-4	Circuit power supply, ECU 792
11.5-5	Circuit power supply, ECU 793
11.5-6	Circuit power supply, ECU/EDU

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WIRING DIAGRAMS, DCE STEP 3 ENGINES

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		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS DCE 50-

Name: WIRING DCE 50-

Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 0/83

Utgåva/Issue: 07

E DRAWING

-D790

ECU790, Main K1 connector pinout				
	Power	/11.5_6.B4	Power Supply	
	CAN	/8.2_1.A7	CAN	
	1.3	See pin 2		
	1.4	See pin 2		
	1.5	See pin 2		
	1.6	See pin 2		
	1.7	See pin 1		
	1.8	See pin 1		
	1.9	/2.0_A1.D8	Input	GEAR SELECTOR
	1.10	/2.0_A1.D8	Input	GEAR SELECTOR
	1.11	/9.3_1.B8	Input	SEAT TURN CW
	1.12	/2.0_A1.C8	Input	FORWARD
	1.13	/2.0_A1.C8	Input	REVERSE
	1.14	/4.0_1.A7	Input	PARKING BRAKE PRESSURE
	1.15	/2.0_A1.A8	Input	INCHING/DECLUTCH
	1.16	/9.14_1.E8	Input	SPEED LIMIT 2(OPT)
	1.17	/11.5_1.C8	Input	KEY POSITION 3
	1.18	/9.3_1.B8	Input	SEAT TURN CCW
	1.19	/4.0_1.D8	Input	SEAT CONTACT
	1.20	/2.0_B2.B8	Input	SPREADING/FORK POSITON/DIFF. INTERLOCK
	1.21	/2.0_B2.A8	Input	Function 5
	1.22	/4.0_3.C8	Input	BRAKE PRESSURE
	1.23	/4.5.A8	Input	P-BRAKE SWITCH ON
	1.24	/8.2_2.E8	5V Analogue Ref	
	1.25	/8.2_2.E8	0V Analogue Ref	
	1.26	/9.3_4.A7	Analogue Input 0-5V	ACCELERATOR PEDAL
	1.27	/9.3_4.D7	Analogue Input 0-5V	LEFT PEDAL CH 1
	1.28	/8.2_2.D7	Analogue Input 0-5V	PRESSURE LIFT LEVER
	1.29	/7.10.C7	Analogue Input 0-5V	SCALE LOADCELL LEFT
	1.30	/7.10.C7	Analogue Input 0-5V	SCALE LOADCELL RIGHT
	1.31	/7.10.D7	Analogue Input	LOAD CELL TILT
	1.32	/2.0_B3.C2	Analogue Input	DIRECTION HYDROSTATIC MOTOR
	1.33	/2.0_B1.E7	Analogue Input	PRESSURE FORWARD
	1.34	/2.0_B1.E7	Analogue Input	PRESSURE REVERSE
	1.35	/8.2_3.D8	5V Analogue Ref	
	1.36	/7.10.D8	0V Analogue Ref	0 V REF
	1.37	/9.3_1.E1	Analogue Input	SEAT POSITION
	1.38	/8.2_2.B7	Analogue Input	COOLANT LEVEL
	1.39	/9.3_4.B7	Analogue Input	RIGHT PEDAL 180/40 Deg
	1.40	/9.3_4.E7	Analogue Input 0-5V	LEFT PEDAL 180/40 deg
	1.41	/9.3_4.D7	Analogue Input 0-5V	LEFT PEDAL CH 2
	1.42		Analogue Input	

-D790

ECU790, Main K2 connector pinout				
	2.1	/8.2_3.C8	Frequency Input	VEHICLE SPEED
	2.2	/8.2_3.C8	0V Analogue Ref	VEHICLE SPEED
	2.3	/8.2_3.A8	Frequency Input	RPM SENSOR ENGINE
	2.4	/8.2_3.A8	0V Analogue Ref	RPM SENSOR
	2.5		Frequency Input	
	2.6		Frequency Input	
	2.7		0V Analogue Ref	
	2.8	/8.2_2.A8	Reostat Input	FUEL LEVEL
	2.9	/8.2_2.B8	0V Analogue Ref	
	2.10	/11.5_2.C1	Digital Output	IGNITION SHUT OFF
	2.11	/9.3_2.C1	Digital Output	TURN SEAT CCW
	2.12	/7.2_6.B2	Digital Output	SUPPLY VALVE
	2.13	/2.0_B1.C1	Digital Output	HYDROSTATIC MOTOR
	2.14	/4.5.D3	Digital Output	P-BRAKE ON/OFF
	2.15	/3.3.E2	PWM Output	DIFF INTERLOCK
	2.16		RS232	
	2.17	See Pin.K2:16		
	2.18	See Pin K2:16		
	2.19		Temperature Input	
	2.20		Temperature Input	
	2.21	/8.2_2.A8	Temperature Input	TEMP HYDROSTAT OIL
	2.22	/8.2_2.B8	Temperature Input	Temp Outdoor
	2.23	/9.3_2.C1	PWM Output	LOW TURNING SPEED
	2.24	/9.3_1.C8	PWM OUT	SEAT TURNING BRAKE
	2.25	/2.0_B1.A1	PWM Output	PUMP FORWARD EDC
	2.26	/2.0_B1.B1	PWM Output	PUMP REVERSE EDC
	2.27	/2.0_B1.C8	PWM Output	MOTOR PDC
	2.28	/7.2_6.B8	PWM Output	OPTISPEED/REV/LIFT
	2.29	/9.3_2.C1	PWM Output	TURN SEAT CW
	2.30		Analogue Output	
	2.31		Analogue Output	
	2.32		0V Analogue Ref	
	2.33	Not used		
	2.34	Not used		
	2.35	Not used		
	2.36	Not used		
	2.37	Not used		
	2.38	/9.3_1.C1	Digital Output	SEAT FORWARD
	2.39	/11.5_1.C5	Digital Output	STARTER
	2.40	/9.6_8A.A1	Digital Output	REVERSE LIGHT
	2.41	/9.3_1.D1	Digital Output	SEAT TURNED
	2.42	See Pin K1:1		

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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

Kalmar

Benämning: KRETS KORSREFERENS ECU 790

Name: WIRING CROSS REFERENCE ECU 790

Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 0.0_1/83

Utgåva/Issue: 07

E DRAWING

-D793

ECU793, R1 connector pinout				
	A1	/11.5_5.B4		Power Supply
	B1	/2.0_A3.A1	VFS0+, FWD VFS HI SIDE OUT	Analogue Output
	C1	/2.0_A3.A8	VFS 0-, VFS LO SIDE IN	Analogue Output
	D1	/2.0_A3.C1	VFS 1+ 2ND VFS HI SIDE OUT	Analogue Output
	E1	/2.0_A3.C8	VFS 1- 2ND VFS LO SIDE IN	Analogue Output
	F1	/2.0_A3.B1	VFS+ REV VFS HI SIDE OUT	Analogue Output
	G1	/2.0_A3.B8	VFS 2- REV VFS LO SIDE IN	Analogue Output
	H1	/2.0_A3.C1	VFS 3+ 1ST/3RD VFS HI SIDE OUT	Analogue Output
	J1	/2.0_A3.C8	VFS 3- 1ST/3RD VFS LO SIDE IN	Analogue Output
	K1	/2.0_A3.D1	DO0 RSP DRIVE SOLENOID +	Digital Output
	A2	/2.0_A4.E8	VFS 0+ PRESSURE SENSOR	Reostat Input0-5kOhm
	B2		DIGIN0 2nd GEAR	Input
	C2		DIGIN1 1st GEAR	Input
	D2		DIGIN2 SEAT ROTATED	Input
	E2		DO1 ALARM OUTPUT	Digital Output
	F2	/2.0_A4.F8	DO2 PRESSURE SENSOR	Digital Output
	G2		DIGIN3 3rd GEAR	Input
	H2		DIGIN4 FORWARD	Input
	J2		DIGIN5 REVERSE	Input
	K2	/2.0_A3.D8	DO3 DRIVE SOLENOID-	Digital Output
	A3	See pin A1		
	B3	/2.0_A4.B8	SS0+ IN DRUM SPEED	RPM
	C3	/2.0_A4.C8	SS0- DRUM SPEED	RPM
	D3	/2.0_A4.B8	SS1+ IN OUTPUT SPEED	RPM
	E3	/2.0_A4.B8	SS1- OUTPUT SPEED	RPM
	F3	/2.0_A4.A8	SS2+ ENGINE SPEED SENSOR	RPM
	G3	/2.0_A4.A8	SS2- ENGINE SPEED SENSOR	RPM
	H3	/2.0_A4.A8	ANI1 ENGINE SPEED	AnalogueInput0-5kOhm
	J3	/2.0_A4.D8	ANI2 IN TEMP SENSOR COOLER	Analogue Input 0-5V
	K3	/2.0_A4.D8		Signal GND

-D793

ECU793, R2 connector pinout				
	L1		PWM4+	PWM Output
	M1	/2.0_A4.E8	ANI4 5V OUT	5V Analogue Ref
	N1		PWM5+	PWM Output
	P1		ANI 5	Analogue Input 0-5V
	R1	/2.0_A3.D1	PWM6+ BRAKE VALVE	PWM Output
	S1		ANI6 ACCELERATOR PEDAL	Analogue Input 0-5V
	L2			CAN
	M2	See pin L2		
	N2	/8.2_5.C2		RS 232
	P2	See pin N2		
	R2	/2.0_A4.C8	SS3+ IN TURBINE SPEED	RPM
	S2	See contact R1, pin A1		
	L3		DIGIN6 INCHING	Input
	M3		DIGIN7 MAN/AUT GEAR	Input
	N3		DIGIN8 PARKING BRAKE	Input
	P3			
	R3		ANI3 BRAKE PEDAL	Analogue Input 0-5V
	S3	See contact R1, pin A1		

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	Sign.	Datum/Date	Huvudnr./Project no.
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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS KORSREFERENS ECU 793

Name: WIRING CROSS REFERENCE ECU 793

Produkt/Product: DCE50- TIER 3

Ritn.nr./ Drawing No.: A49842.0100

Blad/Sheet: 0.0_2/83

Utgåva/Issue: 07

E DRAWING

-D796

ECU/PWM, Main connector pinout

Power	/11.5_6.C4	Power Supply
CAN	/8.2_1.E7	CAN
1.3	See pin 2	
1.4	See pin 2	
1.5	See pin 2	
1.6	See pin 2	
1.7	See pin 1	
1.8	See pin 1	
1.9	/7.0_2.A8	Analog Input
1.10	/7.0_2.B8	Analog Input
1.11	/7.0_2.C8	Analog Input
1.12	/7.0_2.C8	Analog Input
1.13	/7.0_2.D8	Analog Input
1.14	See pin 1	
1.15	See pin 1	
1.16	/7.2_1.A8	Analog Input
1.17	/7.2_1.B8	Analog Input
1.18	/7.2_2A.A8	Analog Input
1.19	/7.2_2A.B8	Analogue Input
1.20	/7.2_2A.B8	Analog Input
1.21	/7.2_2A.C8	Analog Input
1.22	/7.2_1.E8	Analogue Input
1.23		Temperature Input
1.24		Temperature Input
1.25		Temperature Input
1.26	/7.0_2.A8	0V Analog Reference
1.27	/7.0_2.A1	10V Analog Reference
1.28	See pin 1	
1.29		Temperature Input
1.30	/4.0_1.E8	Input
1.31	/7.2_1.C8	Input
1.32	/7.2_4.B8	Input
1.33	/7.2_1.D8	Input
1.34	/7.2_1.D8	Input
1.35		Input
1.36	/7.2_4.A8	Input
1.37	/7.2_4.C8	Input
1.38	/7.2_2A.D8	Input
1.39	/7.2_4.D8	Input
1.40	/7.2_4.B8	Input
1.41	/7.2_5A.B8	Input
1.42	Not Used	

LEVER LIFT
LEVER TILT
LEVER SIDE SHIFT
LEVER FORK POSITION
LEVER EXTRA
LIFT HEIGHT
TILT ANGLE
PRESSURE RIGHT CLAMP P1
PRESSURE RIGHT CLAMP P2
PRESSURE LEFT CLAMP P1
PRESSURE LEFT CLAMP P2
CLAMP PRESSURE
POWER SUPPLY LEVERS
POWER SUPPLY LEVERS
HYDRAULIC FUNCTIONS ENABLE
LIFT HEIGHT SELECTION
VERTICAL POSITION
INCREASE HEIGHT
DECREASE HEIGHT
OVERRIDE DRIVE/LOWER STOP
AUTO RELEASE/AUTO CLAMP
LOCK UPPER ARM
EXTENDER
PAPER FUNCTIONS ON/OFF
SHIFT HYDRALIC FUNCTION
ULTRA SONIC SENSOR, LOAD AT LOW POSITION

-D796

ECU/PWM, PWM 1 connector pinout

Power, pin 1 and 9	/11.5_6.C6	PWM POWER	
2.2	Not Used		
2.3	/7.0_1.A8	PWM Output	LIFT DOWN
2.4	/7.0_1.A8	PWM Output	LIFT UP
2.5	/7.0_1.B8	PWM Output	TILT OUT
2.6	/7.0_1.B8	PWM Output	TILT IN
2.7	/7.0_1.C8	PWM Output	SIDE SHIFT LEFT
2.8	/7.0_1.C8	PWM Output	SIDE SHIFT RIGHT
2.9	See pin1		
2.10	/7.0_1.A1	Common PWM Out +24 V	POWER SUPPLY FOR VALVES
2.11	/7.0_1.D8	PWM Output	FORK POSITION OUT
2.12	/7.0_1.D8	PWM Output	FORK POSITION IN
2.13	/7.0_1.E8	PWM Output	EXTRA OUT
2.14	/7.0_1.E8	PWM Output	EXTRA IN
2.15	/7.2_2B.B1	PWM Output	UPPER ARMS OFF
2.16		PWM Output	VERTICAL ACTIVE

-D796

ECU/PWM, PWM 2 connector pinout

3.1	/11.5_6.D7	PWM Power Supply	
3.2	Not Used		
3.3	/7.2_2B.C1	PWM Output	CLAMP PRESSURE 1
3.4			
3.5			
3.6			
3.7			
3.8	/7.2_2B.E1	PWM Output	LASER
3.9	See pin1		
3.10	/7.2_2B.C8	Common PWM Out +24 V	
3.11	/7.2_2B.C1	PWM Output	CLAMP PRESSURE 2
3.12	/7.2_3.A8	PWM Output	GREEM LAMP (CLAMP PRESSURE OK)
3.13	/7.2_3.B8	PWM Output	YELLOW LAMP (VERTICAL LATCH)
3.14	/7.2_3.C8	PWM Output	RED LAMP (OVERLOAD,EXTENDER OUT,OVERRIDE)
3.15	/7.2_2B.D1	PWM Output	SIDESHIFT/UPPER ARMS UP-DOWN
3.16	/7.2_2B.E1	PWM Output	(EXT/ROTATION)/(SIDESHIFT/ROTATION(OPT))

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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS KORSREFERENS ECU 796

Name: WIRING CROSS REFERENCE ECU 796

Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 0.0_3/83

Utgåva/Issue: 07

E DRAWING

=Joystick2

-D796

ECU/PWM, Main connector pinout

Power			
CAN			
1.3	See pin 2		
1.4	See pin 2		
1.5	See pin 2		
1.6	See pin 2		
1.7	See pin 1		
1.8	See pin 1		
1.9	/7.0_5A.A8	Analogue Input	LIFT/LOWER
1.10	/7.0_5A.B8	Analogue Input	TILT
1.11	/7.0_5A.B8	Analogue Input	SIDE SHIFT
1.12	/7.0_5A.C8	Analogue Input	SPREAD
1.13			
1.14	See pin 1		
1.15	See pin 1		
1.16			
1.17			
1.18			
1.19			
1.20			
1.21			
1.22			
1.23			
1.24			
1.25			
1.26	/7.0_5A.A8	0V Analogue Ref	
1.27	/7.0_5A.A1	10V Analogue Ref	
1.28	See pin 1		
1.29			
1.30	/7.0_5A.F8	Input	
1.31	/7.0_5A.E8	Input	
1.32	/7.0_5A.D8	Input	
1.33	/7.0_5A.D8	Input	
1.34	/7.0_5A.E8	Input	
1.35	/7.0_5A.D8	Input	
1.36			
1.37			
1.38			
1.39			
1.40			
1.41			
1.42	Not Used		

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https://truckmanualshub.com/

Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS KORSREFERENS ECU 796

Name: WIRING CROSS REFERENCE ECU 796

Produkt/Product: DCE50- TIER 3

Ritn.nr./ Drawing No.: A49842.0100

Blad/Sheet: 0.0_4/83

Utgåva/Issue: 07

E-DRAWING

-D792

ECU792, Main K1 connector pinout	PIN NUMBER	DRAWING	FUNCTION	TYPE
	1.1	/5.2_2A.D8	SUPPLY 0V	0V REF
	1.2	/5.2_1A.A8	ALT STEERING ON	DIG. INPUT
	1.3	/5.2_2A.A8	STEER WHEEL MOVEMENT	DIG. INPUT
	1.4	/5.2_1A.C8	GEAR UP	DIG. INPUT
	1.5	/5.2_1A.D8	GEAR DOWN	DIG. INPUT
	1.6	/5.2_1A.F8	STEERING RIGHT	PWM OUTPUT
	1.7	/5.2_1A.E8	STEERING LEFT	PWM OUTPUT
	1.8	/5.2_1A.F1	STEERING RIGHT	ANALOGUE INPUT
	1.9	/5.2_1A.E1	STEERING LEFT	ANALOGUE INPUT
	1.10			
	1.11			
	1.12			
	1.13			
	1.14	/5.2_2A.E8	SUPPLY 5V	5V REF
	1.15			
	1.16			
	1.17			
	1.18			
	1.19			
	1.20	SEE PIN 13		
	1.21	SEE PIN 13		
	1.22			
	1.23			
	1.24			
	1.25			
	1.26			
	1.27			
	1.28	/11.5_4.B4	SUPPLY 24 V	POWER SUPPLY
	1.29	SEE PIN 28		
	1.30			
	1.31	/5.2_2A.D8	STEERING LEVER	ANALOGUE INPUT
	1.32	/5.2_2A.E8	STEERING AXLE	ANALOGUE INPUT
	1.33			
	1.34			
	1.35	/5.2_2A.B8	MINIWHEEL CHANNEL A	ANALOGUE INPUT
	1.36	/5.2_2A.C8	MINIWHEEL CHANNEL B	ANALOGUE INPUT
	1.37	/8.2_1.B7	CAN	CAN
	1.38	SEE PIN 37		
	1.39	SEE PIN 37		
	1.40	/5.2_1A.B1	ALT.STEERING ON	DIG.OUT
	1.41			
	1.42	SEE PIN 28		

=VBFS
-D792

ECU792, Main K1 connector pinout	PIN NUMBER	DRAWING	FUNCTION	TYPE
	1.1	/5.2_2B.D8	SUPPLY 0V	0V REF
	1.2	/5.2_1B.A8	ALT. STEERING ON	DIG.INPUT
	1.3	/5.2_2B.A8	STEER WHEEL MOVEMENT	DIG.INPUT
	1.4	/5.2_1B.C8	GEAR UP	DIG.INPUT
	1.5	/5.2_1B.D8	GEAR DOWN	DIG.INPUT
	1.6	/5.2_1B.F8	STEERING RIGHT	PWM OUTPUT
	1.7	/5.2_1B.E8	STEERING LEFT	PWM OUTPUT
	1.8	/5.2_1B.F1	STEERING RIGHT	ANALOGUE INPUT
	1.9	/5.2_1B.E1	STEERING LEFT	ANALOGUE INPUT
	1.10			
	1.11			
	1.12			
	1.13			
	1.14	/5.2_2B.E8	SUPPLY 5V	5V REF
	1.15			
	1.16			
	1.17			
	1.18			
	1.19			
	1.20	SEE PIN 13		
	1.21	SEE PIN 13		
	1.22			
	1.23			
	1.24			
	1.25			
	1.26			
	1.27			
	1.28			
	1.29	SEE PIN 28		
	1.30			
	1.31	/5.2_2B.D8	STEERING LEVER	ANALOGUE INPUT
	1.32	/5.2_2B.E8	STEERING AXLE	ANALOGUE INPUT
	1.33			
	1.34			
	1.35	/5.2_2B.B8	MINIWHEEL CHANNEL A	ANALOGUE INPUT
	1.36	/5.2_2B.C8	MINIWHEEL CHANNEL B	ANALOGUE INPUT
	1.37			
	1.38	SEE PIN 37		
	1.39	SEE PIN 37		
	1.40	/5.2_1B.B1	ALT. STEERING ON	DIG.OUT
	1.41			
	1.42	SEE PIN 28		

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

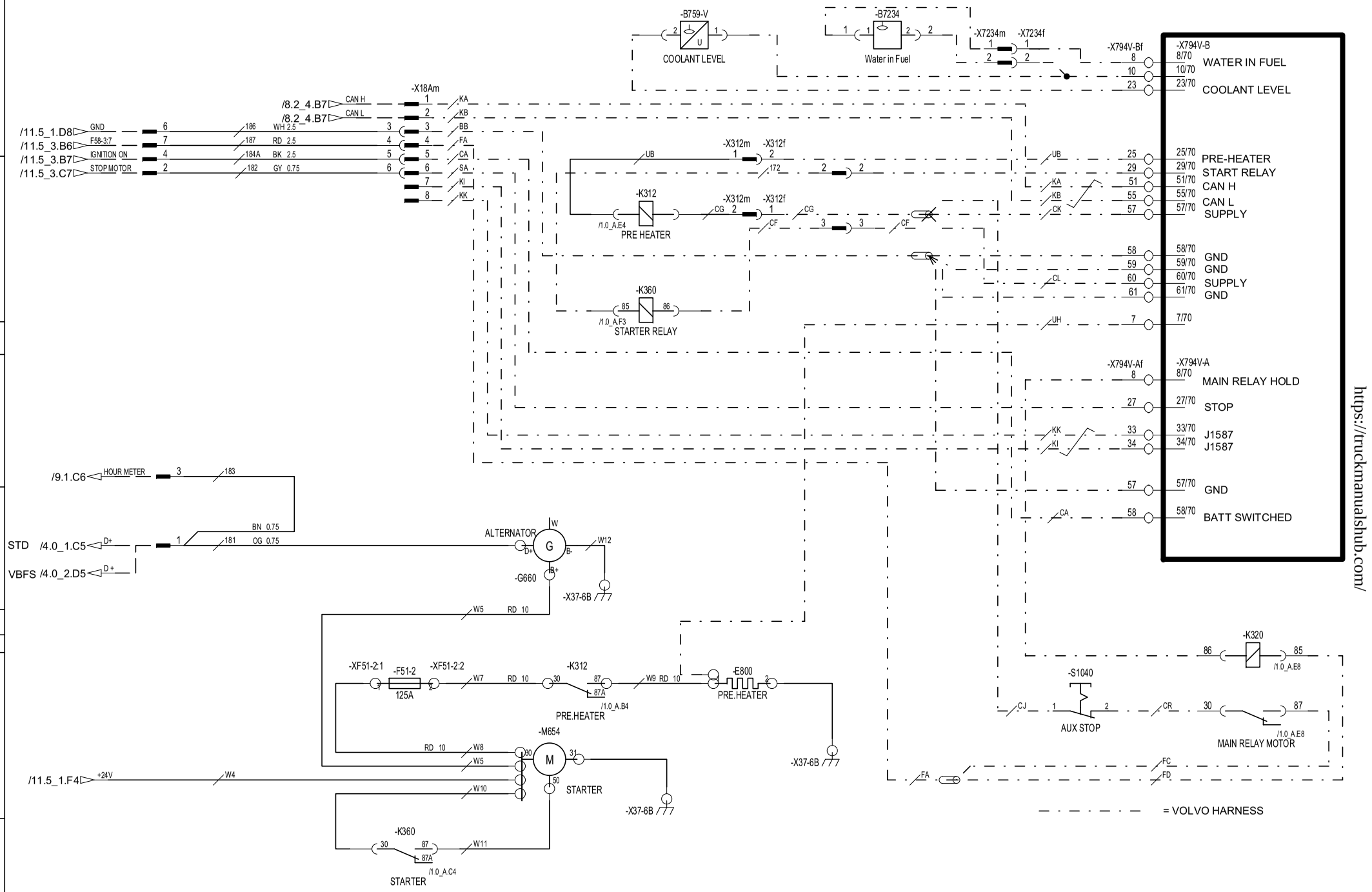
Kalmar

Benämning: KRETS KORSREFERENS ECU 792
Name: WIRING CROSS REFERENCE ECU 792

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 0.0_5/83
Utgåva/Issue: 07

E DRAWING



Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	125A fuse and fuseholder for Volvo engine added	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning: KRETS MOTOR VOLVO TAD 750/650

Name: WIRING MOTOR VOLVO TAD750/650

Produkt/Product: DCE50- TIER 3

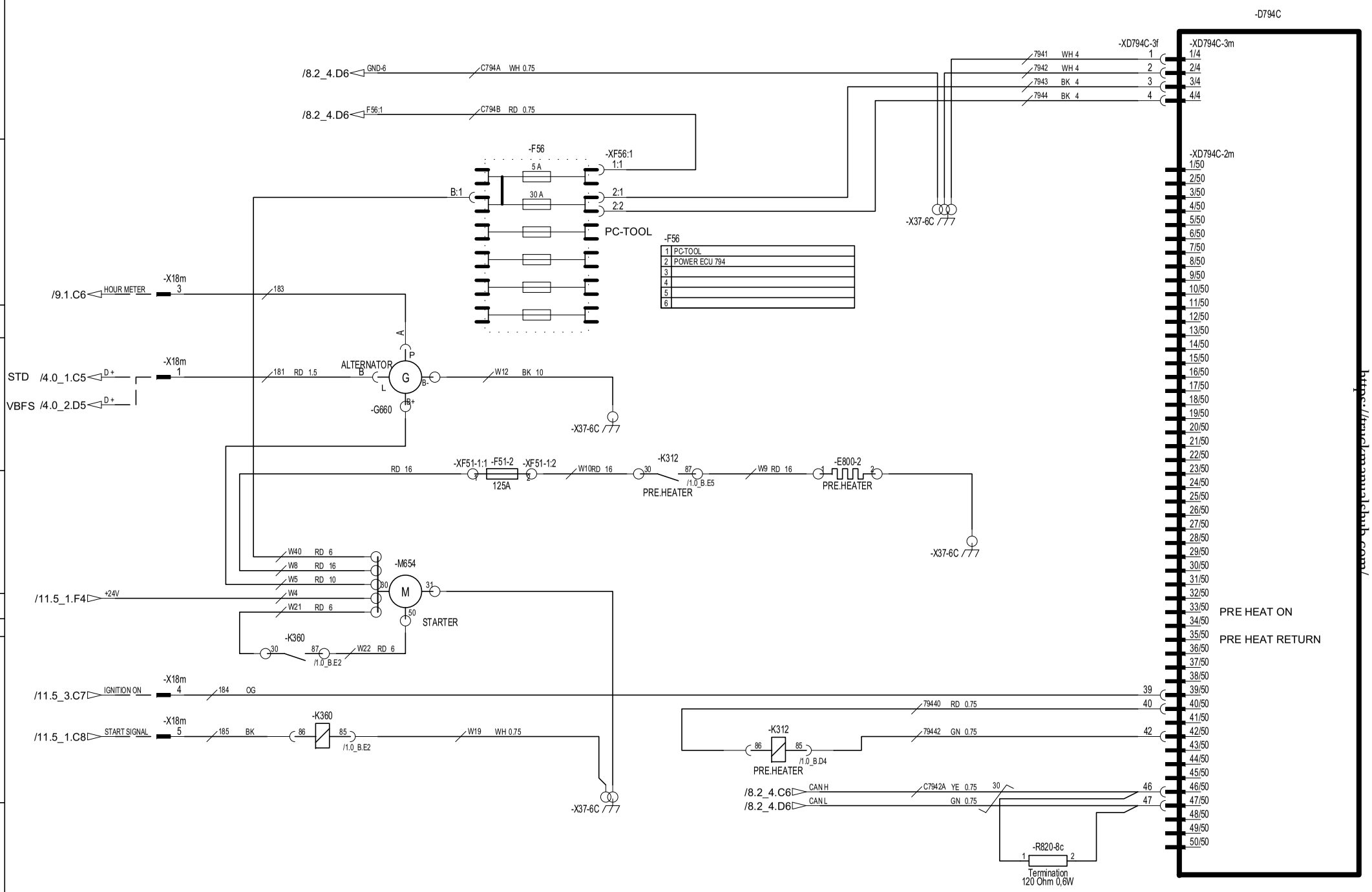
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 1.0_A/83

Utgåva/Issue: 07

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

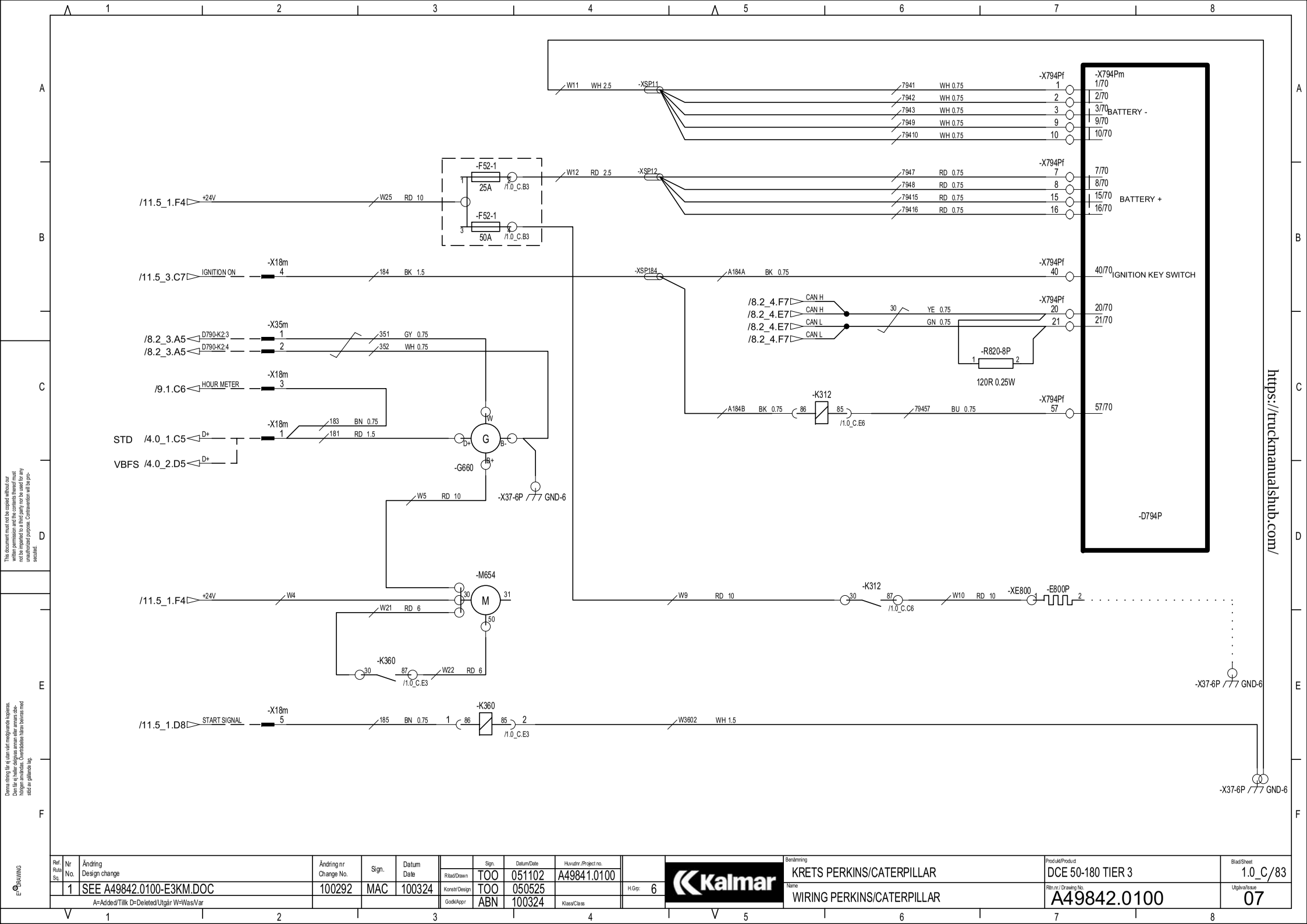
Kalmar

Benämning: KRETS MOTOR CUMMINS
Name: WIRING ENGINE CUMMINS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 1.0_B/83
Utgåva/Issue: 07

E DRAWING



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
R:tad/Drawn	TOO	051102	A49841.0100
Konstr/Design	TOO	050525	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

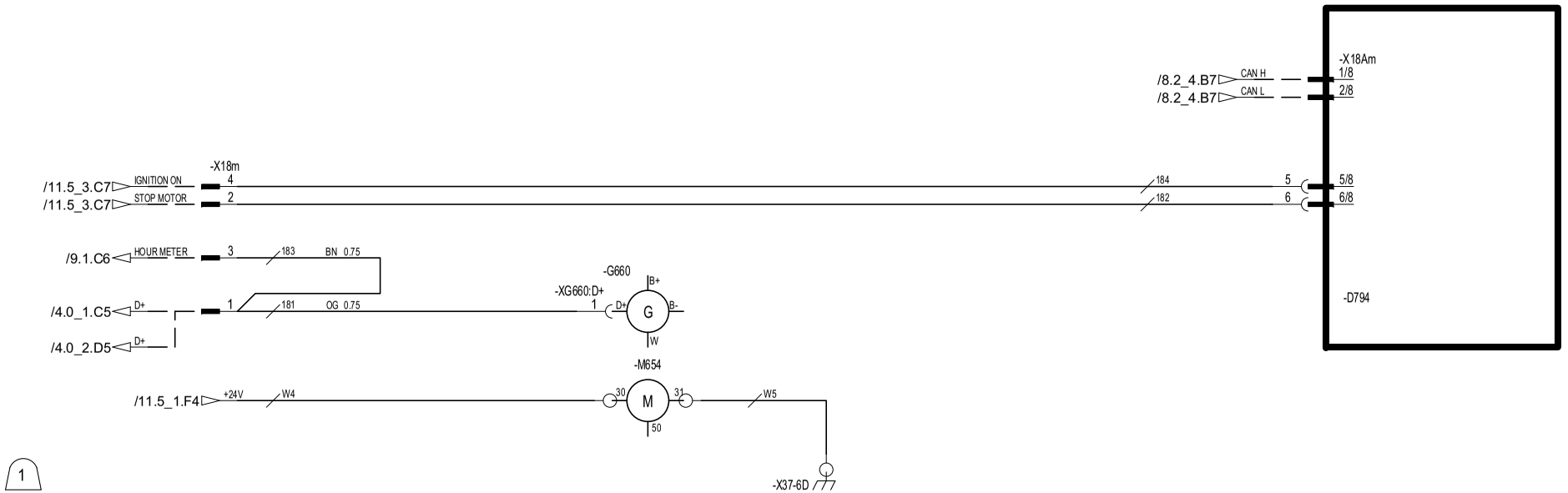
Kalmar

Benämning: KRETS PERKINS/CATERPILLAR
Name: WIRING PERKINS/CATERPILLAR

Produkt/Product: DCE 50-180 TIER 3
Ritn.nr./ Drawing No.: A49842.0100

Blad/Sheet: 1.0_C/83
Utgåva/Issue: 07

E DRAWING



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1		100292	MAC	100324

A=Added/Tillk D=Deleted/Utgår W=Was/Var

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	091223	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS MOTOR VOLVO TAD761

Name: WIRING MOTOR VOLVO TAD761

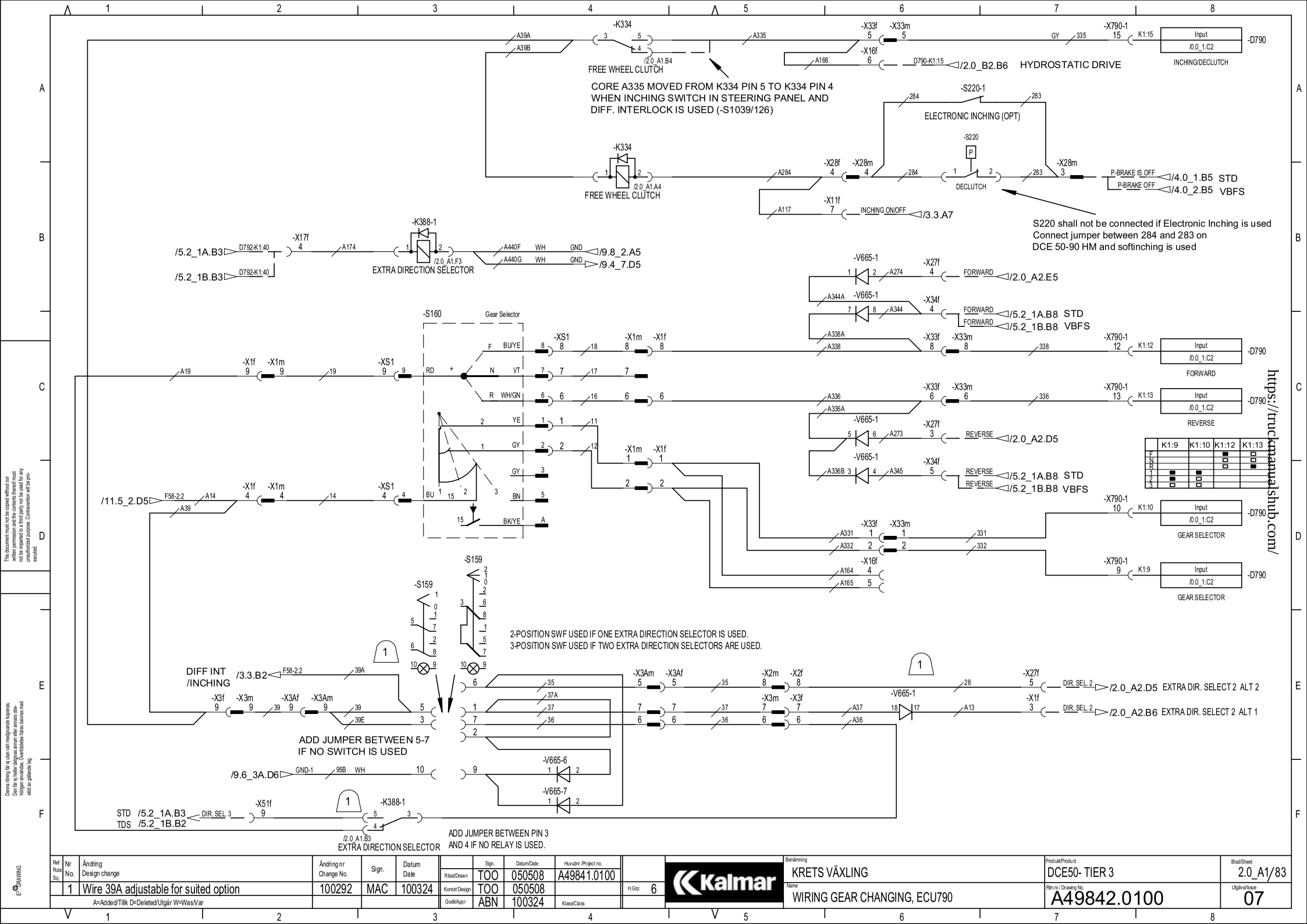
Produkt/Product: DCE50- TIER 3

Ritn.nr./ Drawing No.: A49842.0100

Blad/Sheet: 1.0_D/83

Utgåva/Issue: 07

E DRAWING



Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	Wire 39A adjustable for suited option	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

Benämning / Name: KRETS VÄXLING
WIRING GEAR CHANGING, ECU790

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

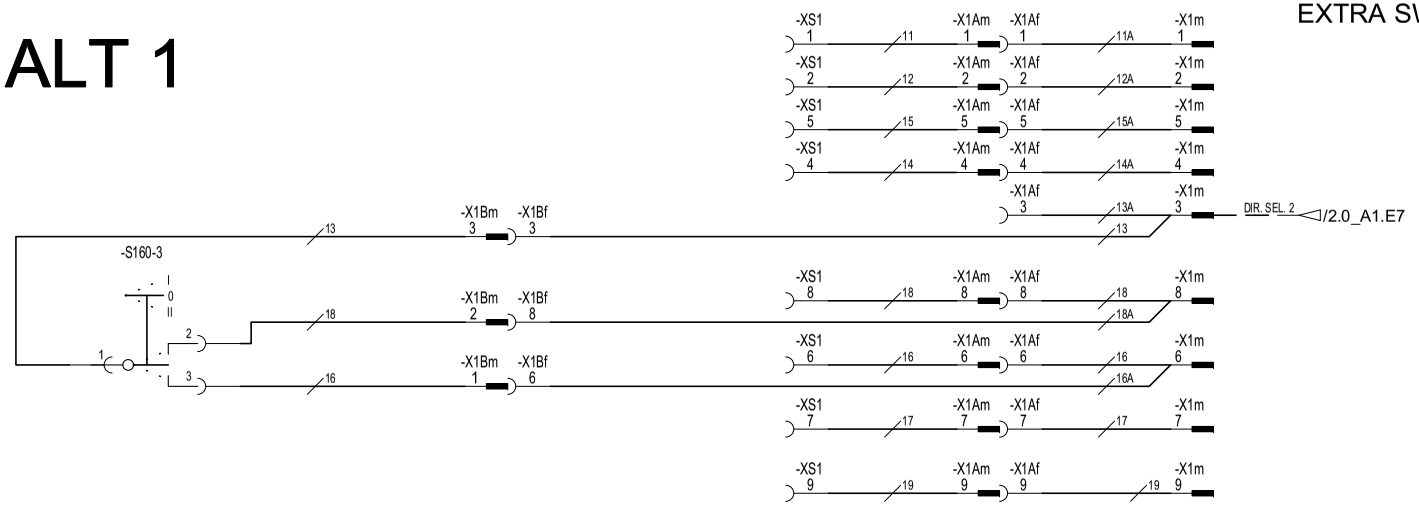
Blad/Sheet: 2.0_A1/83
Utgåva/Issue: 07

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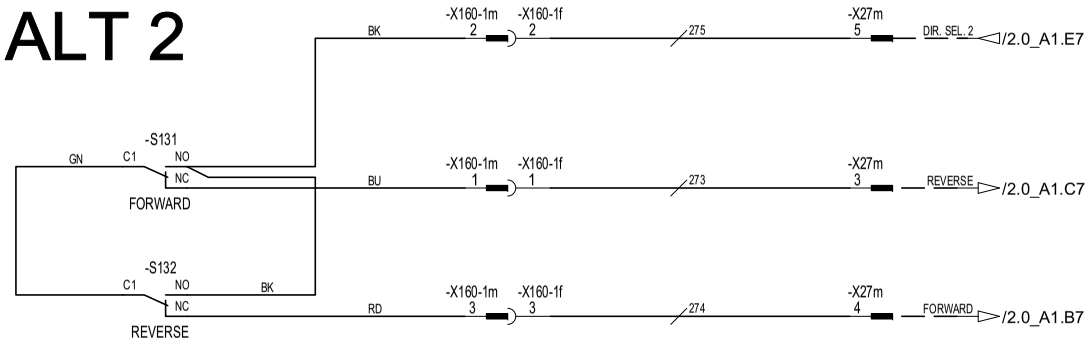
ALT 1

EXTRA SWITCH AT LIFT LEVER



ALT 2

EXTRA SWITCH AT SPEED PEDAL



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

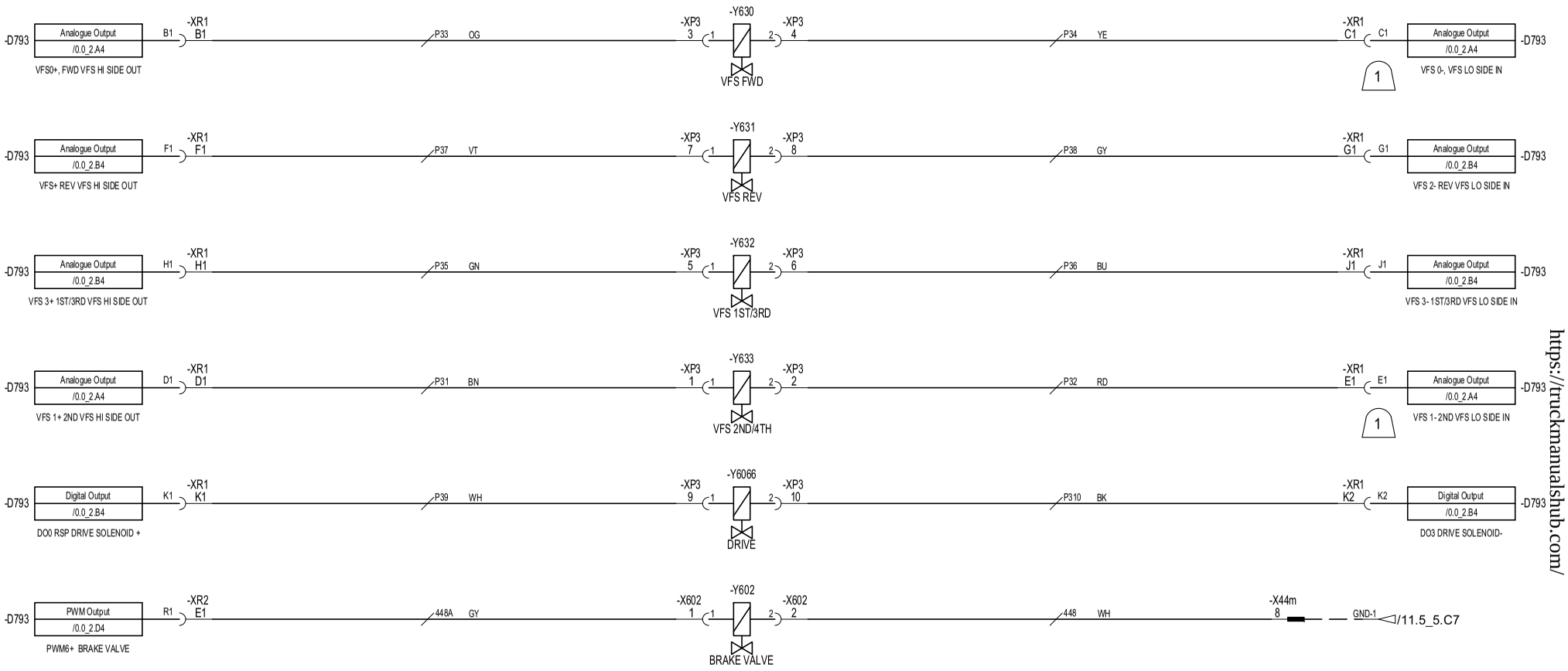
Kalmar

Benämning: KRETS EXTRA FRAM/BACK
Name: WIRING EXTRA FWD/REV

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_A2/83
Utgåva/Issue: 07

E DRAWING



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning / Name: KRETS VÄXLING, AUT/ECU793

WIRING GEAR CHANGING, AUT/ECU793

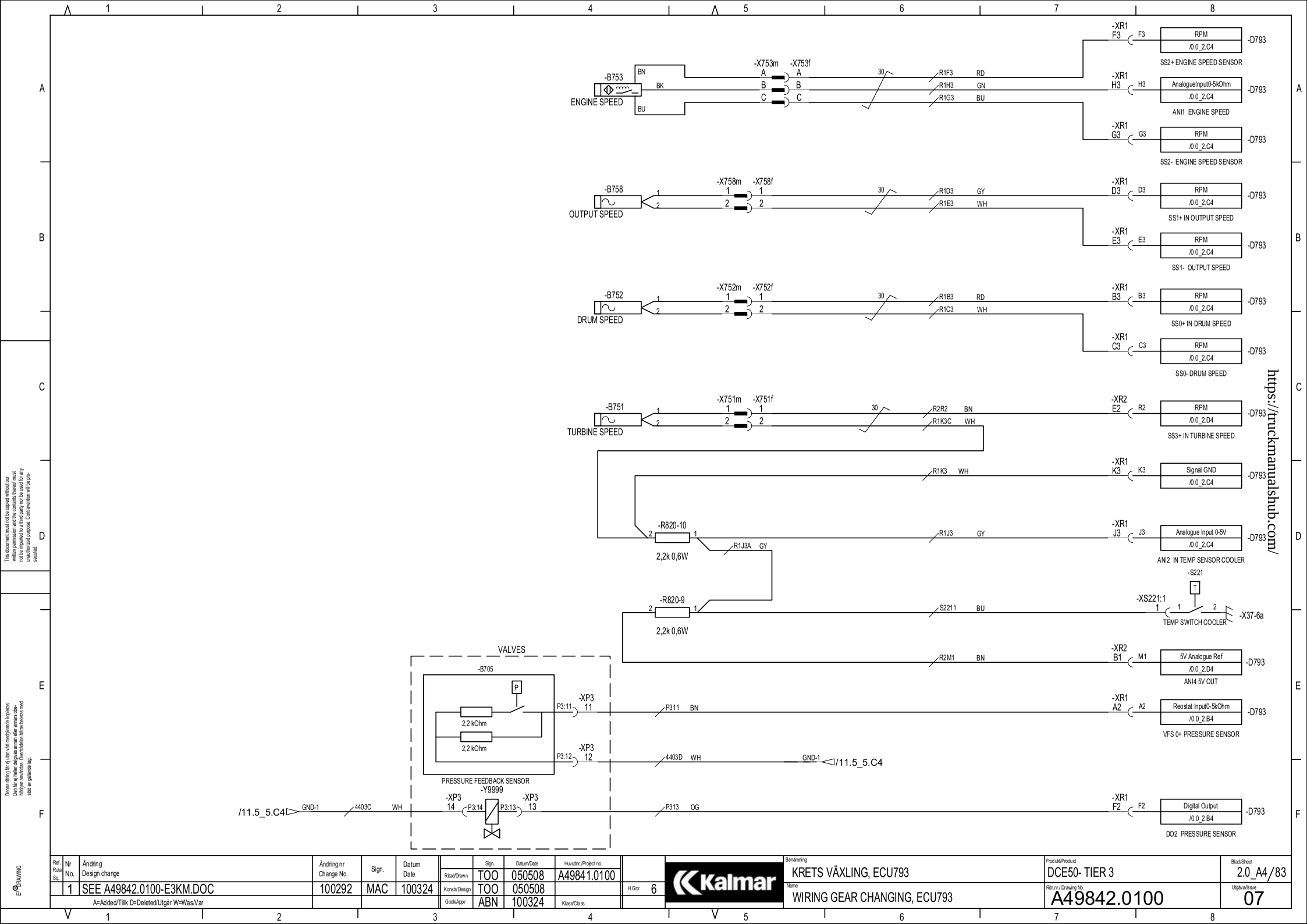
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_A3/83

Utgåva/Issue: 07

E DRAWING



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

E DRAWING

Kalmar

Benämning: KRETS VÄXLING, ECU793

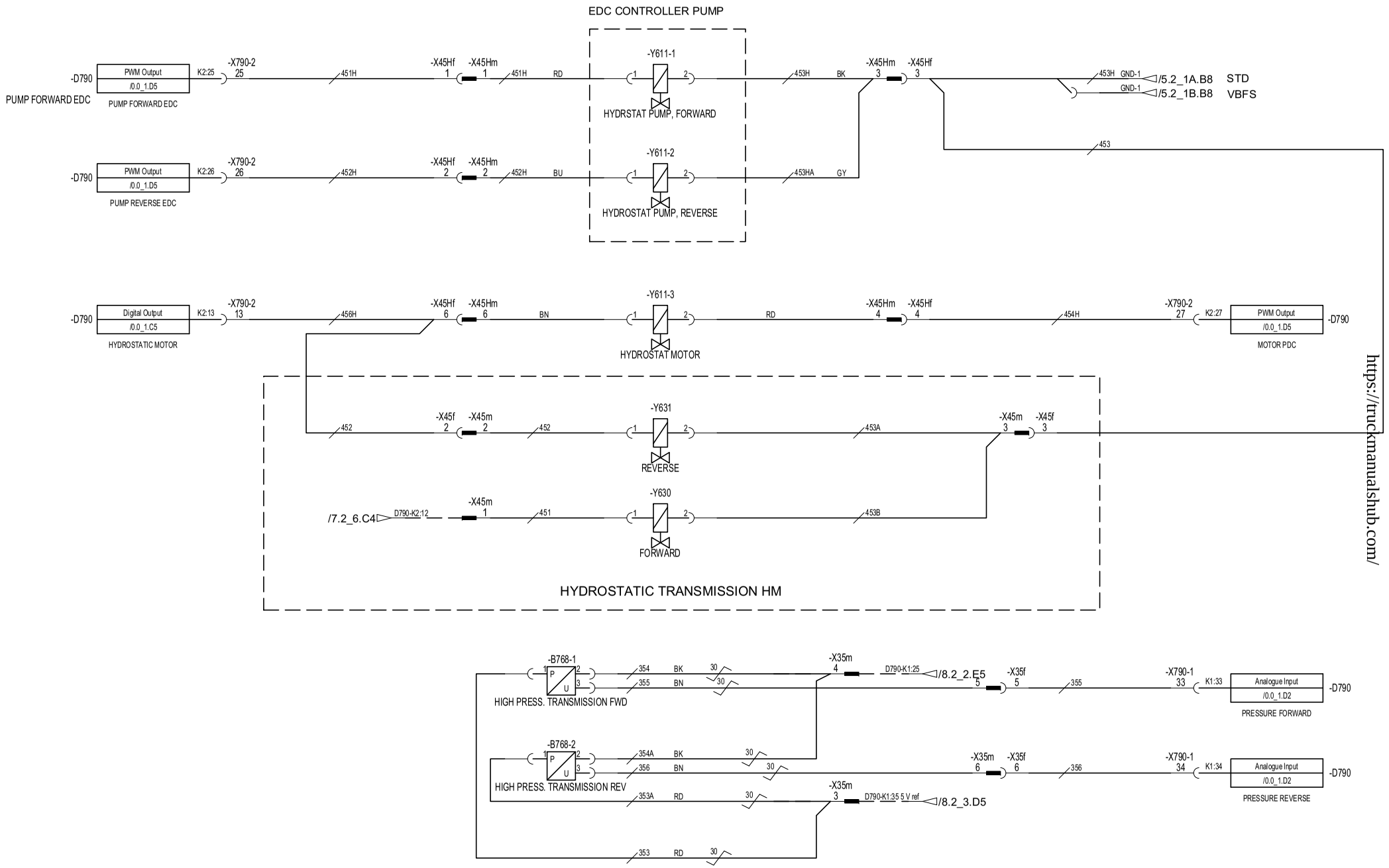
Name: WIRING GEAR CHANGING, ECU793

Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_A4/83

Utgåva/Issue: 07



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

Kalmar

Benämning / Name: KRETS HYDROSTAT
WIRING HYDROSTATIC TRANSMISSION

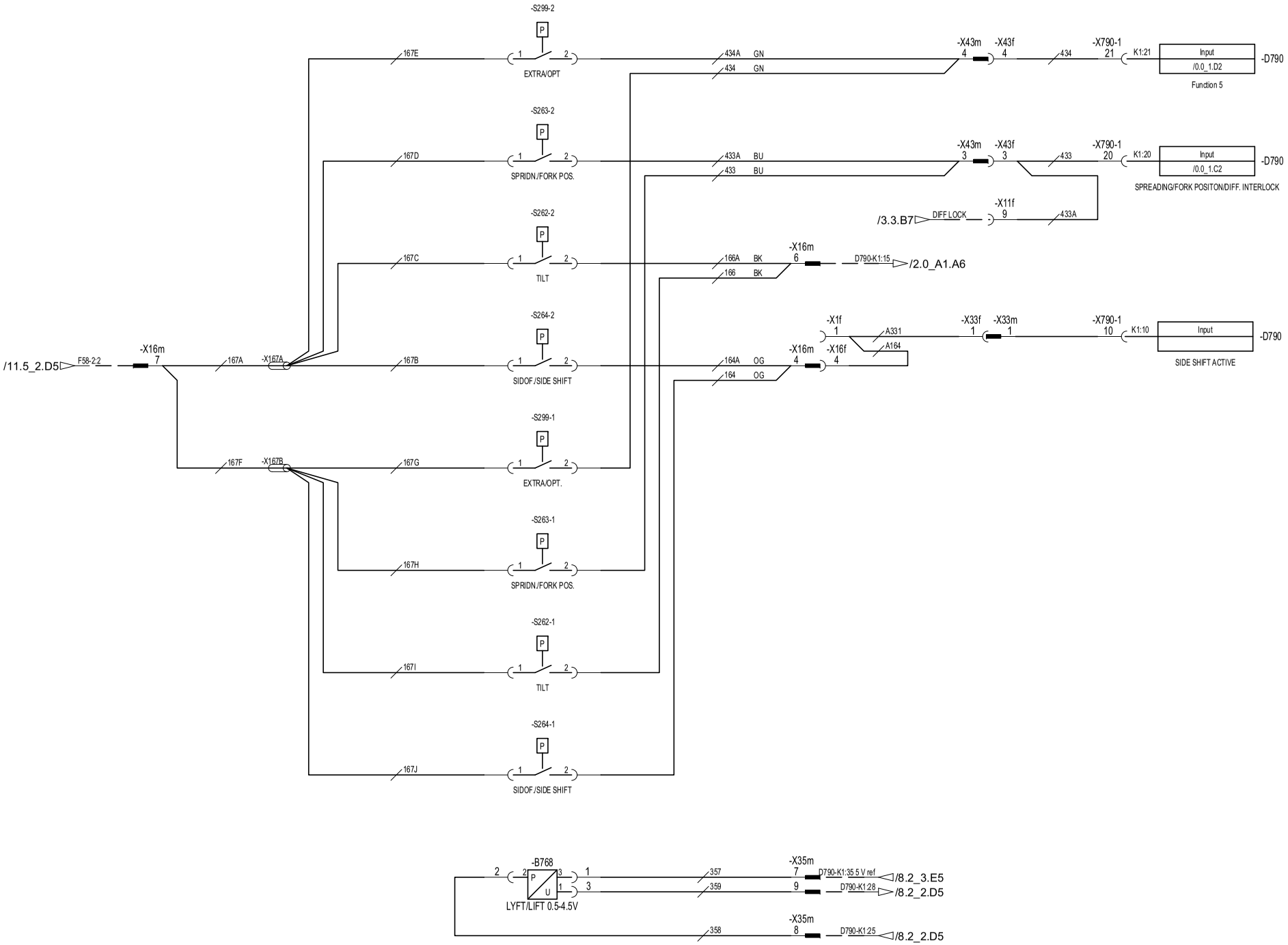
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_B1/83

Utgåva/Issue: 07

E DRAWING



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	wire 433A added for diff Interlock	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

Kalmar

Benämning: KRETS HYDROSTAT

Name: WIRING HYDROSTATIC TRANSMISSION

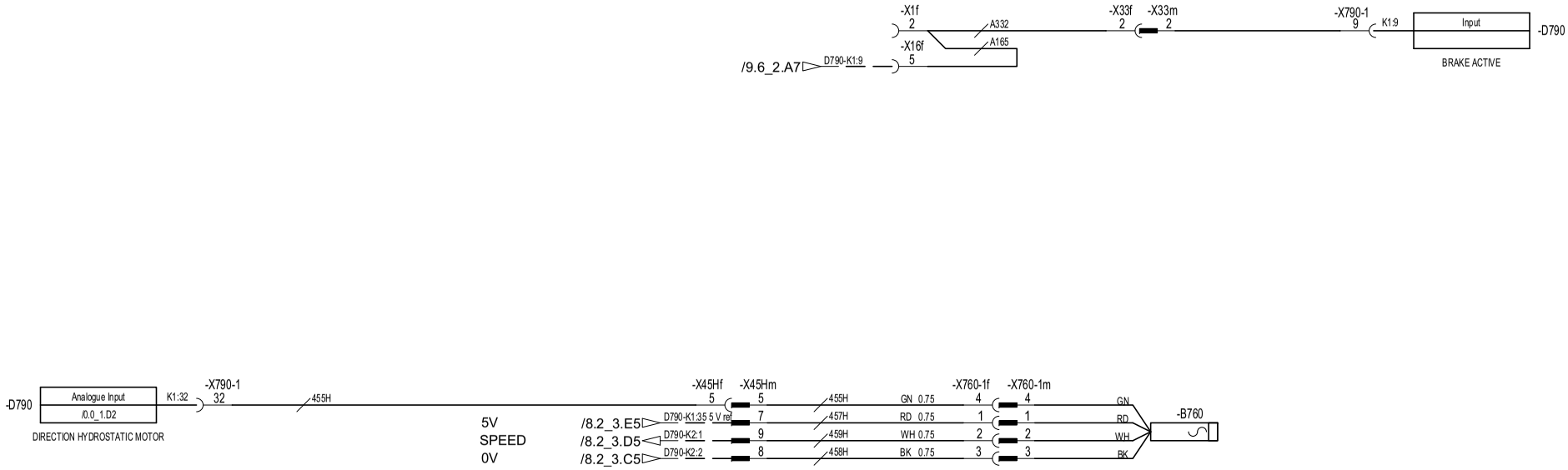
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_B2/83

Utgåva/Issue: 07

E DRAWING



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E DRAWING

Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning
KRETS HYDROSTAT

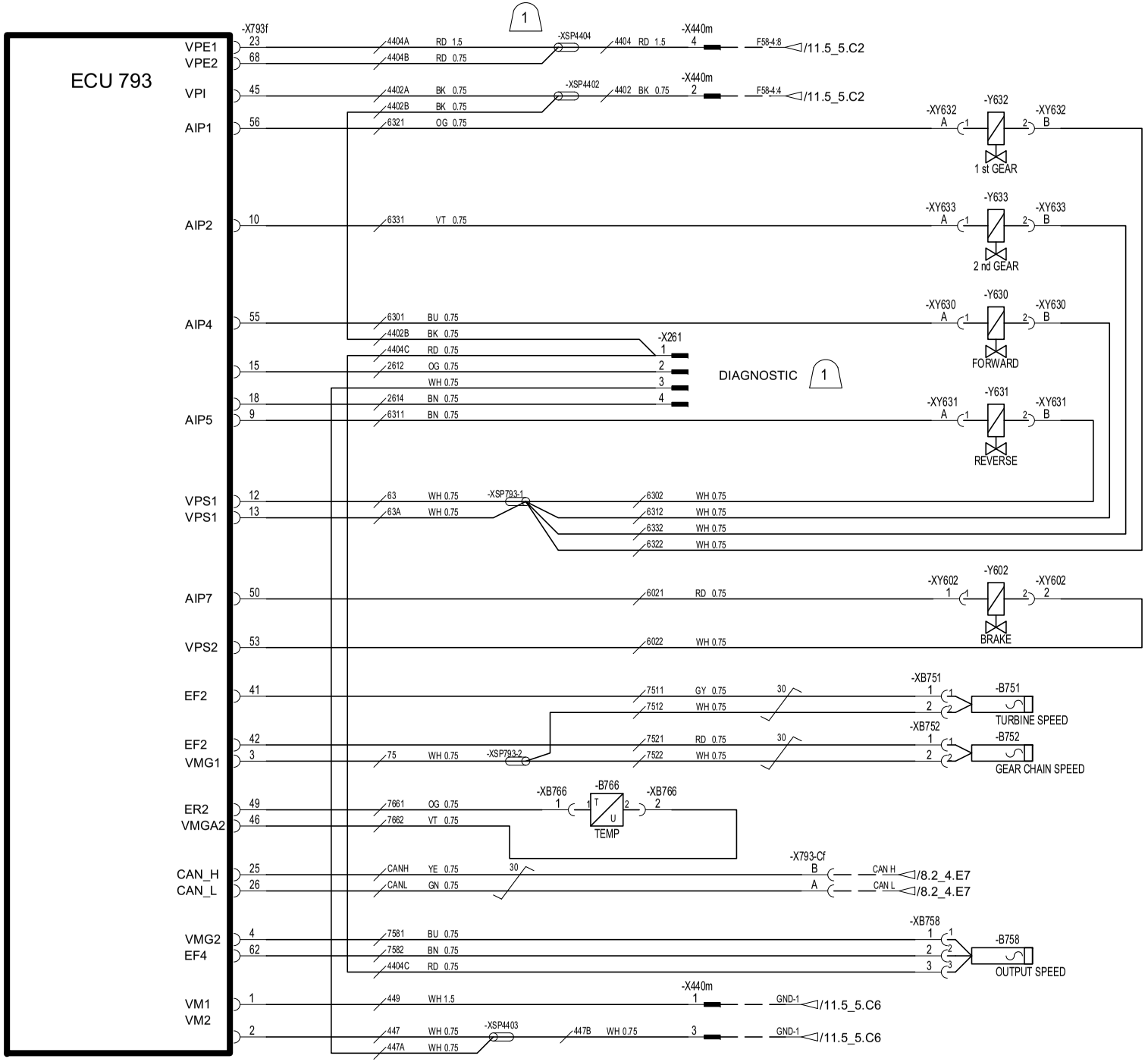
Name
WIRING, HYDROSTATIC TRANSMISSION

Produkt/Product
DCE50- TIER 3

Ritn.nr / Drawing No.
A49842.0100

Blad/Sheet
2.0_B3/83

Utgåva/Issue
07



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		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	051220	A49841.0100
Konstr/Design	TOO	051125	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS VÄXLING ZF

Name: WIRING GEAR CHANGING ZF

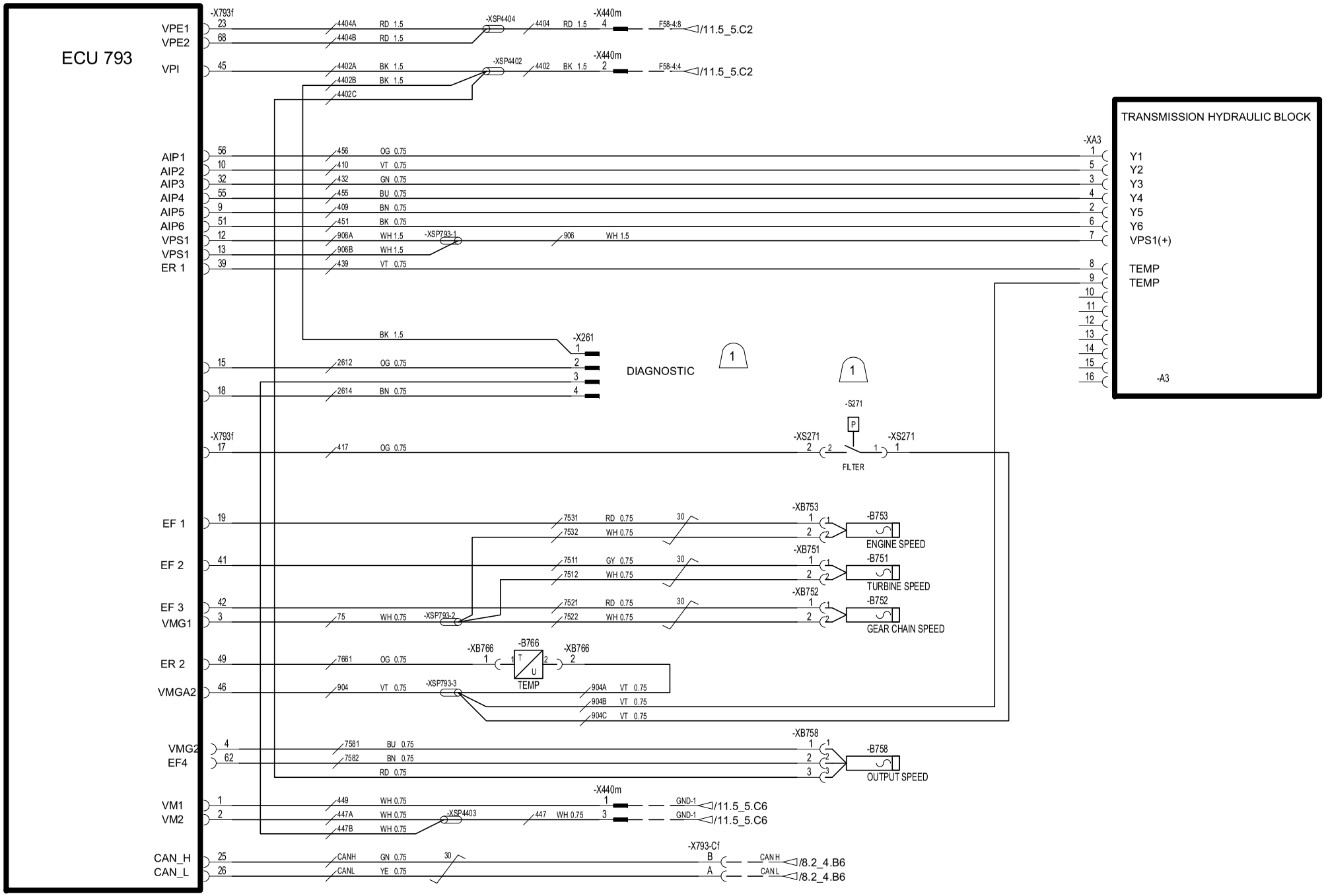
Produkt/Product: DCE 50-90 TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_C1/83

Utgåva/Issue: 07

E DRAWING



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		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	060927	A49841.0100
Konstr/Design	TOO	060601	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

E DRAWING

Kalmar

Benämning: KRETS VÄXLING ZF

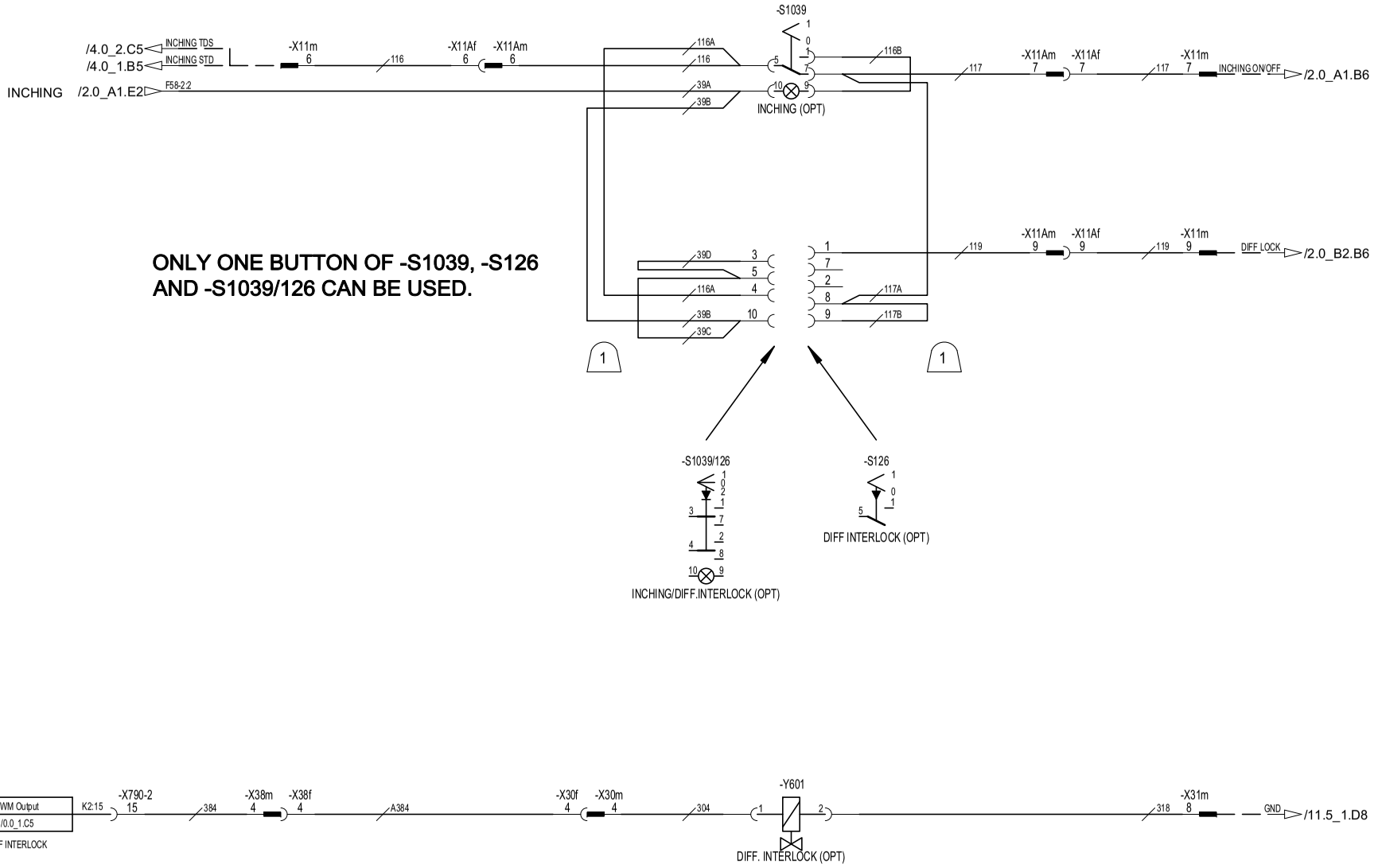
Name: WIRING GEAR CHANGING ZF

Produkt/Product: DCE 90-180

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 2.0_C2/83

Utgåva/Issue: 07



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A=Added/Tillk D=Deleted/Utgår W=Was/Var					

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Konstr/Design	TOO	080115	
Godk/Appr	ABN	100324	
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H.Grp: 6

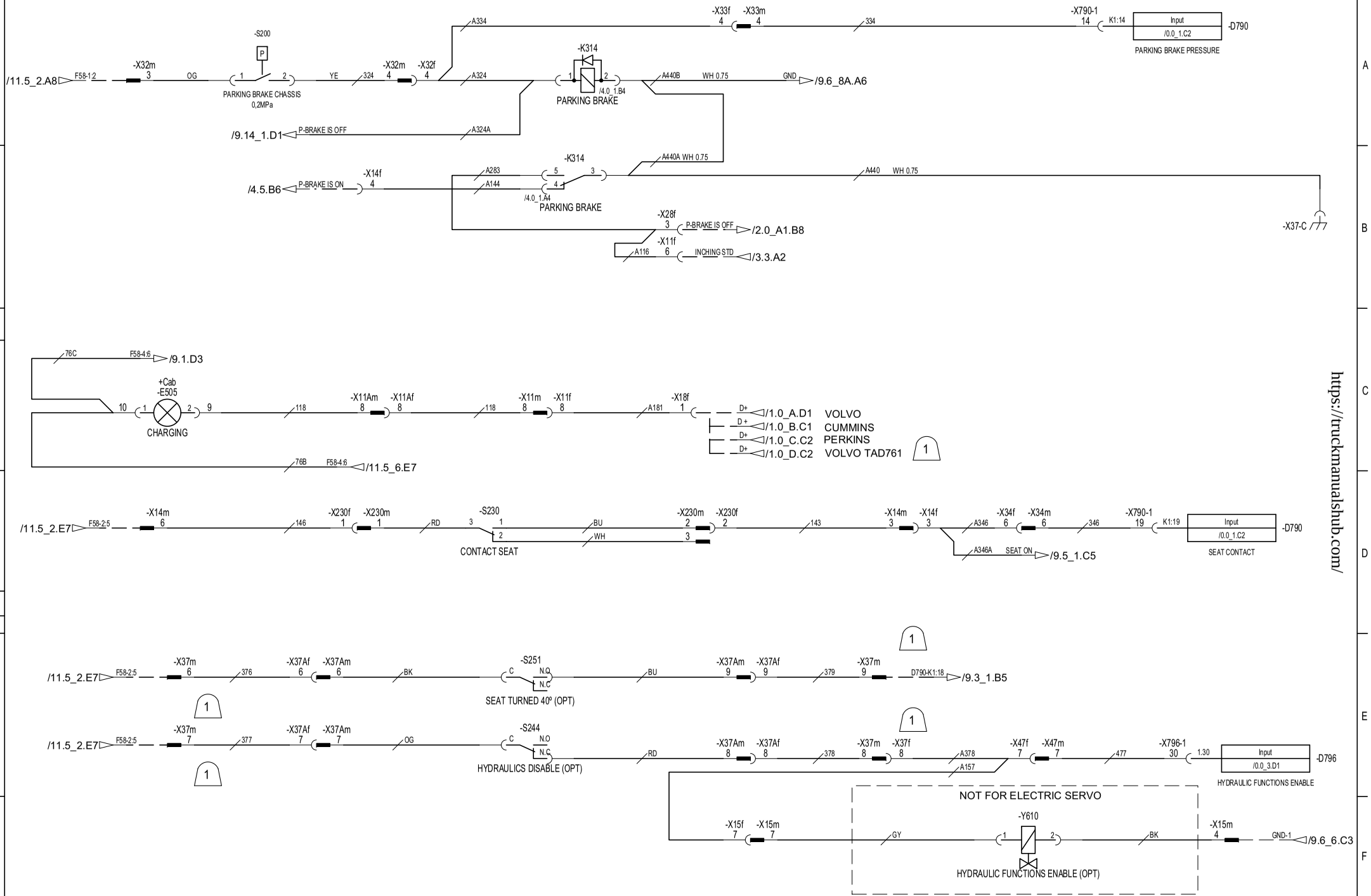
Kalmar

Benämning: KRETS DIFFSPÄRR
Name: WIRING DIFF. INTERLOCK

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 3.3/83
Utgåva/Issue: 07

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	Sign.	Datum/Date	Huvudnr./Project no.
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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

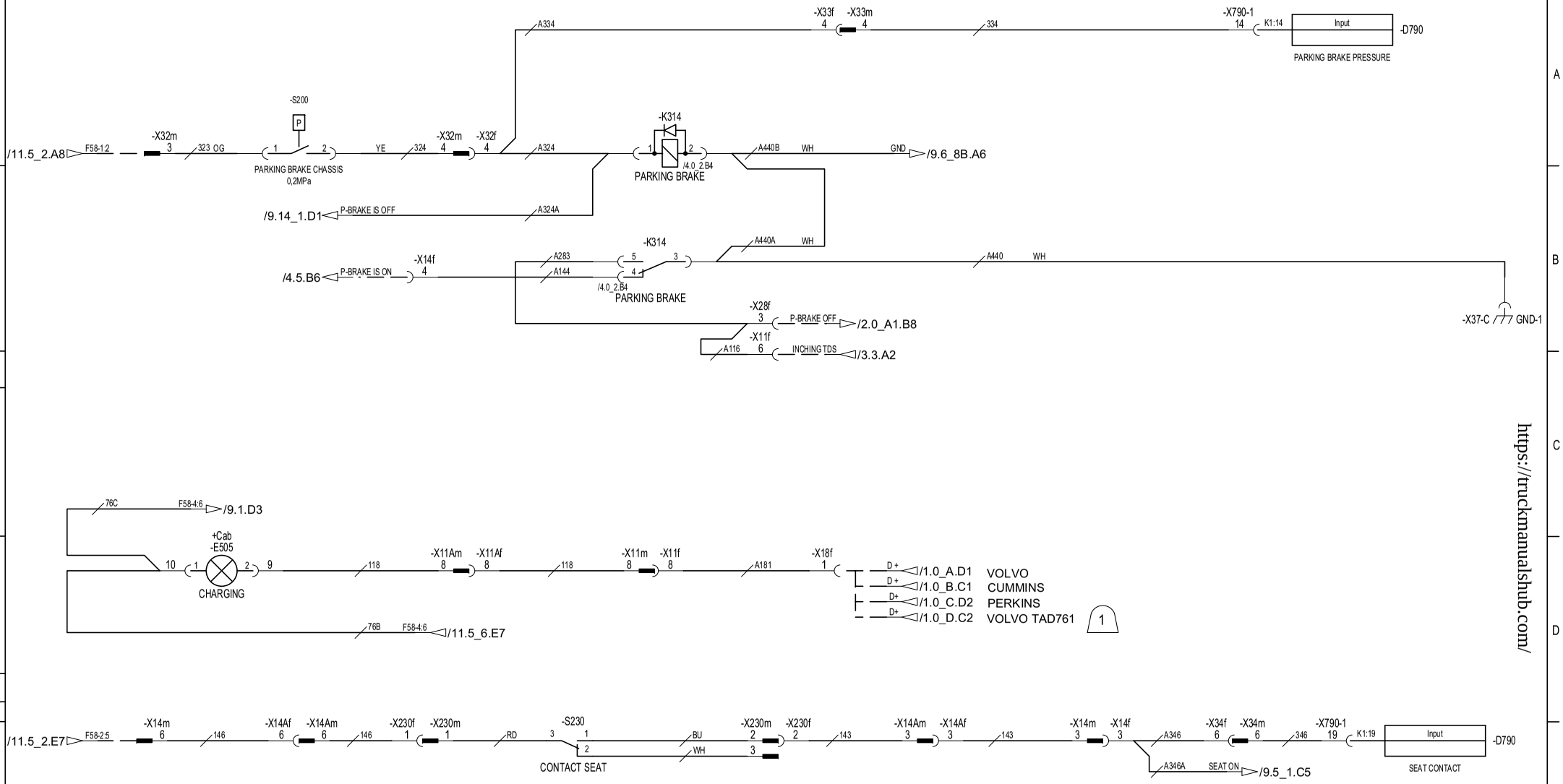
Kalmar

Benämning: KRETS HYTT
Name: WIRING CAB

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 4.0_1/83
Utgåva/Issue: 07

E DRAWING



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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

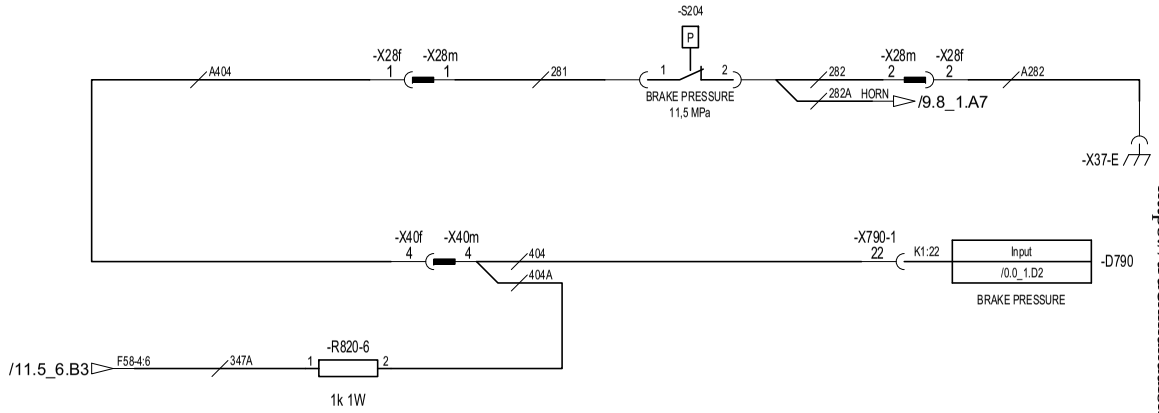
Kalmar

Benämning: KRETS HYTT VBFS
Name: WIRING CAB TDS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 4.0_2/83
Utgåva/Issue: 07

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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS ÖVERVAKNING BROMSTRYCK
WIRING MONITORING BRAKEPRESSURE

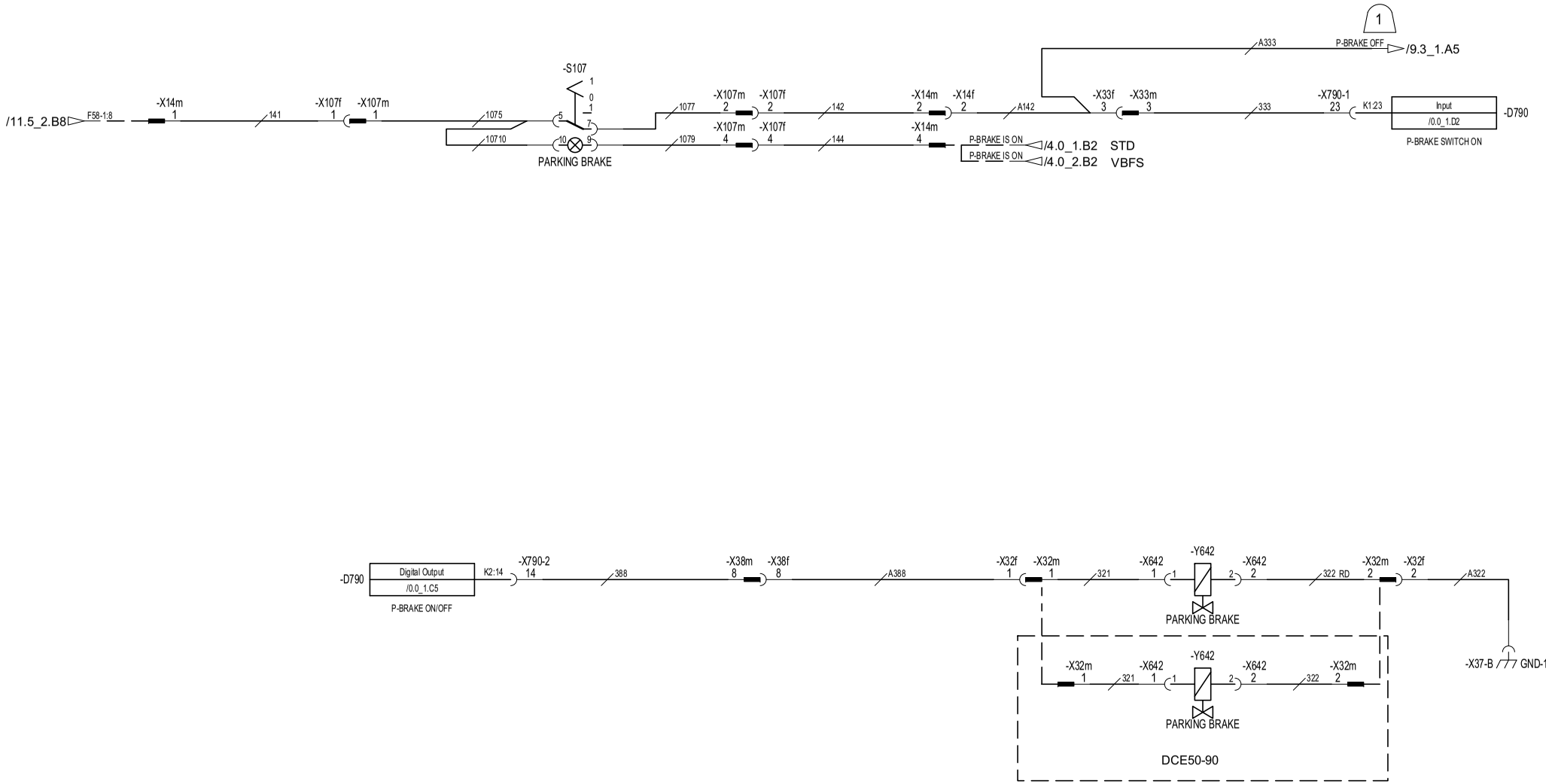
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 4.0_3/83

Utgåva/Issue: 07

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	Sign.	Datum/Date	Huvudnr./Project no.
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Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

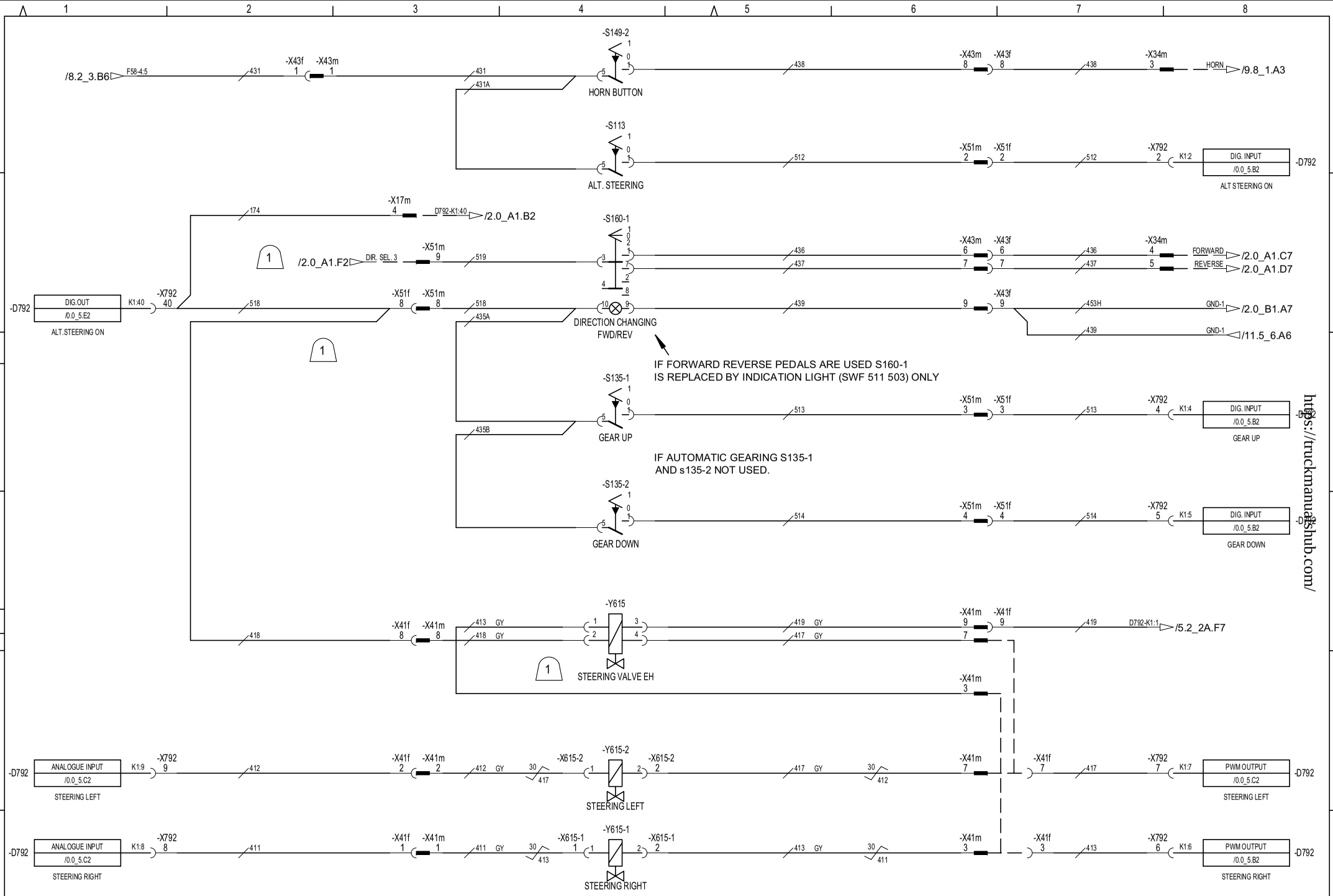
Kalmar

Benämning: KRETS P-BROMS
Name: WIRING PARKING BRAKE

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 4.5/83
Utgåva/Issue: 07

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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS STYRFUNKTION
WIRING STEERING

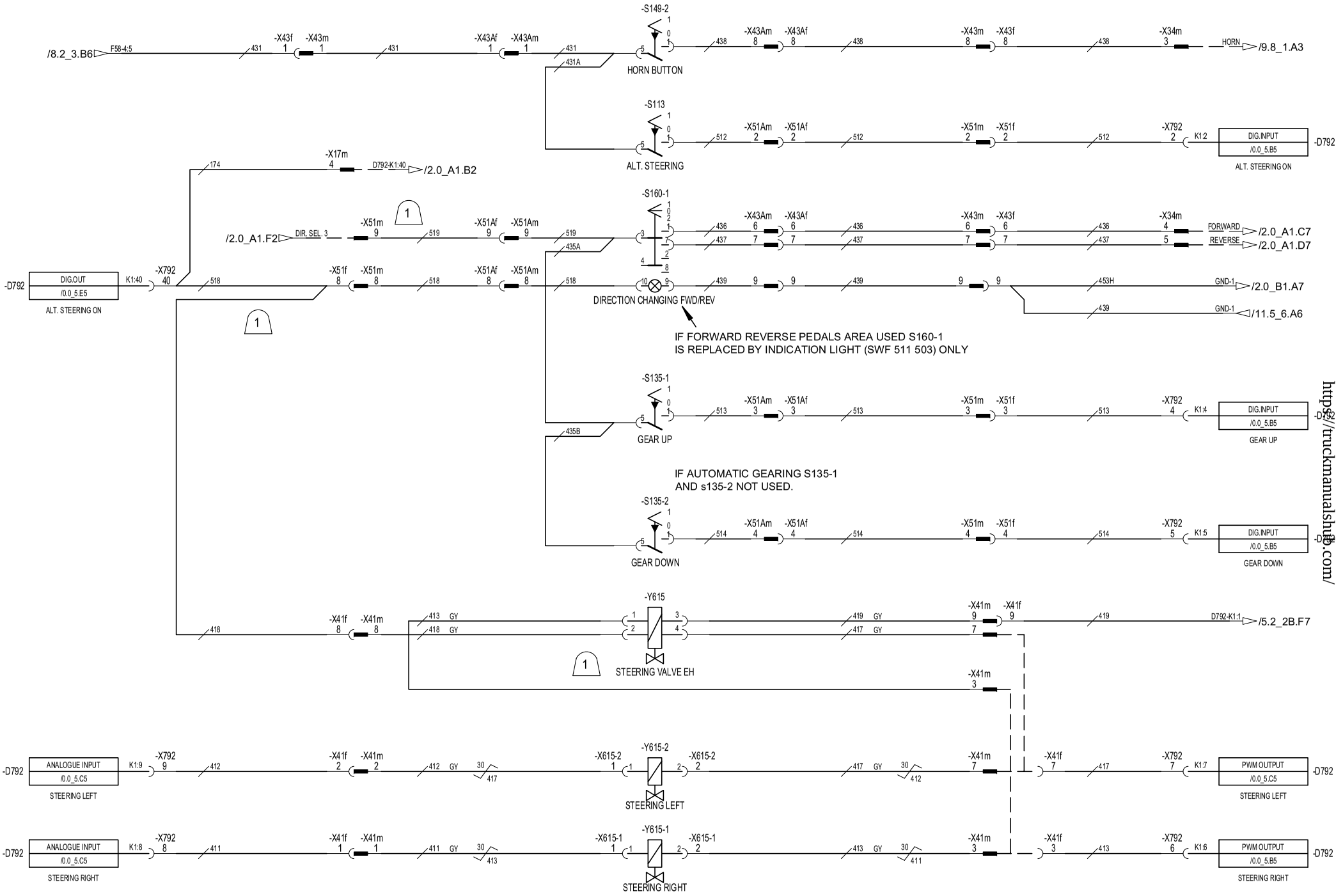
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Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 5.2_1A/83

Utgåva/Issue: 07

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Ritad/Drawn	TOO	050508	A49841.0100
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Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

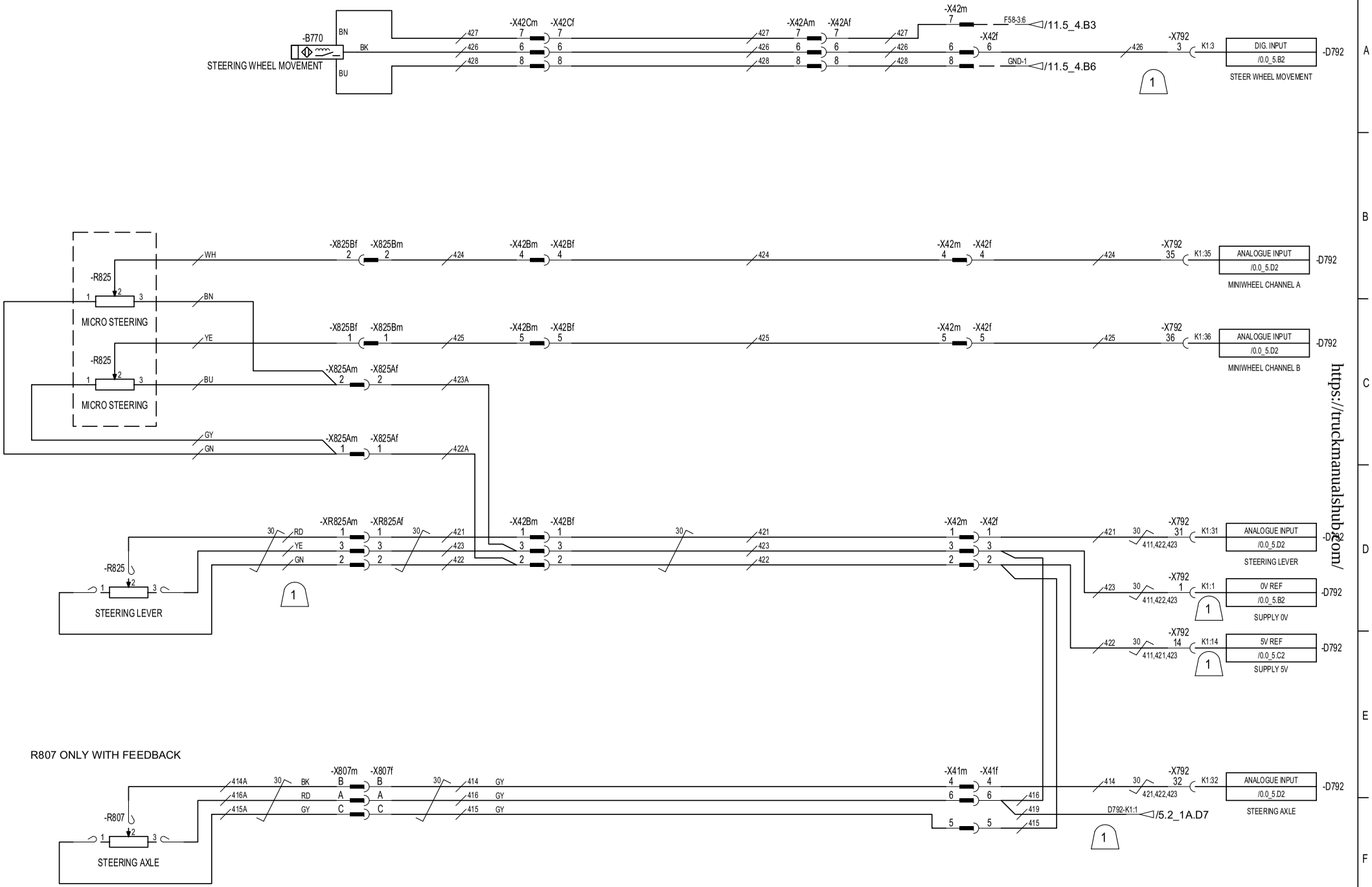
Kalmar

Benämning: KRETS STYRFUNKTION VBFS
Name: WIRING STEERING TDS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 5.2_1B/83
Utgåva/Issue: 07

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Ritad/Drawn	TOO	050508	A49841.0100
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H.Grp: 6

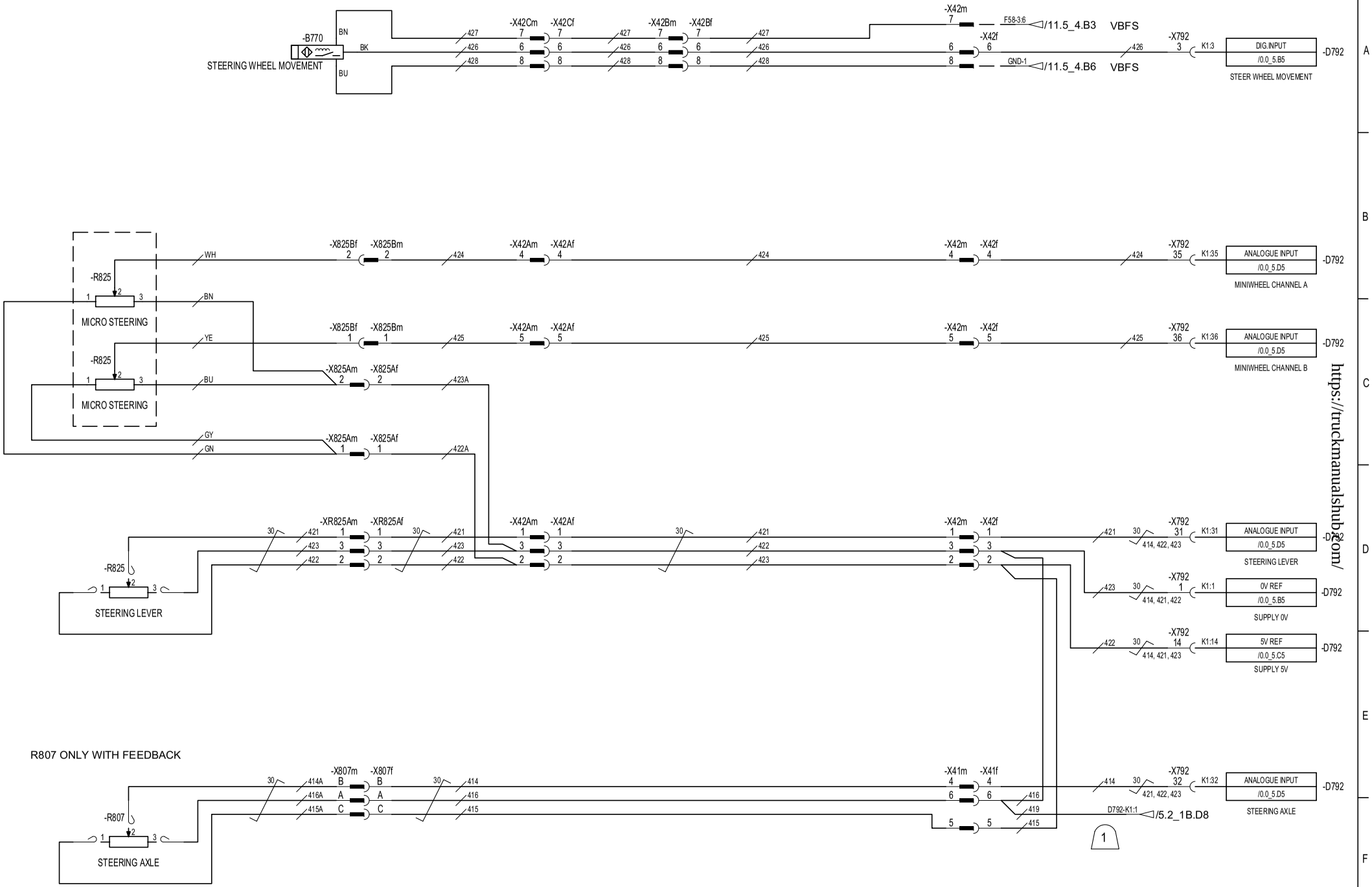
Kalmar

Benämning: KRETS STYRFUNKTION
Name: WIRING STEERING

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 5.2_2A/83
Utgåva/Issue: 07

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Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

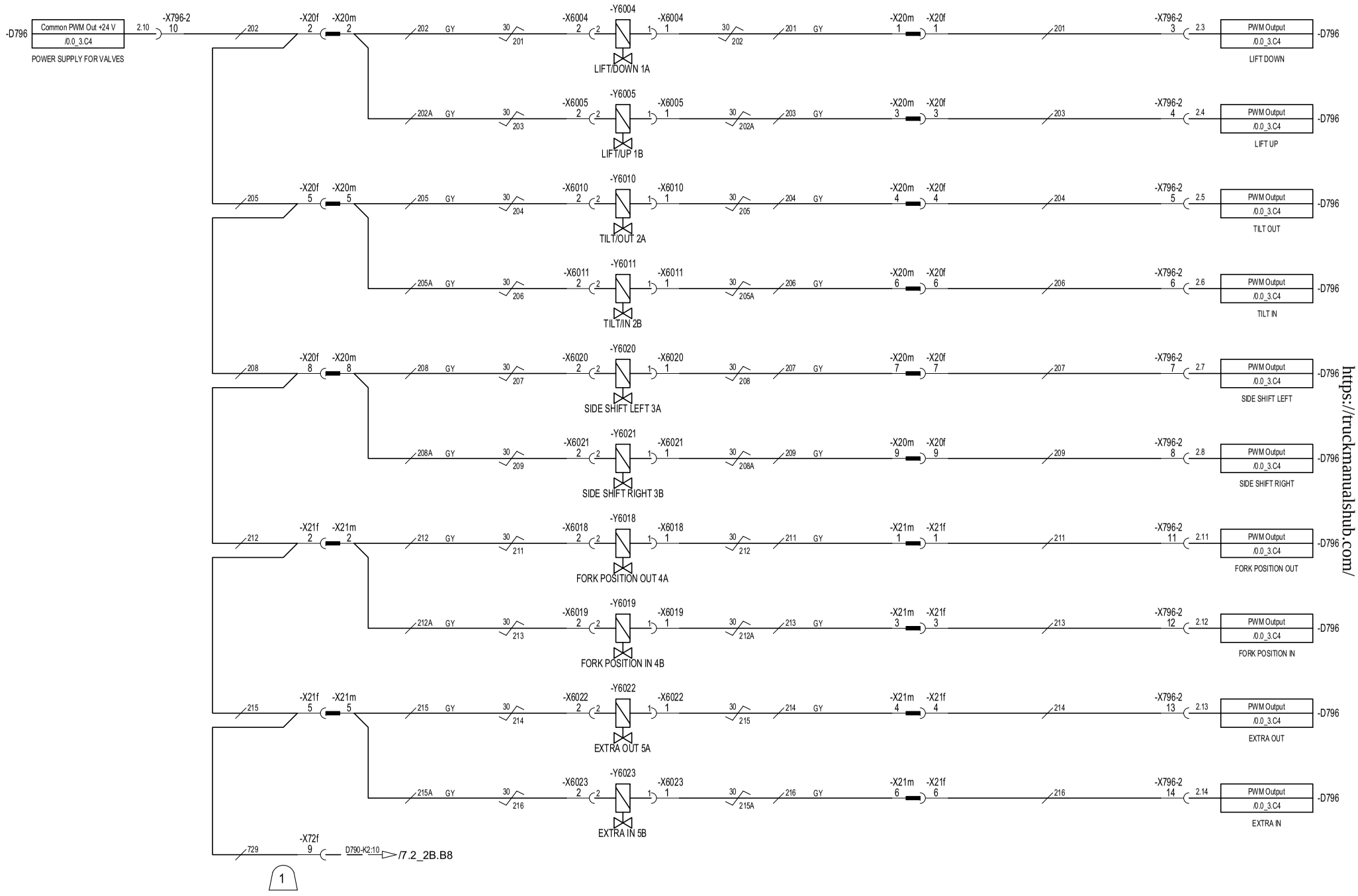
Kalmar

Benämning: KRETS STYRFUNKTION, VBFS
Name: WIRING STEERING, TDS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 5.2_2B/83
Utgåva/Issue: 07

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R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS SERVO & HYDRAULIKFUNKT.

Name: WIRING SERVO & HYDRAULICS

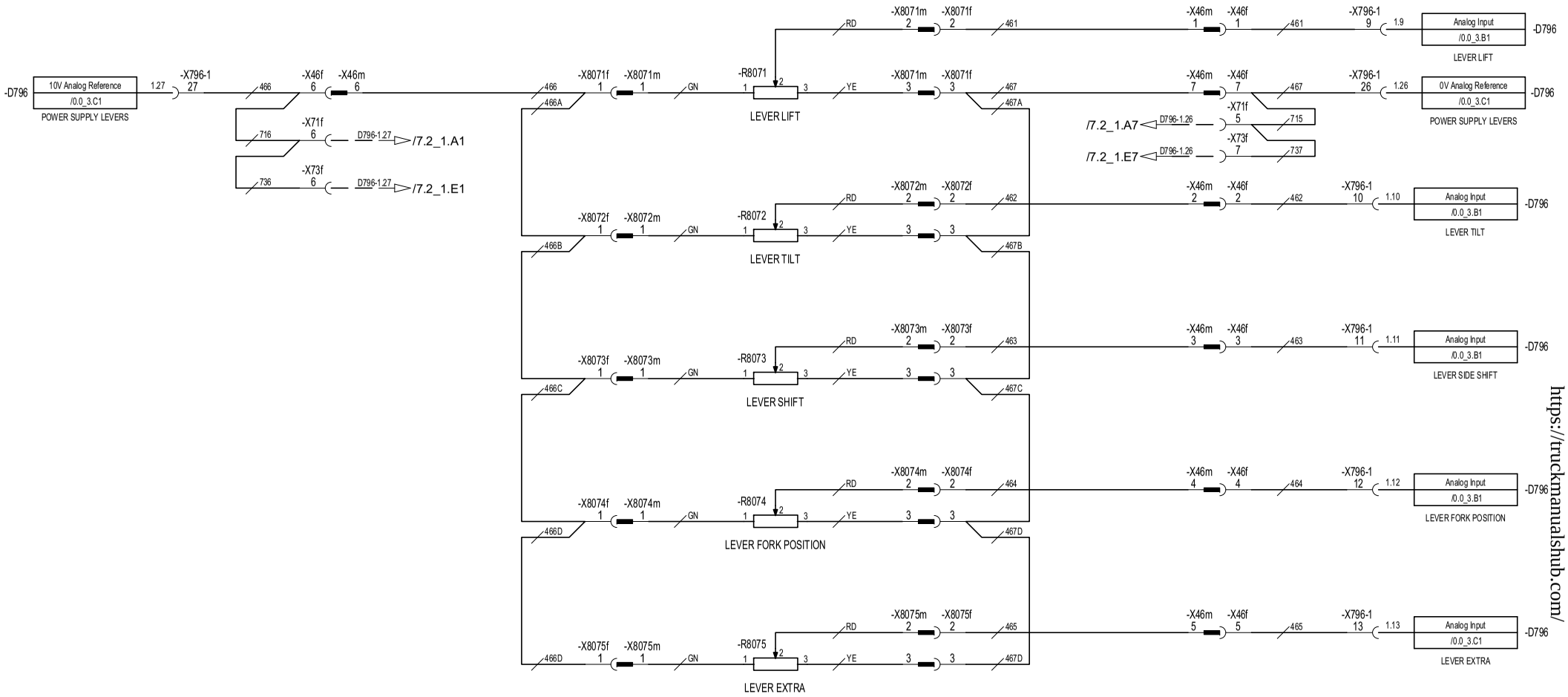
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_1/83

Utgåva/Issue: 07

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R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS SERVO & HYDRAULIKFUNKT.

Name: WIRING SERVO AND HYDRAULICS

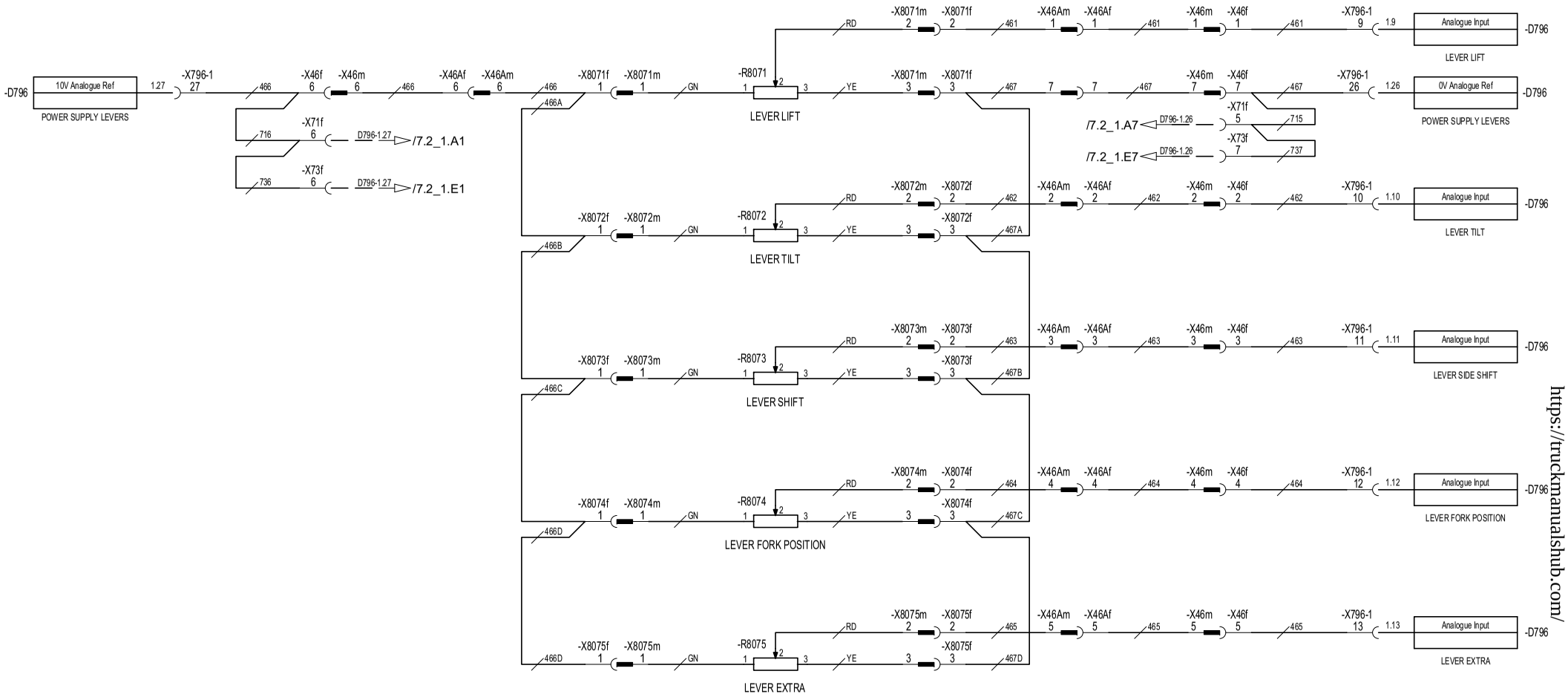
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Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_2/83

Utgåva/Issue: 07

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS SERVO & HYDR. FUNKT, VBFS

Name: WIRING SERVO & HYDRAULICS,TDS

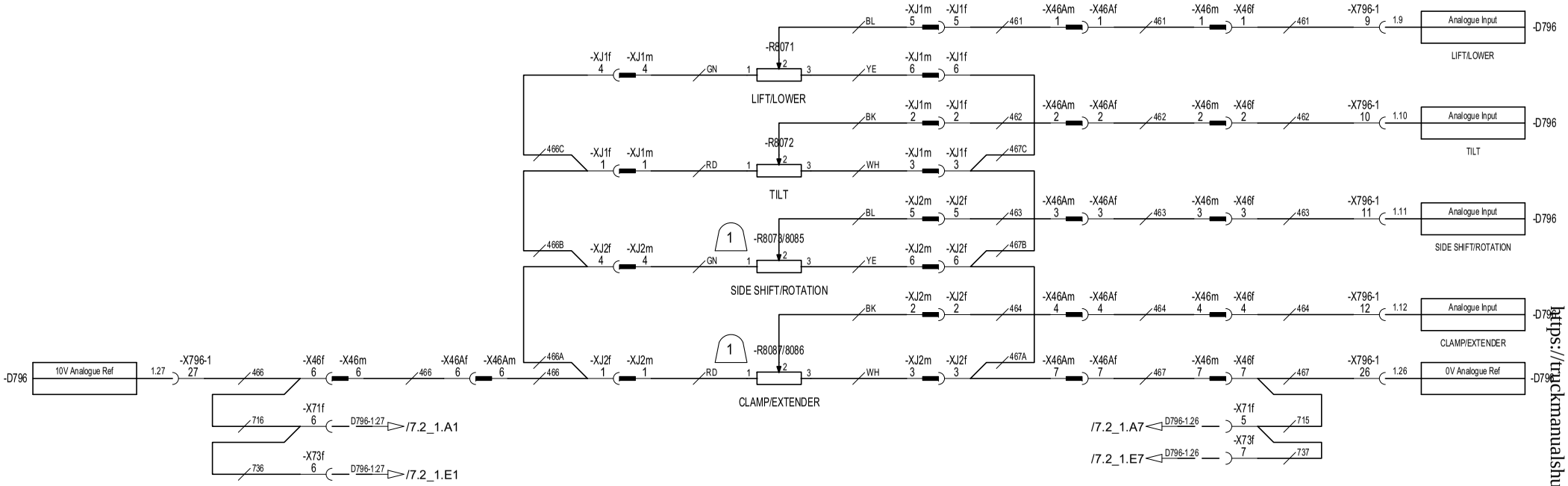
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Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_3/83

Utgåva/Issue: 07

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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R'tad/Drawn	TOO	050525	A49841.0100
Konstr/Design	TOO	050525	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS ECU796, JOYSTICK

Name: WIRING ECU796, JOYSTICK

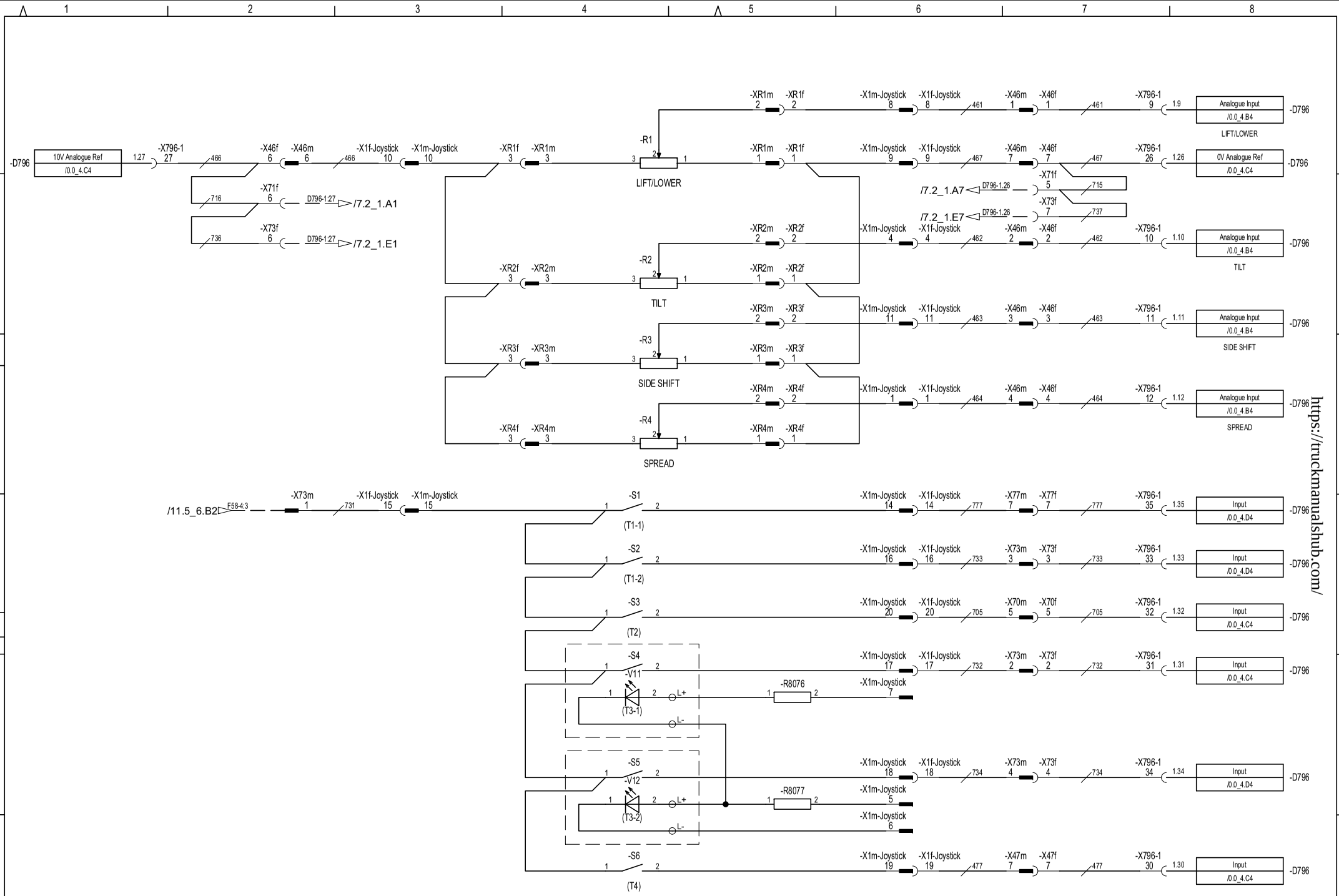
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_4/83

Utgåva/Issue: 07

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https://truckmanualshub.com/

Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050526	A49841.0100
Konstr/Design	TOO	050525	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS ECU796 JOYSTICK 2
WIRING ECU796 JOYSTICK 2

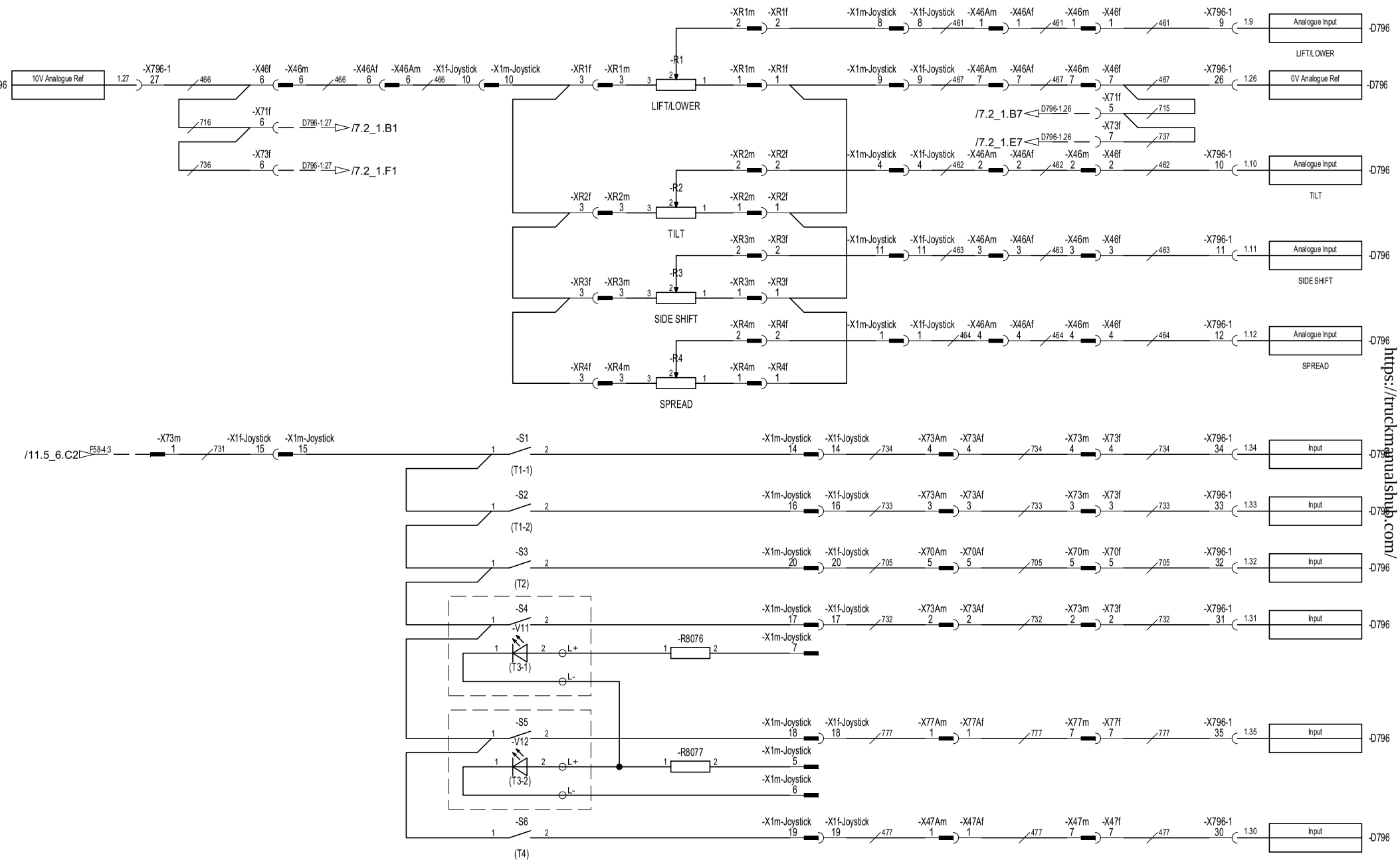
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_5A/83

Utgåva/Issue: 07

E DRAWING



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https://truckmanualshub.com/

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	Sign.	Datum/Date	Huvudnr./Project no.
R'tad/Drawn	TOO	060829	A49841.0100
Konstr/Design	TOO	060601	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning: KRETS ECU796 JOYSTICK 2 VBFS

Name: WIRING ECU796 JOYSTICK 2 TDS

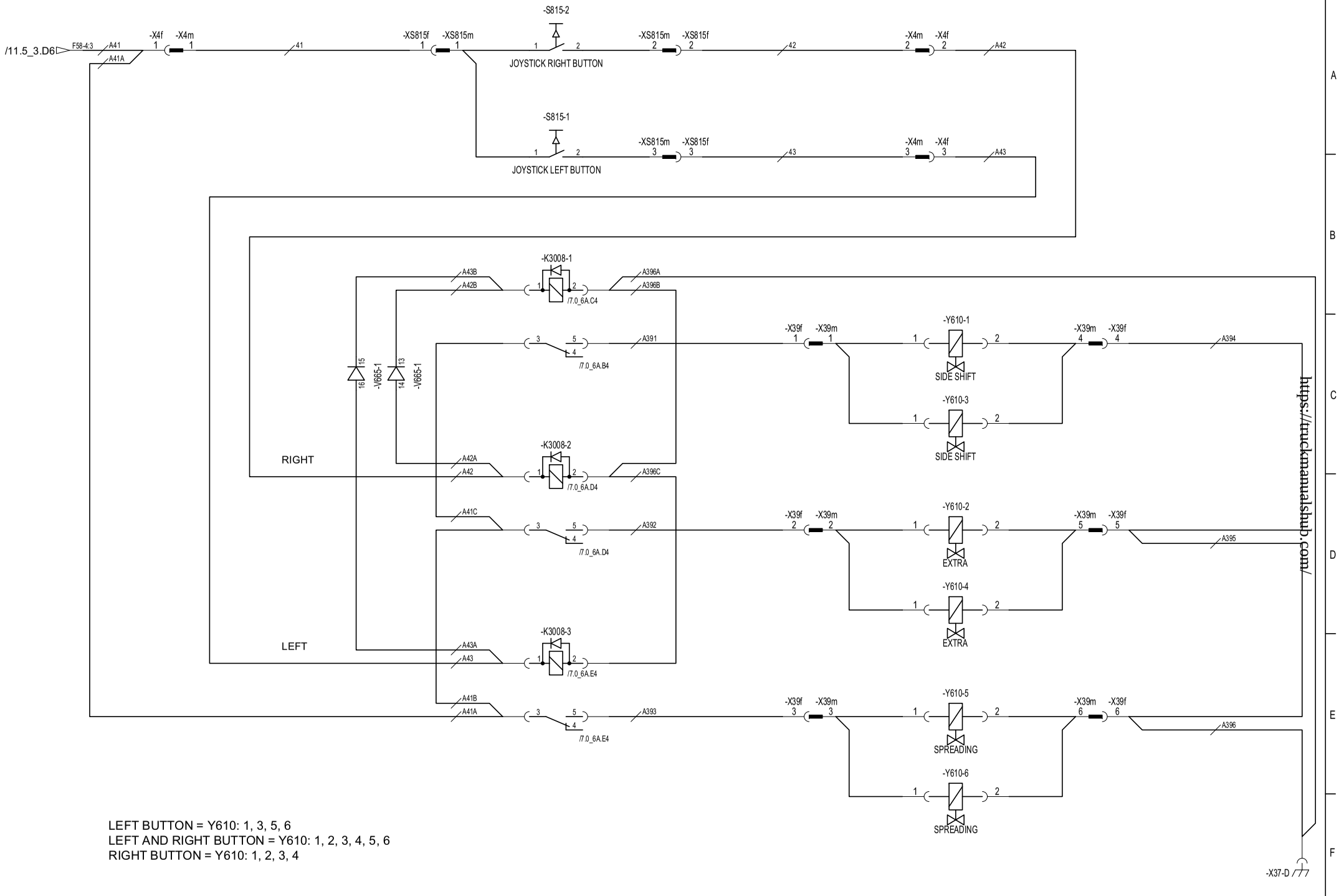
Produkt/Product: DCE 50- T3 SPACE

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_5B/83

Utgåva/Issue: 07

E DRAWING



LEFT BUTTON = Y610: 1, 3, 5, 6
LEFT AND RIGHT BUTTON = Y610: 1, 2, 3, 4, 5, 6
RIGHT BUTTON = Y610: 1, 2, 3, 4

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	Sheet added	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	070915	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

Kalmar

Benämning / Name: KRETS HYDRAULISK JOYSTICK
WIRING HYDRAULIC JOYSTICK

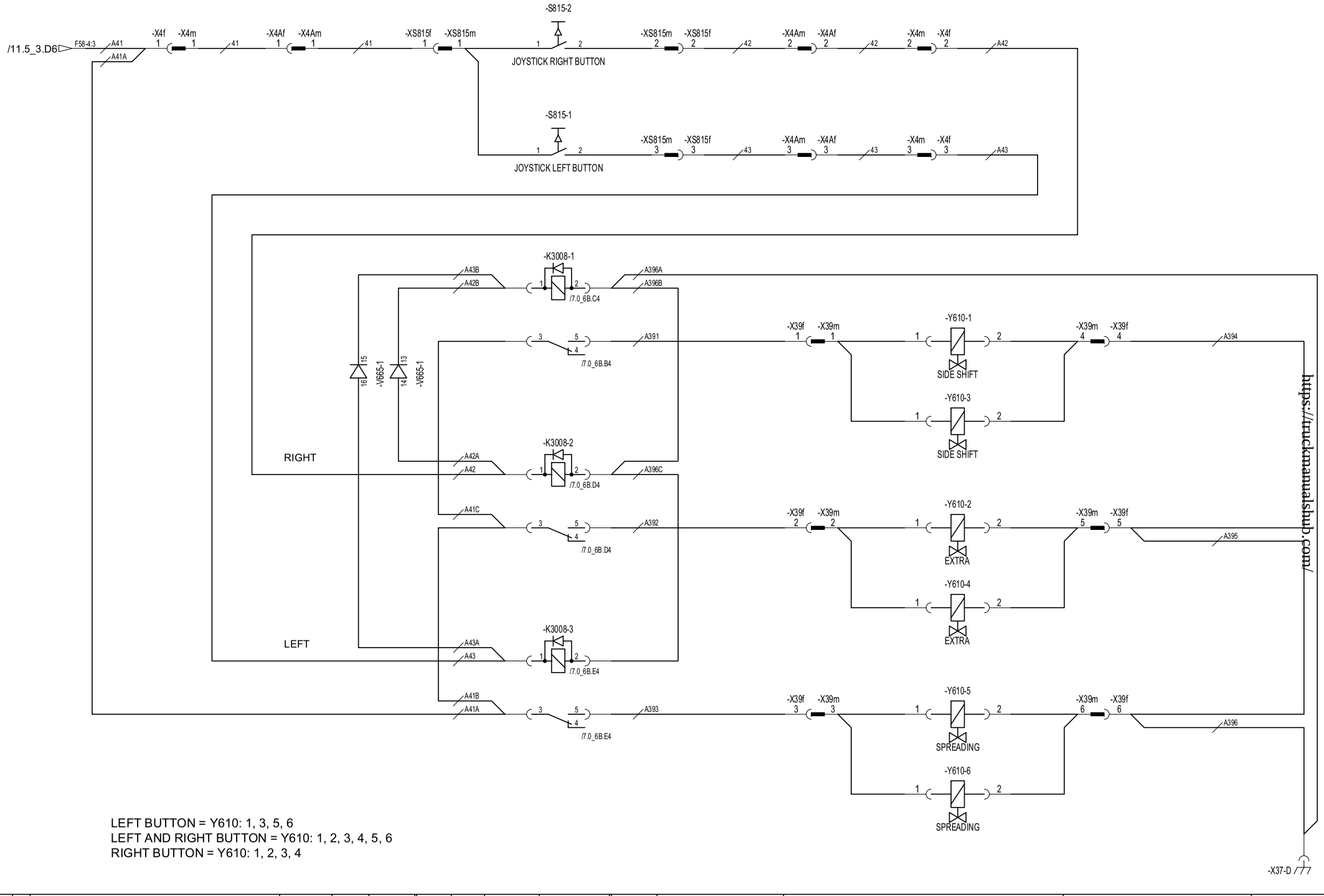
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_6A/83

Utgåva/Issue: 07

E DRAWING



LEFT BUTTON = Y610: 1, 3, 5, 6
LEFT AND RIGHT BUTTON = Y610: 1, 2, 3, 4, 5, 6
RIGHT BUTTON = Y610: 1, 2, 3, 4

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https://truckmanualshub.com/

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	1		100292	MAC	100324

A=Added/Tillk D=Deleted/Utgår W=Was/Var

	Sign.	Datum/Date	Huvudnr./Project no.
R'tad/Drawn	TOO	070915	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning: KRETS HYDRAULISK JOYSTICK, VBFS

Name: WIRING HYDRAULIC JOYSTICK, TDS

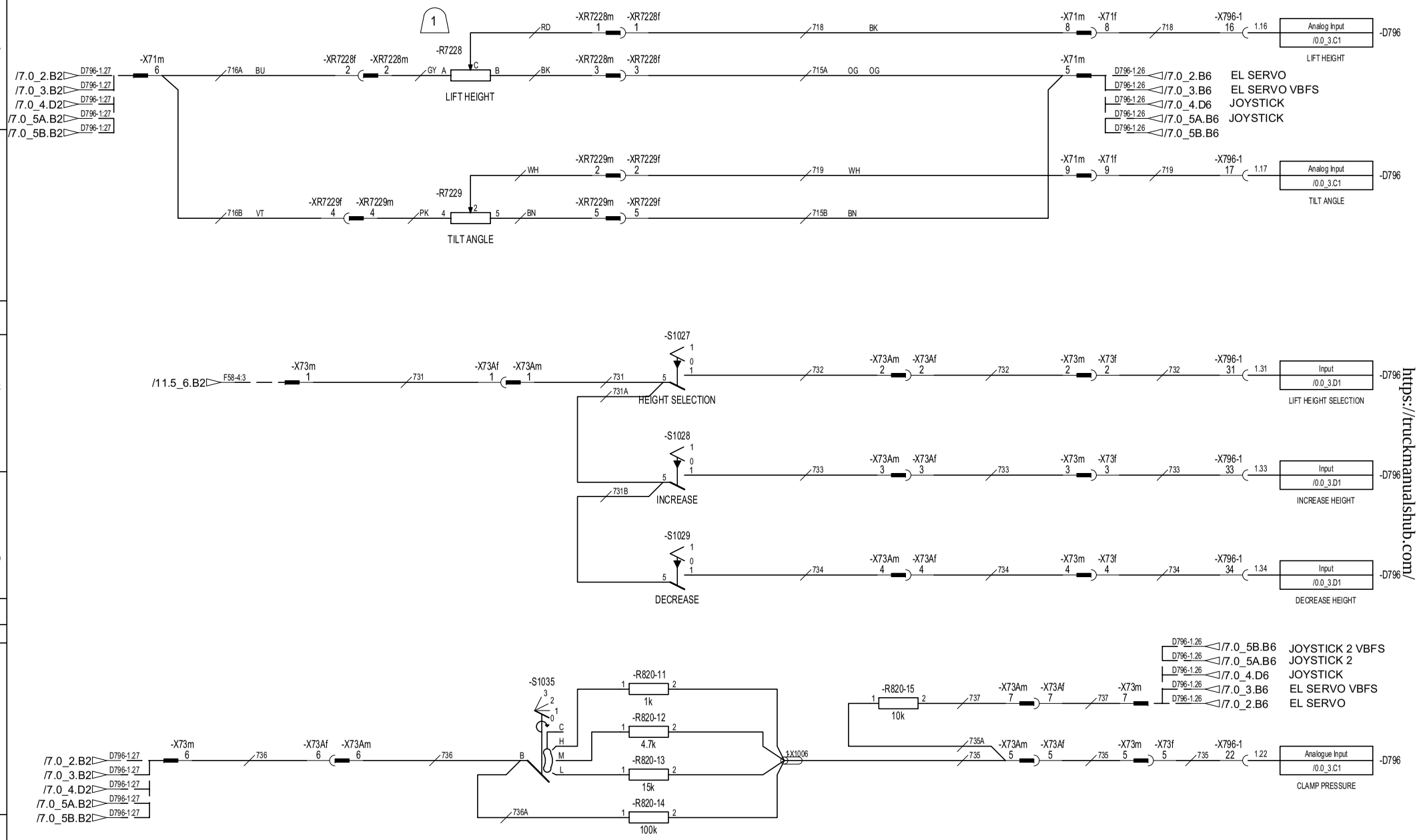
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.0_6B/83

Utgåva/Issue: 07

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	1	Changed from 3 to 6 pins plug -R7229	100292	MAC	100324
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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning: KRETS LYFTH.TILTV.AUTOH.KLÄMTRYCK

Name: WIRING LIFTH.TILTANG.AUTOH.CL.PRES.

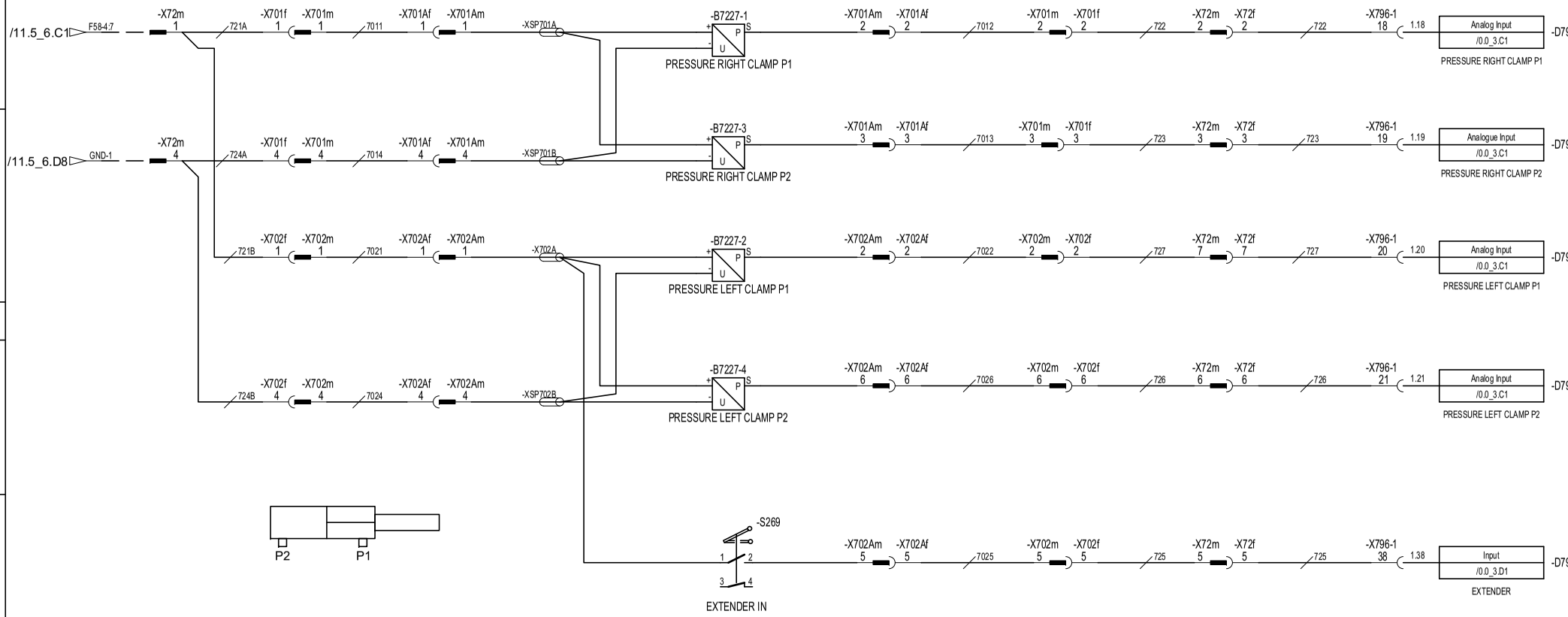
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.2_1/83

Utgåva/Issue: 07

E DRAWING



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

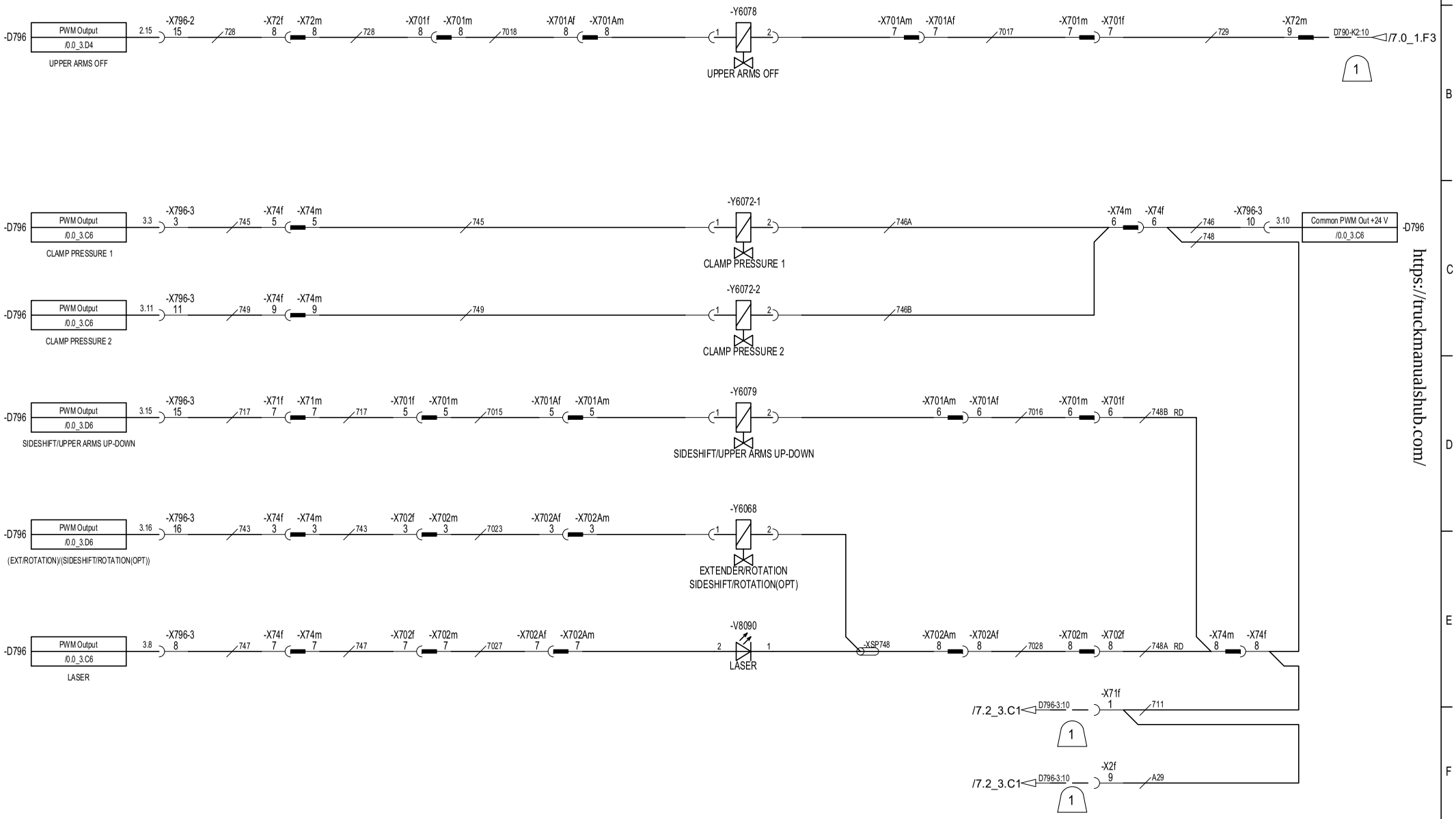
Kalmar

Benämning: KRETS AGGREGAT GIVARE
Name: WIRING ATTACHMENT SENSORS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.2_2A/83
Utgåva/Issue: 07

E DRAWING



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	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	060627	A49841.0100
Konstr/Design	TOO	060627	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

E DRAWING

Kalmar

Benämning / Name: KRETS AGGREAGT VENTILER

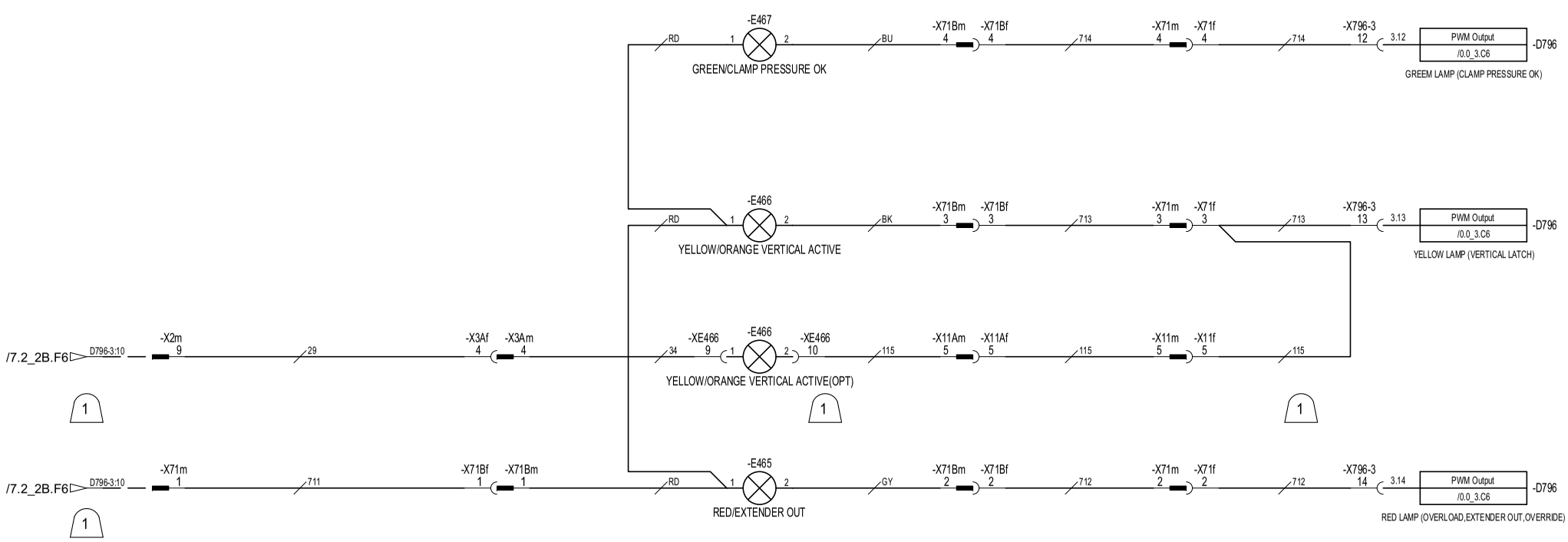
WIRING ATTACHMENT VALVES

Produkt/Product: DCE 50-90 TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.2_2B/83

Utgåva/Issue: 07



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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS INDIKERING
WIRING INDICATION LAMPS

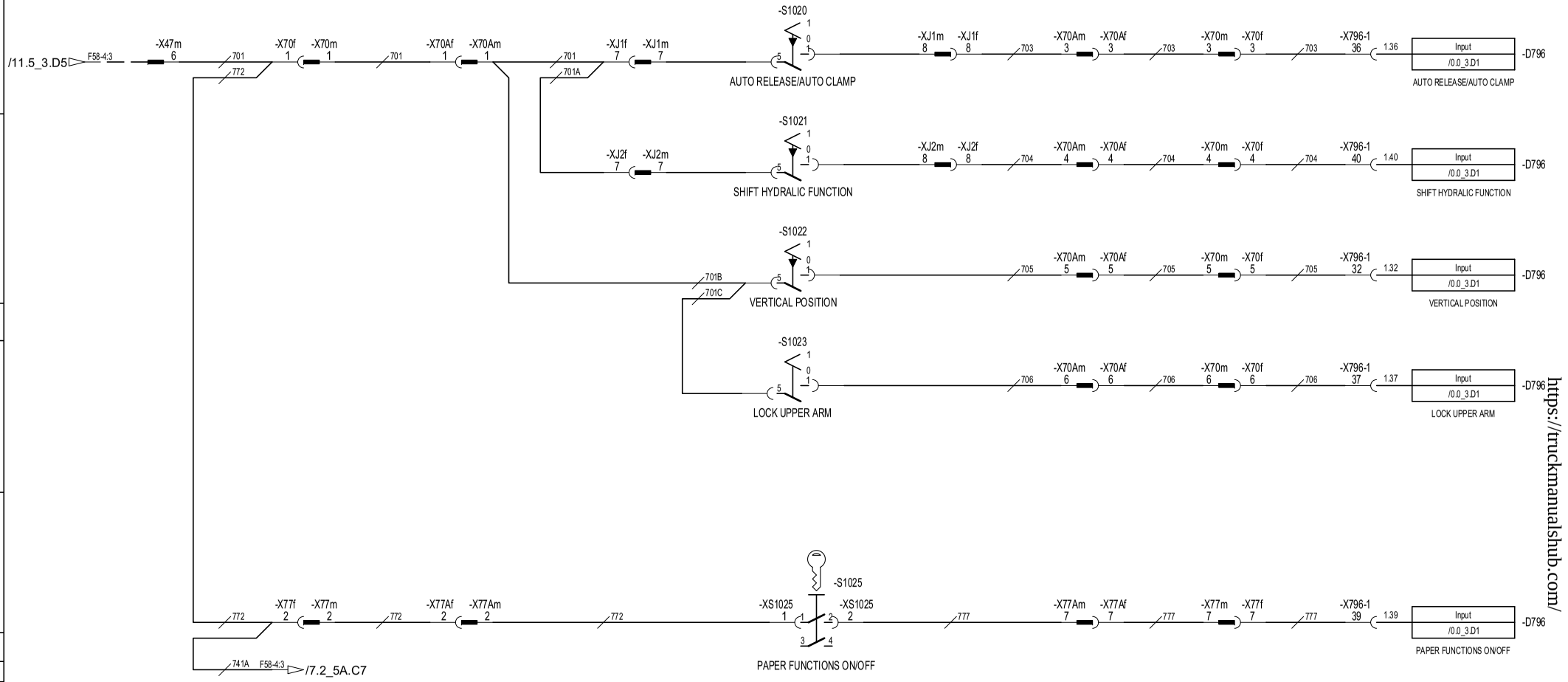
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.2_3/83

Utgåva/Issue: 07

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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS BRYTARE PAPPERFUNKT.

Name: WIRING SWITCHES PAPER FUNCT.

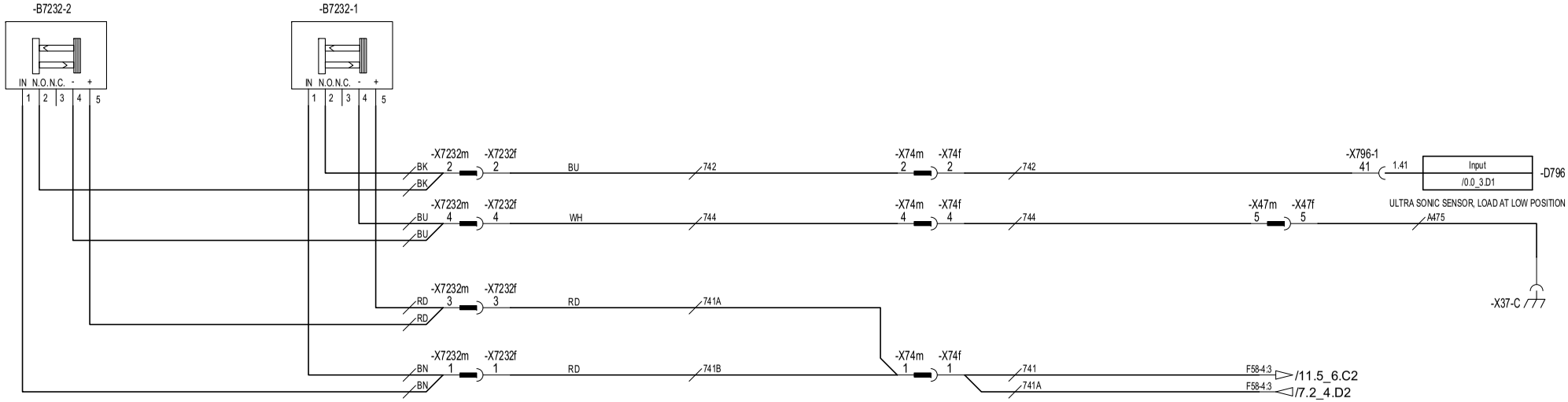
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

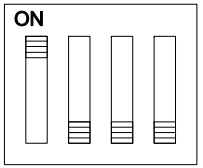
Blad/Sheet: 7.2_4/83

Utgåva/Issue: 07

E DRAWING



POSITION OF THE SWITCHES



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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning
KRETS SÄNKSTOPP

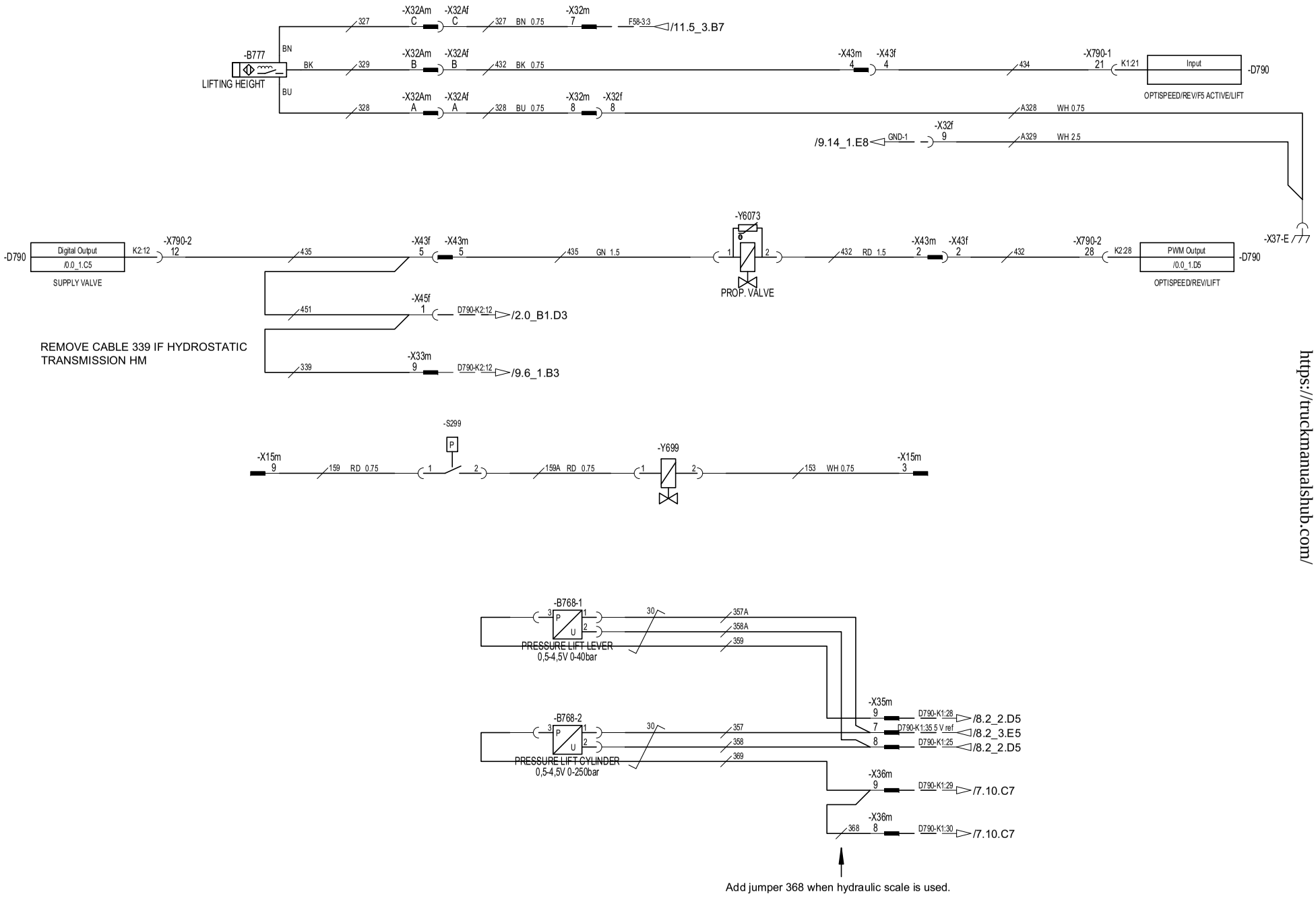
Name
WIRING STOP LOWER

Produkt/Product
DCE50- TIER 3

Ritn.nr / Drawing No.
A49842.0100

Blad/Sheet
7.2_5A/83

Utgåva/Issue
07



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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

Kalmar

Benämning / Name: KRETS OPTI SPEED/REV/LIFT
WIRING OPTI SPEED/REV/LIFT

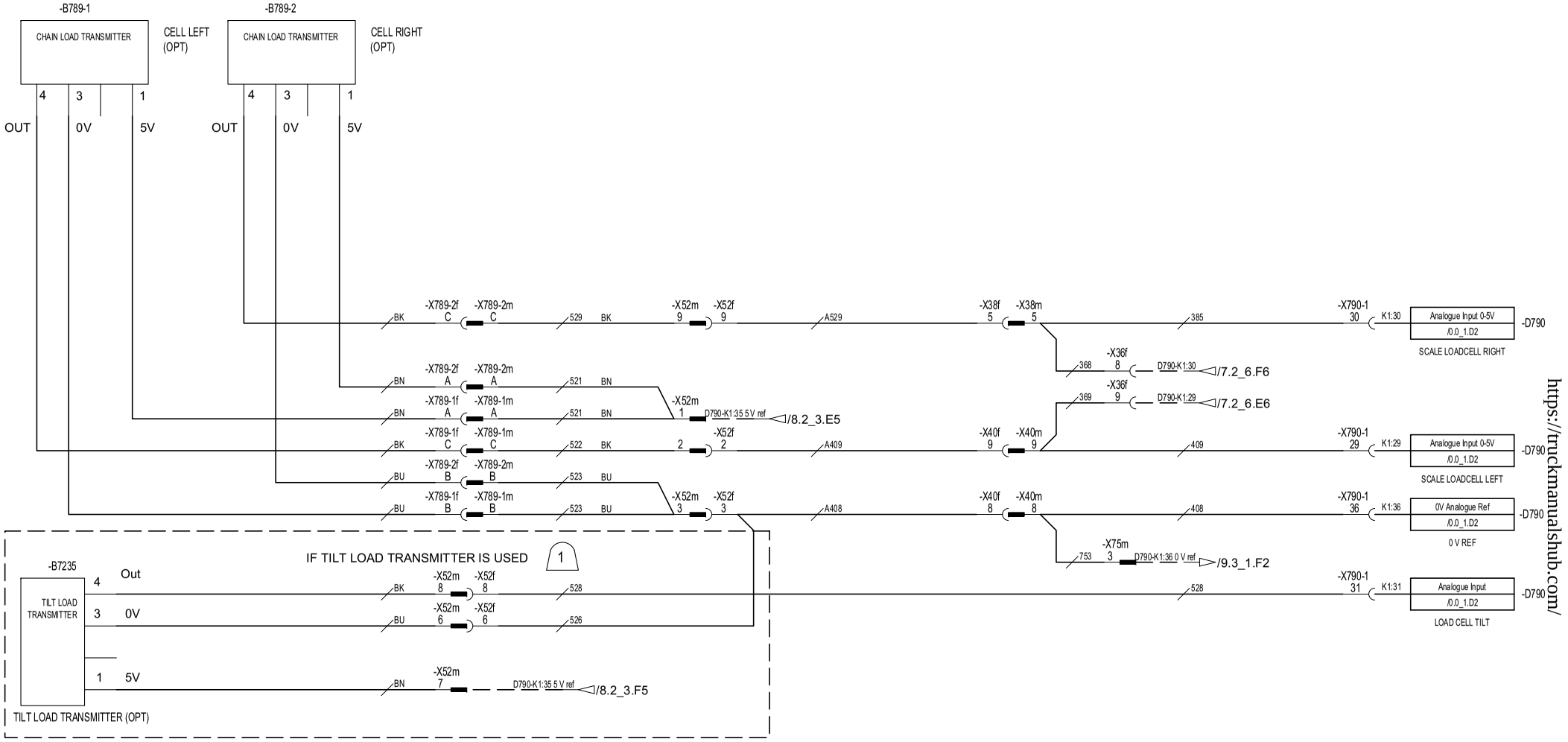
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.2_6/83

Utgåva/Issue: 07

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	1	W: 37:6 A:52:8	100292	MAC	100324
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	Sign.	Datum/Date	Huvudnr./Project no.
R.tad/Drawn	TOO	050526	A49841.0100
Konstr/Design	TOO	050525	
Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

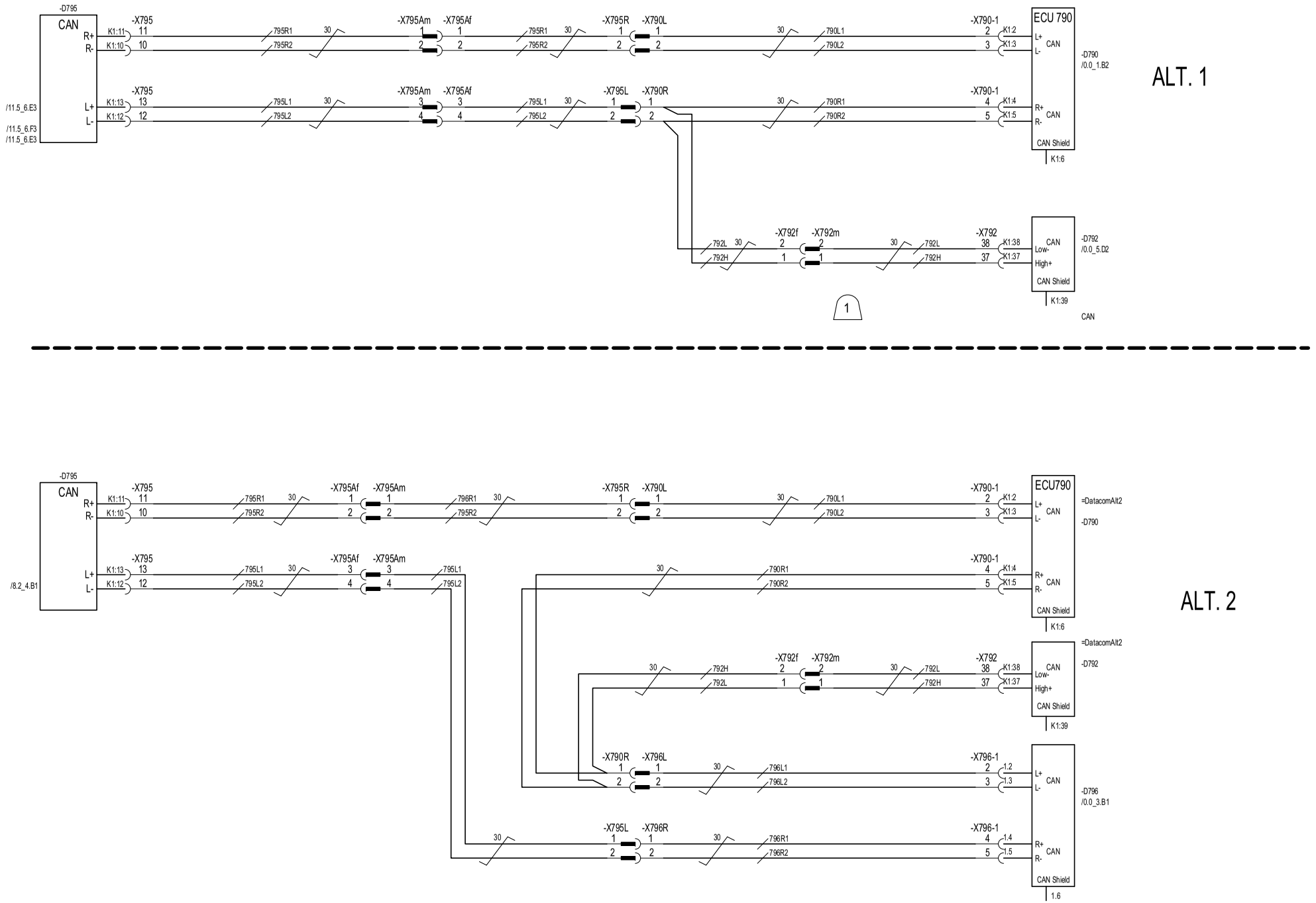
Kalmar

Benämning: KRETS ELEKTRIS K VÅG
Name: WIRING ELECTRONIC SCALE

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 7.10/83
Utgåva/Issue: 07

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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

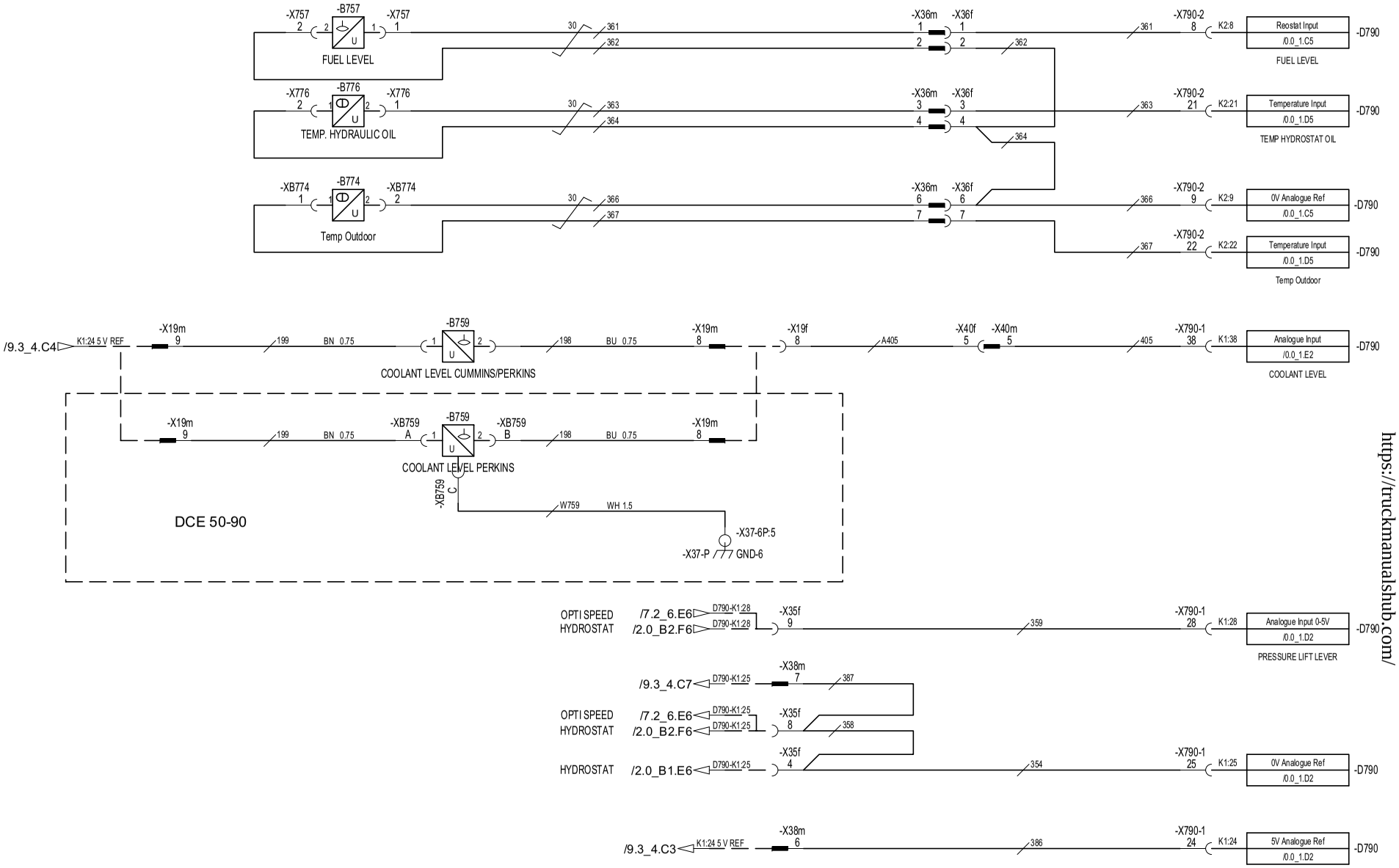
Kalmar

Benämning: KRETS DATAKOM REDCAN
Name: WIRING DATA COM. RED CAN

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 8.2_1/83
Utgåva/Issue: 07

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

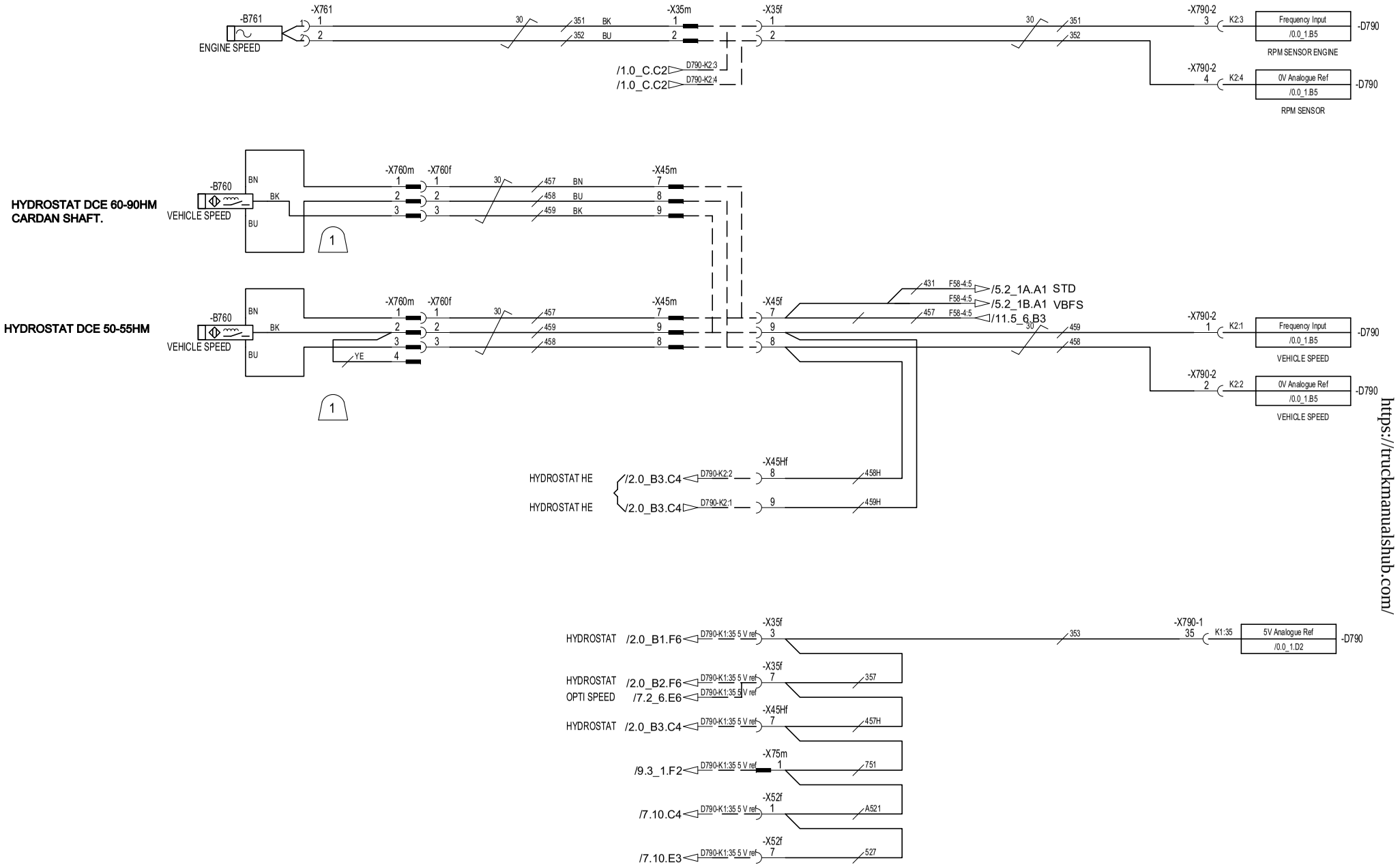
Kalmar

Benämning: KRETS ÖVERVAKNING
Name: WIRING MONITORING

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 8.2_2/83
Utgåva/Issue: 07

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS GIV., HASTIGHET & VARVTAL

Name: WIRING SENS., SPEED & ENGINE REV.

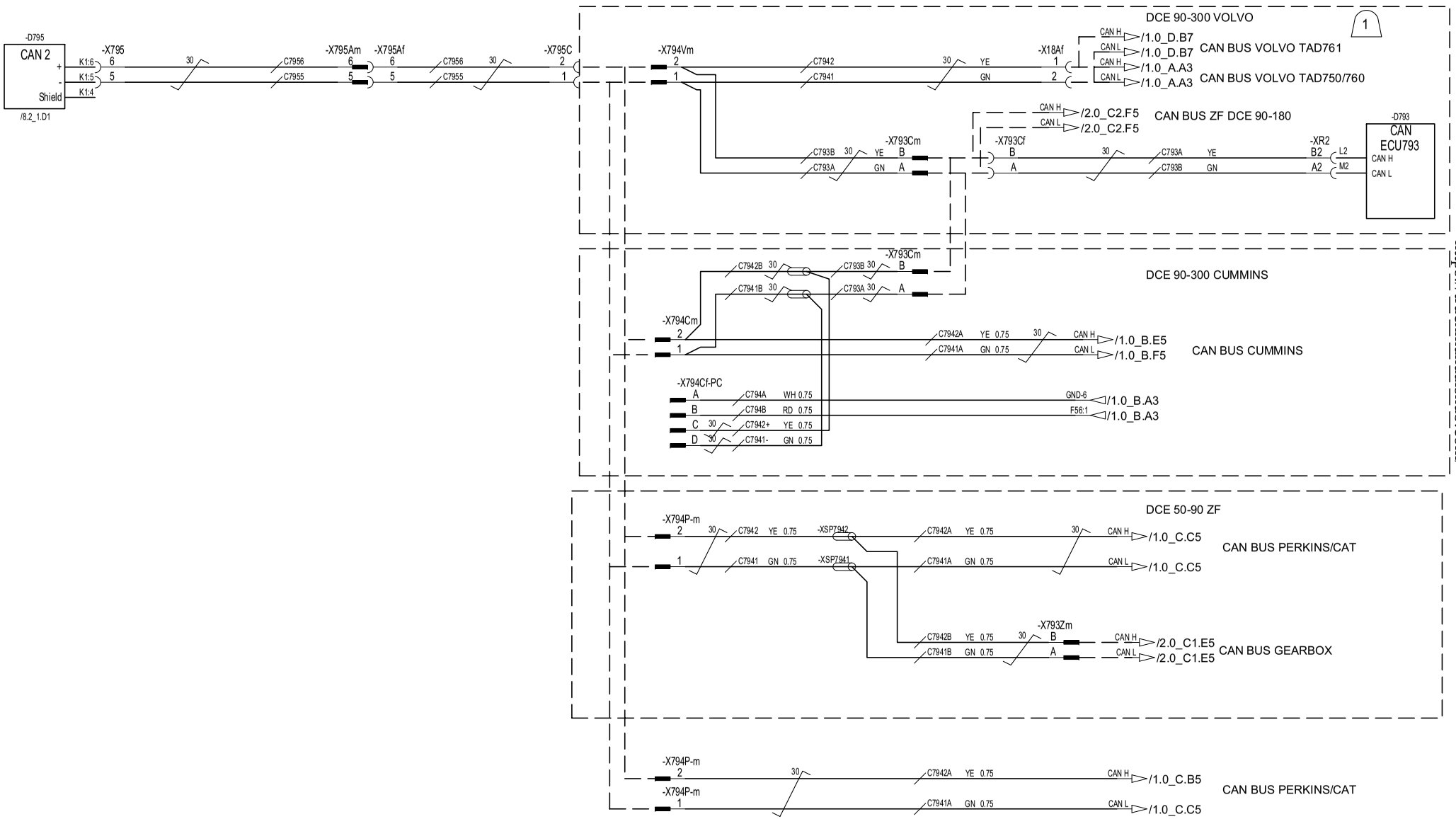
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 8.2_3/83

Utgåva/Issue: 07

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Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

Kalmar

Benämning / Name: KRETS DATAKOM J1939 / WIRING DATA COM. J1939

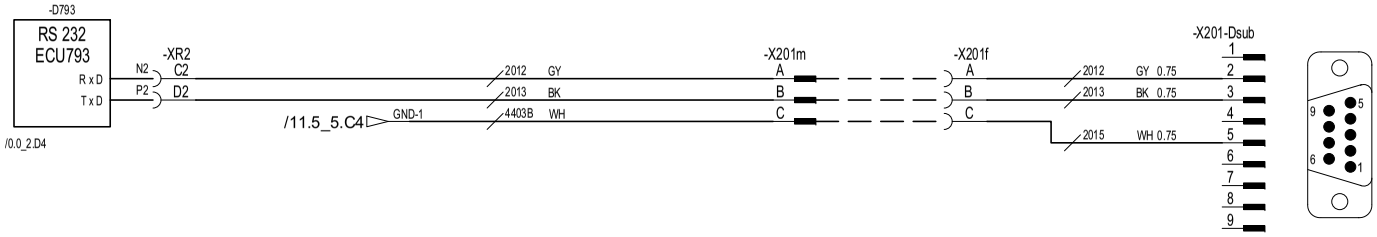
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 8.2_4/83

Utgåva/Issue: 07

E DRAWING



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R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS DATAKOM.

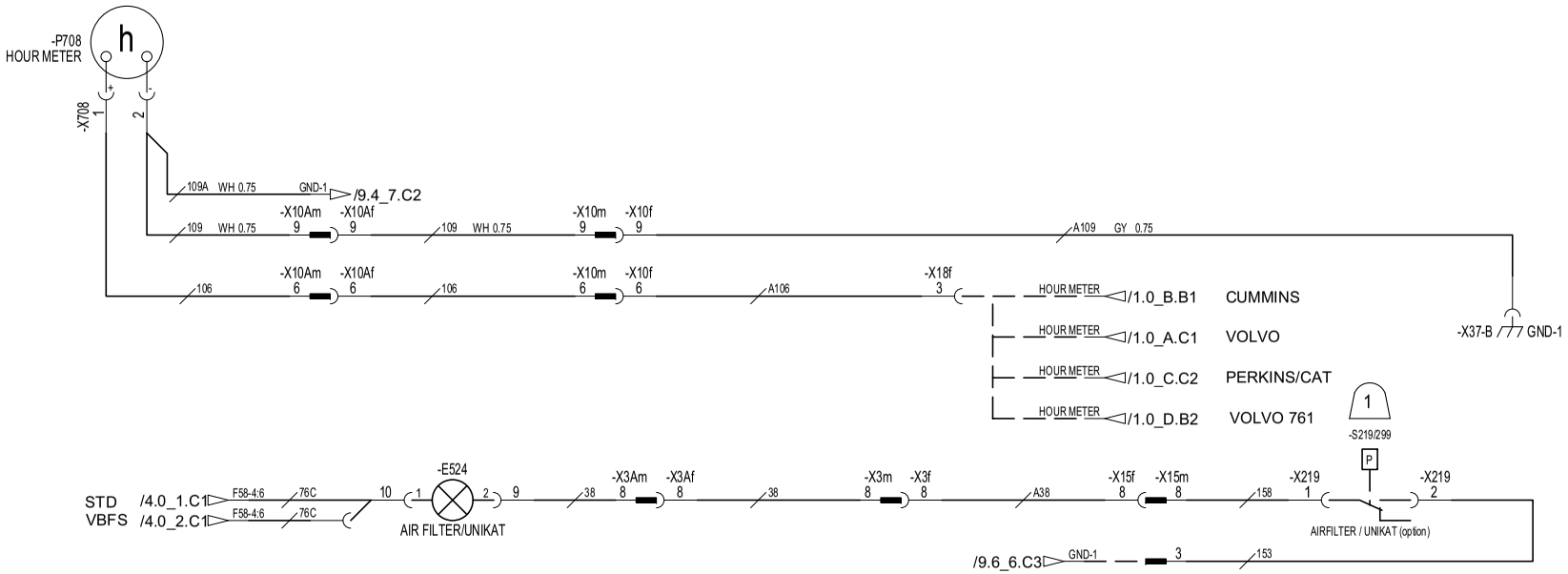
Name: WIRING DATA COM.

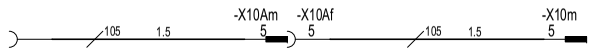
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 8.2_5/83

Utgåva/Issue: 07





OPTION CABLES

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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

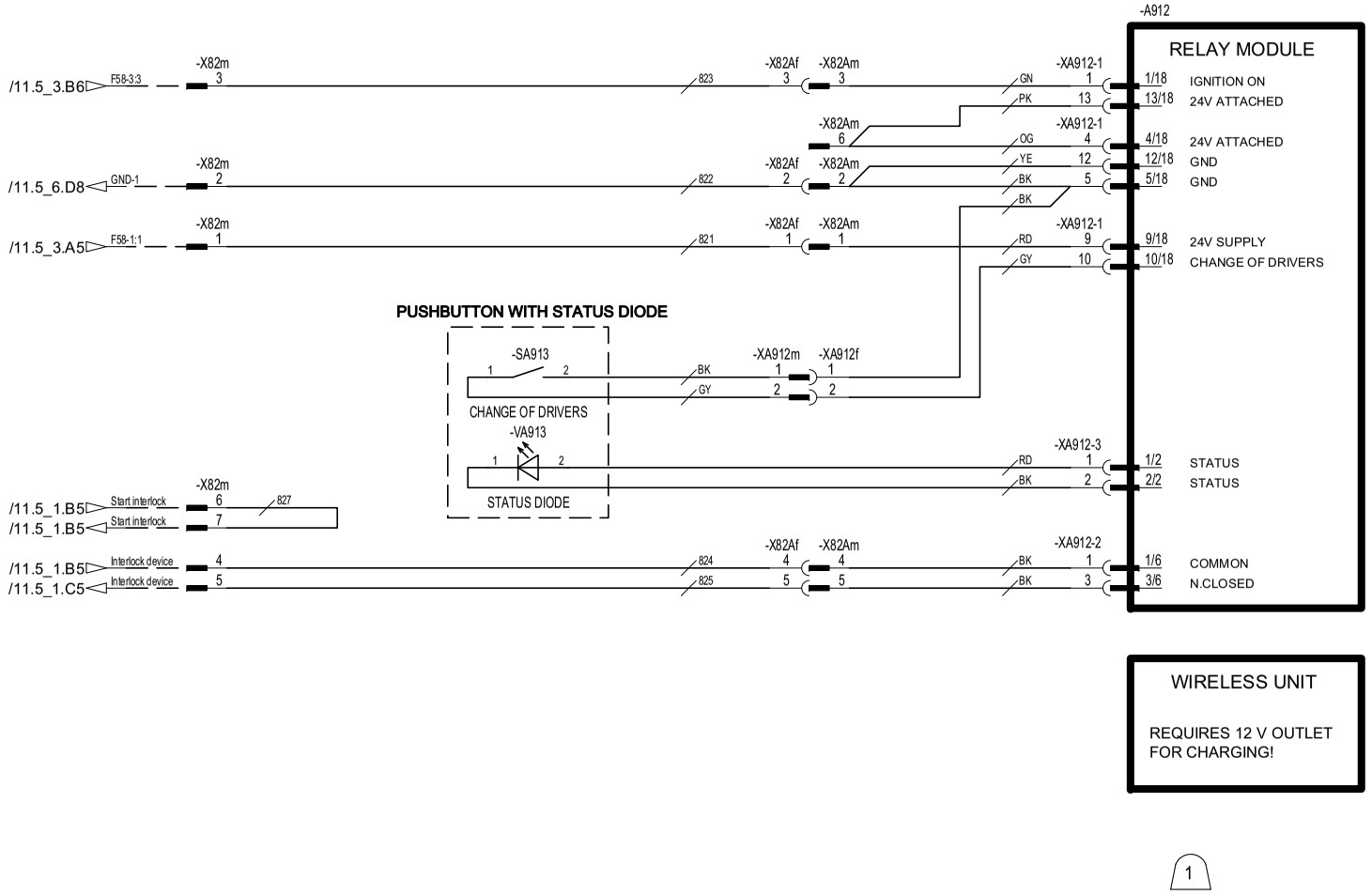
Kalmar

Benämning: KRETS GIVARE/INSTRUMENT
Name: WIRING SENSORS/INSTRUMENT

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.1/83
Utgåva/Issue: 07

E-DRAWING



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Konstr/Design	TOO	071210	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

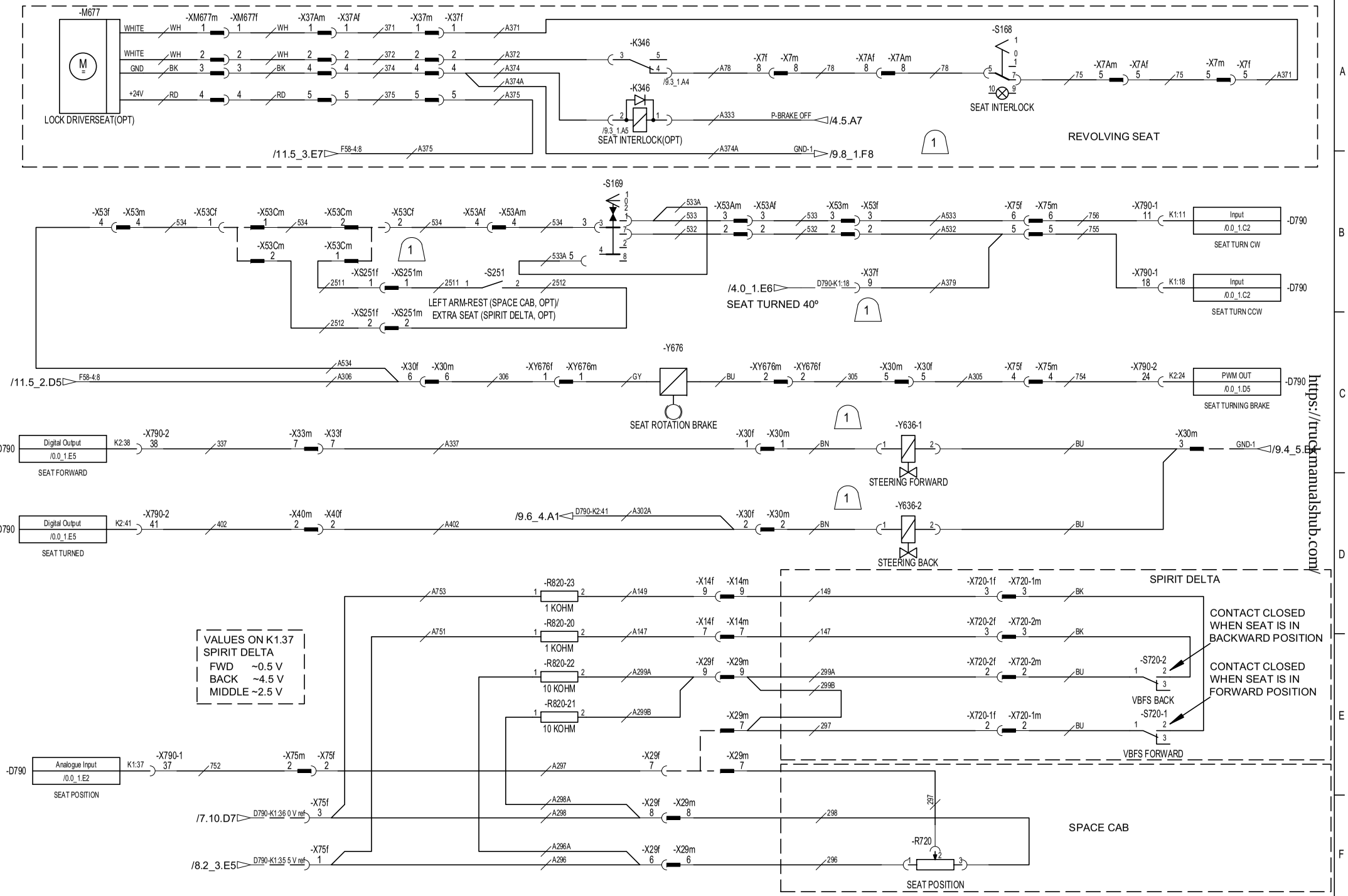
Kalmar

Benämning: KRETS ALKOLÅS
Name: WIRING INTERLOCK DEVICE

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.2/83
Utgåva/Issue: 07

E DRAWING



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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Kalmar

Benämning: KRETS HYTT, STOLSVÄNDNING
Name: WIRING CABIN, SEAT ROTATION

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.3_1/83
Utgåva/Issue: 07

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-A798

-XA798m 5/12
6/12
7/12
8/12
9/12
10/12
11/12
12/12

ELECTRIC MOTOR CONTROL BOX

-XA798m 1/12
2/12
3/12
4/12

-XA798f 1
2
3
4

WH
RD RD 2.5
GN
VT
BU
OG
BU
WH
BU
BN
WH
WH

-K798-1 CW /9.3_2.C4
-K798-1 CW /9.3_2.B4
-K798-2 CCW /9.3_2.D4
-K798-2 CCW /9.3_2.C4
-K798-3 LOW SPEED /9.3_2.E4
-K798-3 LOW SPEED /9.3_2.D4

-V665

/11.5_3.B5 F58-3:5 -X54m 5

-D790 PWM Output /0.0_1.D5 K2:29 -X790-2 29 383 -X38m 3 -X38f 3 A383 -X54f 2 -X54m 2 BK
TURN SEAT CW

-D790 Digital Output /0.0_1.C5 K2:11 -X790-2 11 401 -X40m 1 -X40f 1 A401 -X54f 3 -X54m 3 VT
TURN SEAT CCW

-D790 PWM Output /0.0_1.D5 K2:23 -X790-2 23 389 -X38m 9 -X38f 9 A389 -X54f 1 -X54m 1 BN
LOW TURNING SPEED

-X798

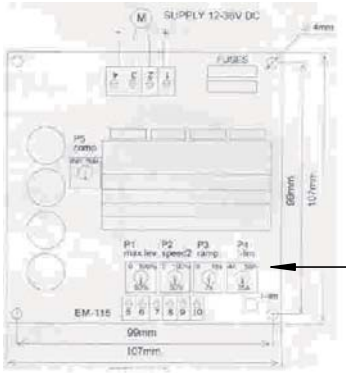
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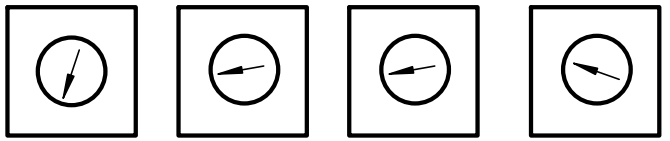
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-XM675m 1
-M675
BU 30 M 31 BN
50
GND

-XM675m 1
-XM675f 1

-X54m 4 WH GND-1 /9.3_3.C5

1





P1 MAX. LEV | P2 SPEED 2 | P3 RAMP | P4 CURRENT LIMIT

ARROWS SHOWS DEFAULT SETTING FOR MOST UNITS.
INDIVIDUAL DIFFEENCES MIGHT OCCUR!

1

Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
	1	SEE A49842.0100-E3KM.DOC	100292	MAC	100324
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	Sign.	Datum/Date	Huvudnr./Project no.
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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

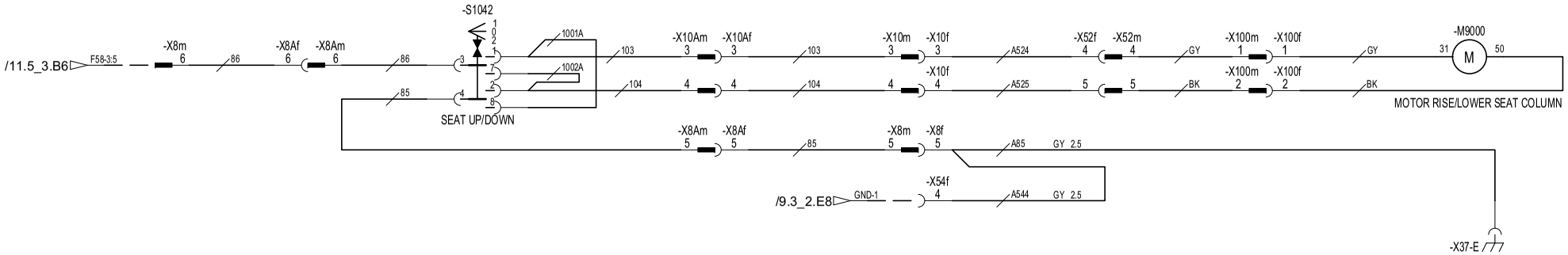
Kalmar

Benämning: KRETS ELEKTRISK STOLSVÄNDNNG
Name: WIRING SEAT ROTATION

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.3_2/83
Utgåva/Issue: 07

E DRAWING



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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

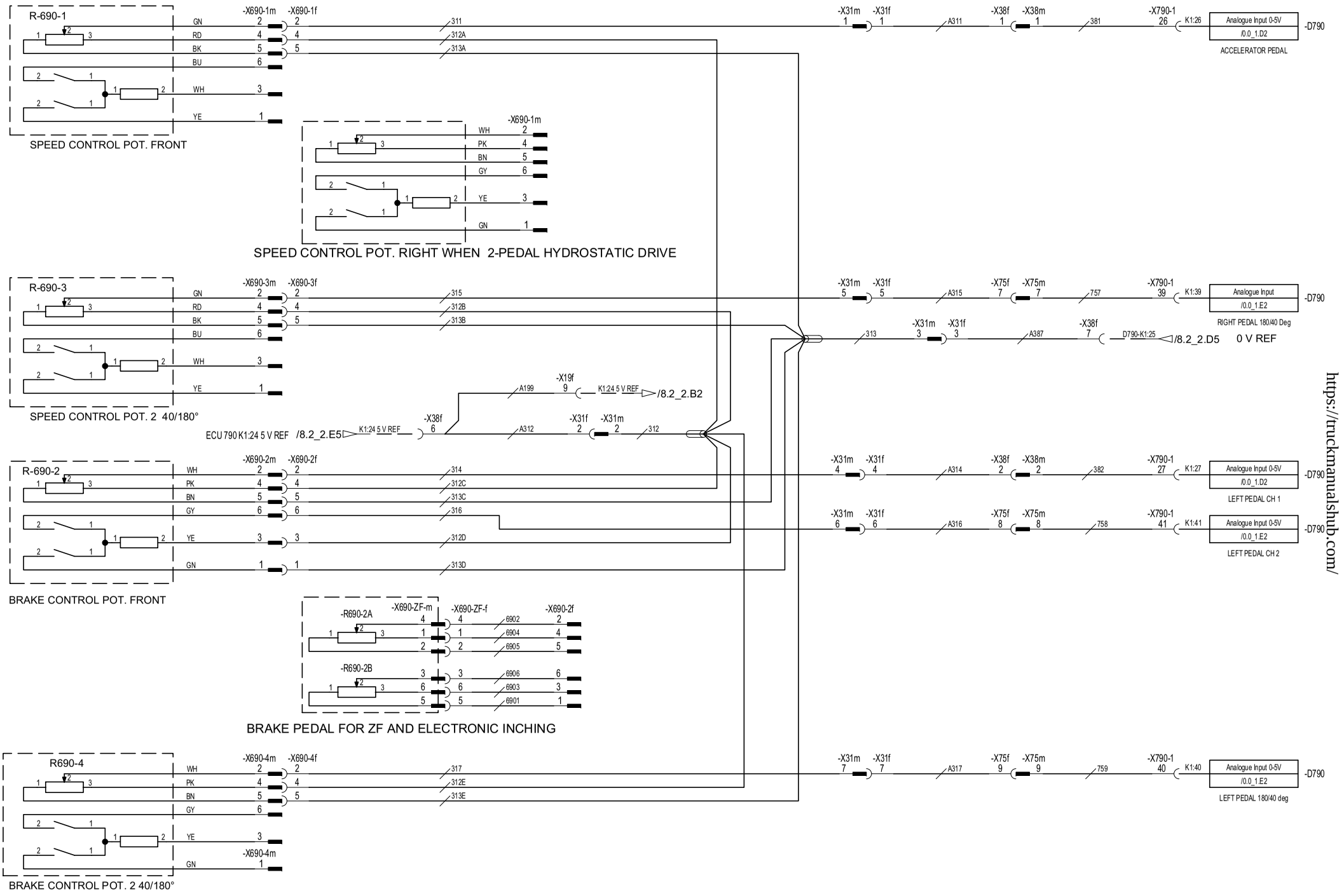
Kalmar

Benämning: KRETS HÖJ/SÄNKBAR STOLSPELARE
Name: WIRING SEAT UP/DOWN

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.3_3/83
Utgåva/Issue: 07

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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6 — Klass/Class

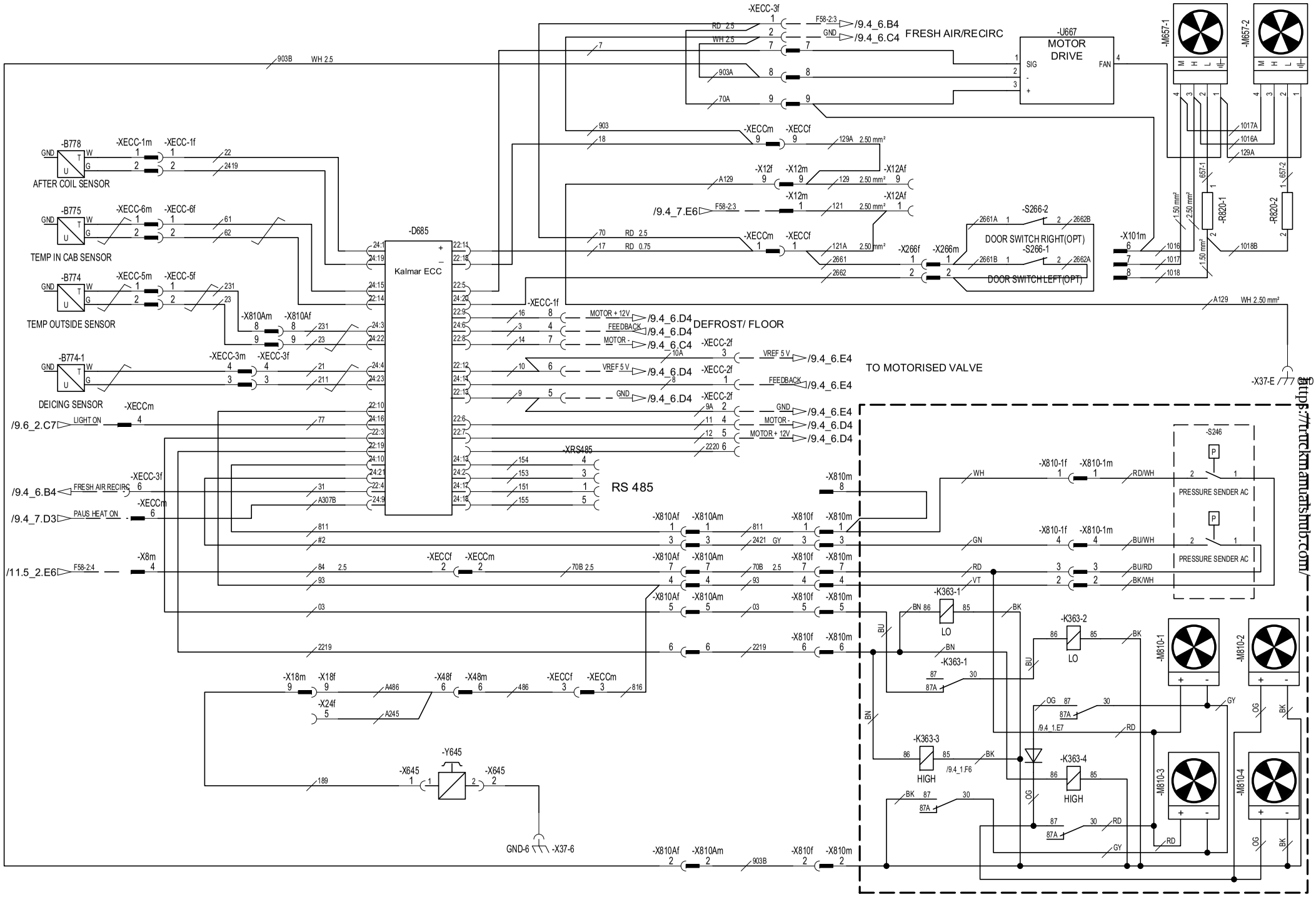
E DRAWING

Kalmar

Benämning: KRETS GASPÅDRAG
Name: WIRING SPEED CONTROL

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.3_4/83
Utgåva/Issue: 07



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Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

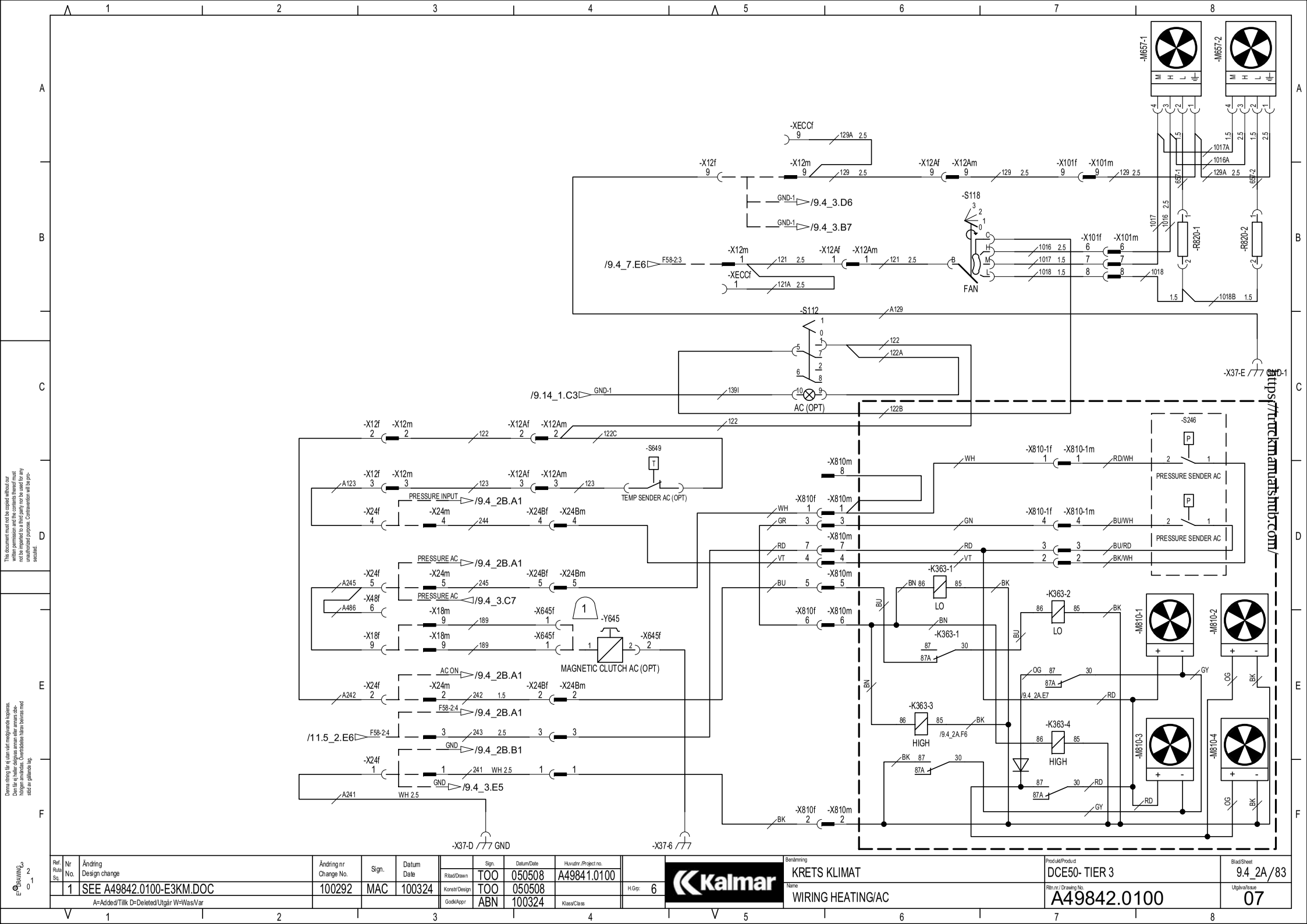
Kalmar

Benämning: KRETS ECC
Name: WIRING ECC

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.4_1/83
Utgåva/Issue: 07

E DRAWING



Ref. Ruta Sq.	Nr No.	Ändring Design change	Ändring nr Change No.	Sign.	Datum Date
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R:tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning
KRETS KLIMAT

Name
WIRING HEATING/AC

Produkt/Product
DCE50- TIER 3

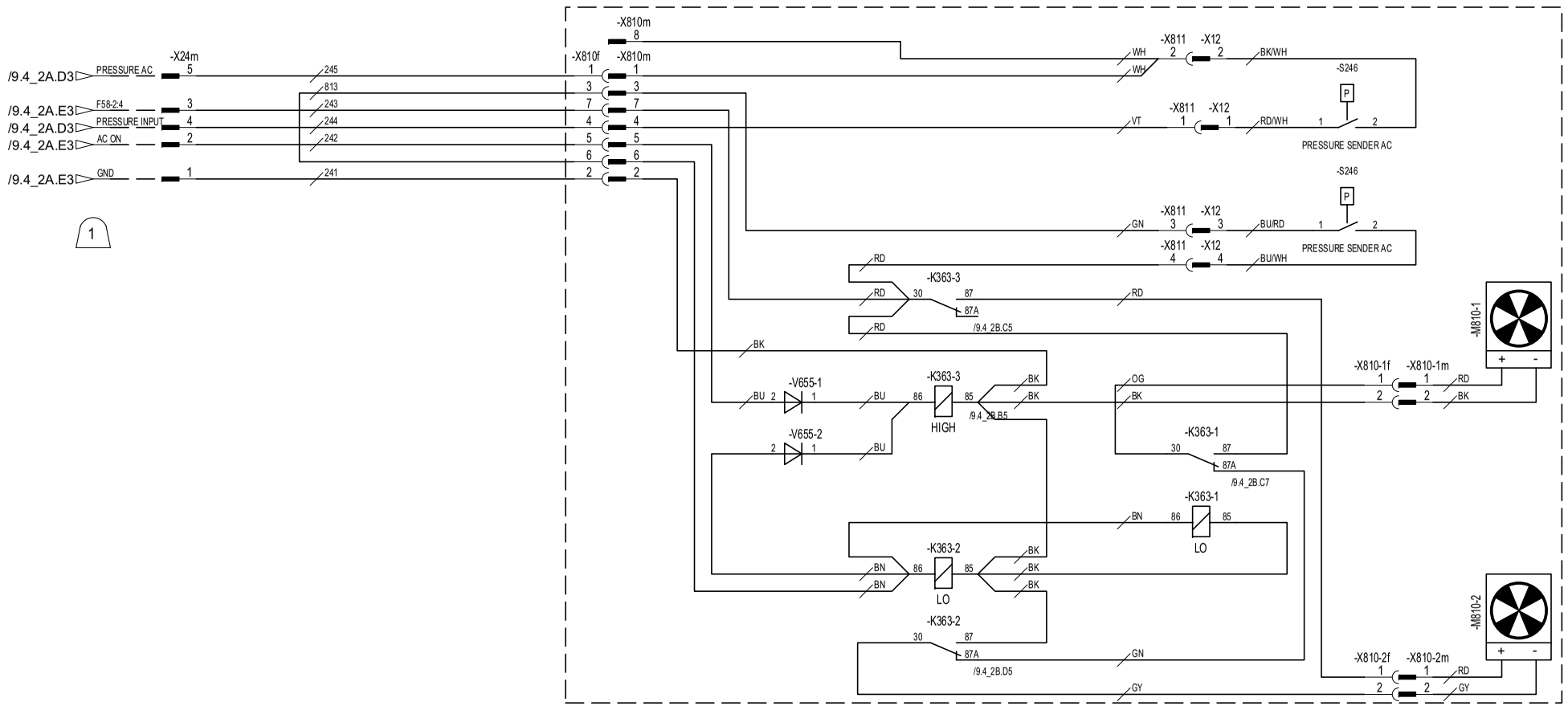
Ritn.nr / Drawing No.
A49842.0100

Blad/Sheet
9.4_2A/83

Utgåva/Issue
07

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Konstr/Design	TOO	050508	
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H.Grp: 6

Kalmar

Benämning / Name: KRETS KLIMAT / WIRING HEATING/AC

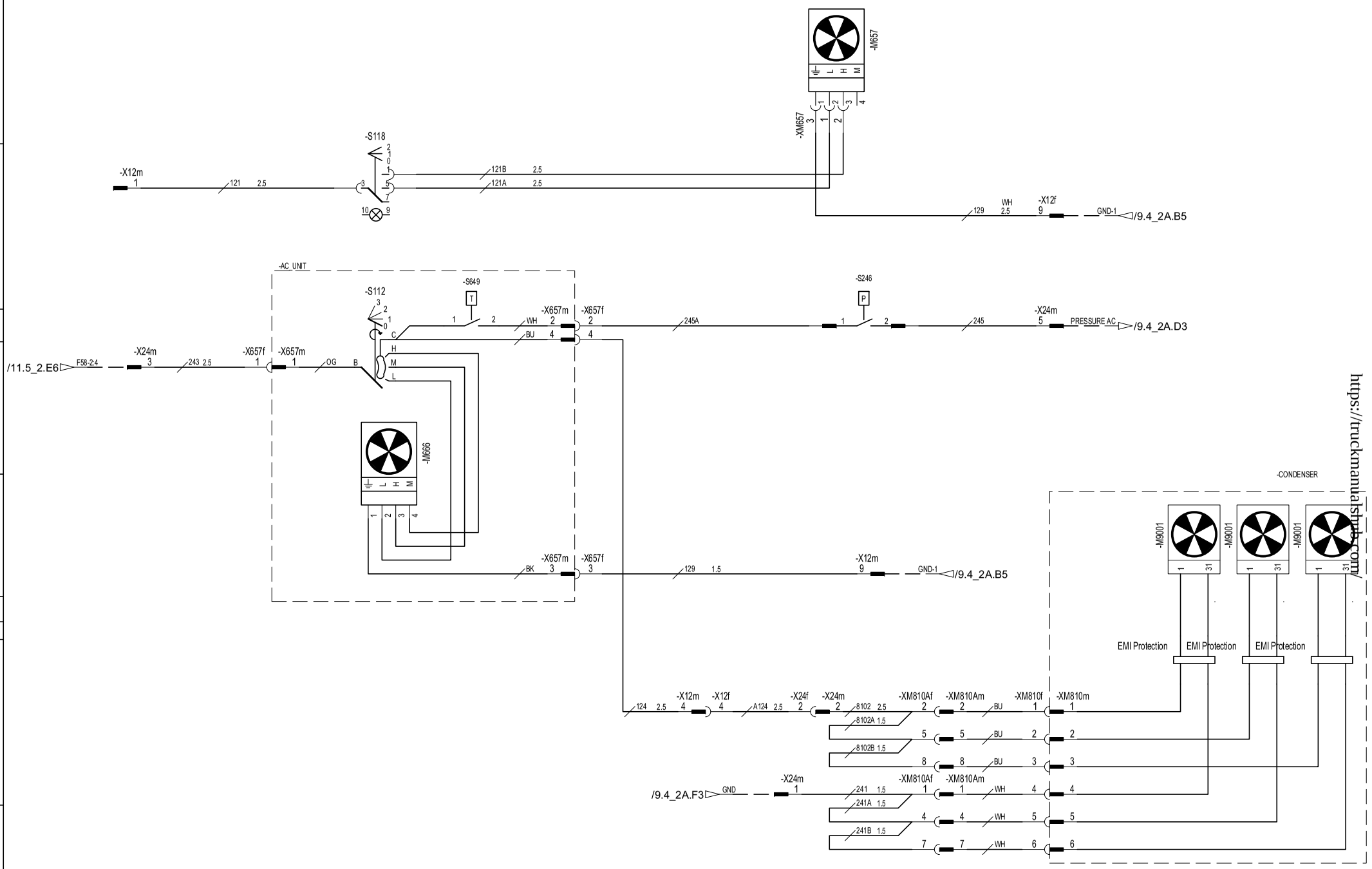
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Konstr/Design	TOO	050711	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS KLIMAT FLEXCAB

Name: WIRING HEATING/AC FLEXCAB

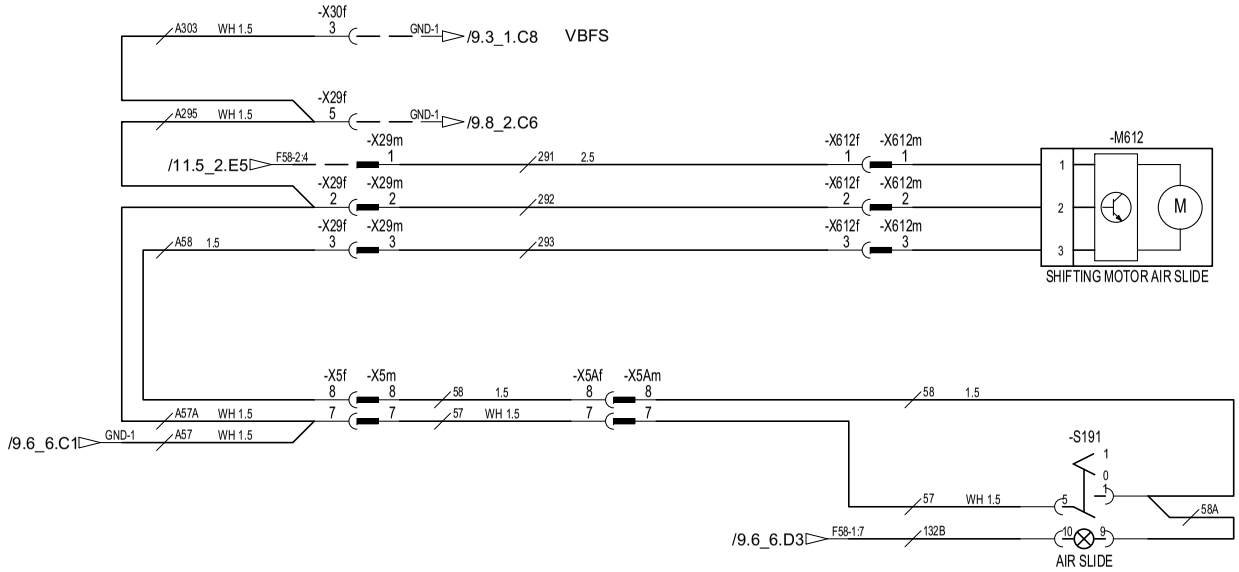
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Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.4_3/83

Utgåva/Issue: 07

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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

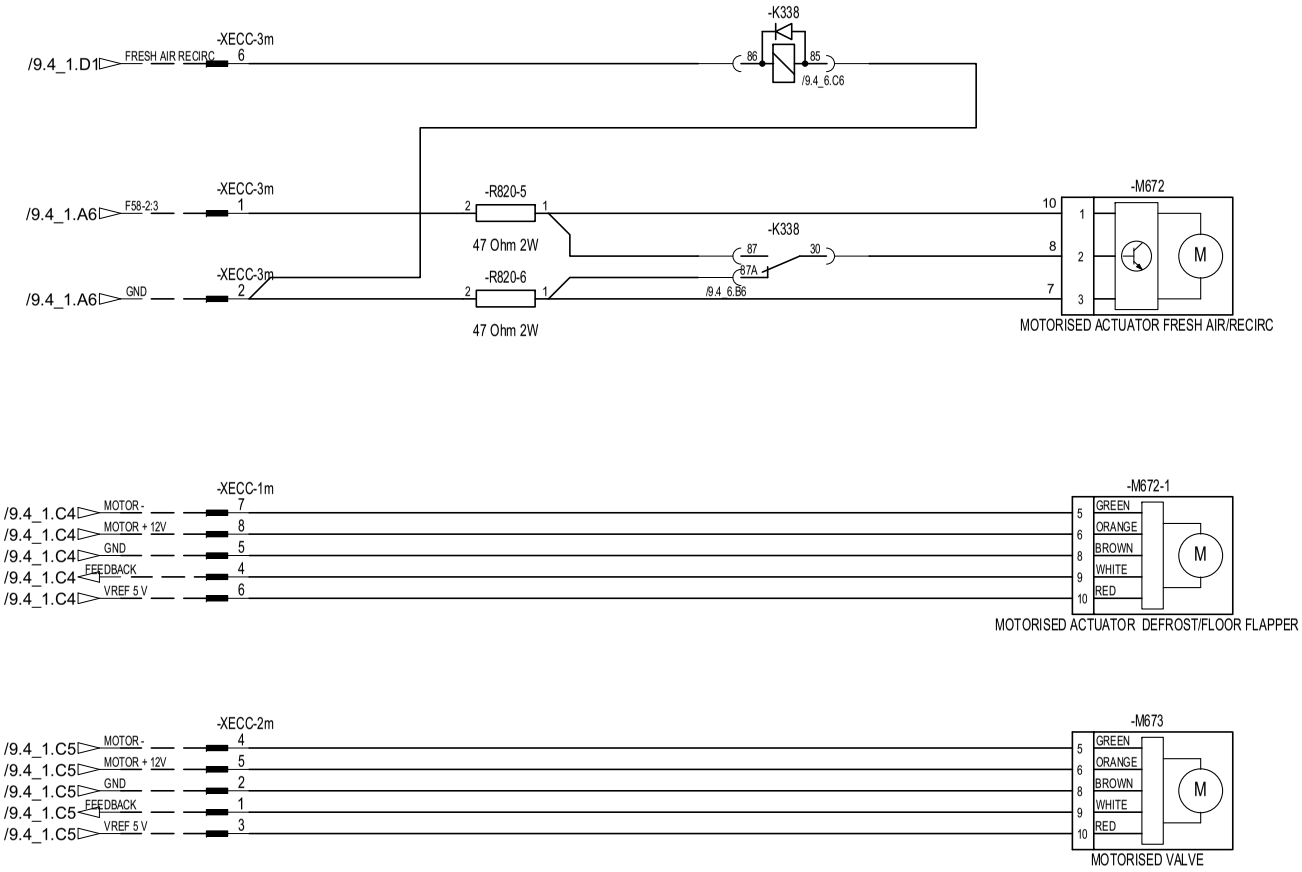
Kalmar

Benämning: KRETS KLIMAT
Name: WIRING HEATING/AC

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.4_5/83
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R'tad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS ECC FLÄKT / WIRING ECC FAN

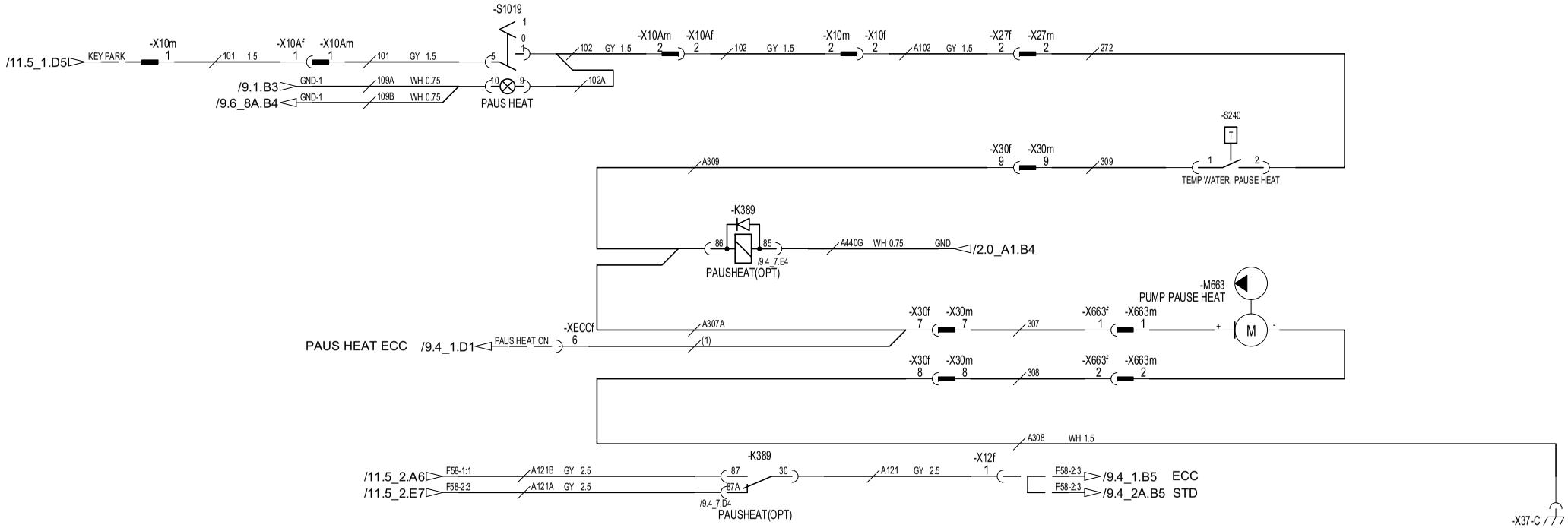
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Ritn.nr / Drawing No.: A49842.0100

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Utgåva/Issue: 07

E DRAWING



PLACE JUMPER BETWEEN 87a AND 30 ON RELAY K389
IF PAUSHEATER NOT IS INSTALLED

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	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	PVE	051011	A49841.0100
Konstr/Design	TOO	050525	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS RASTVÄRME(OPT) / WIRING PAUSHEAT(OPT)

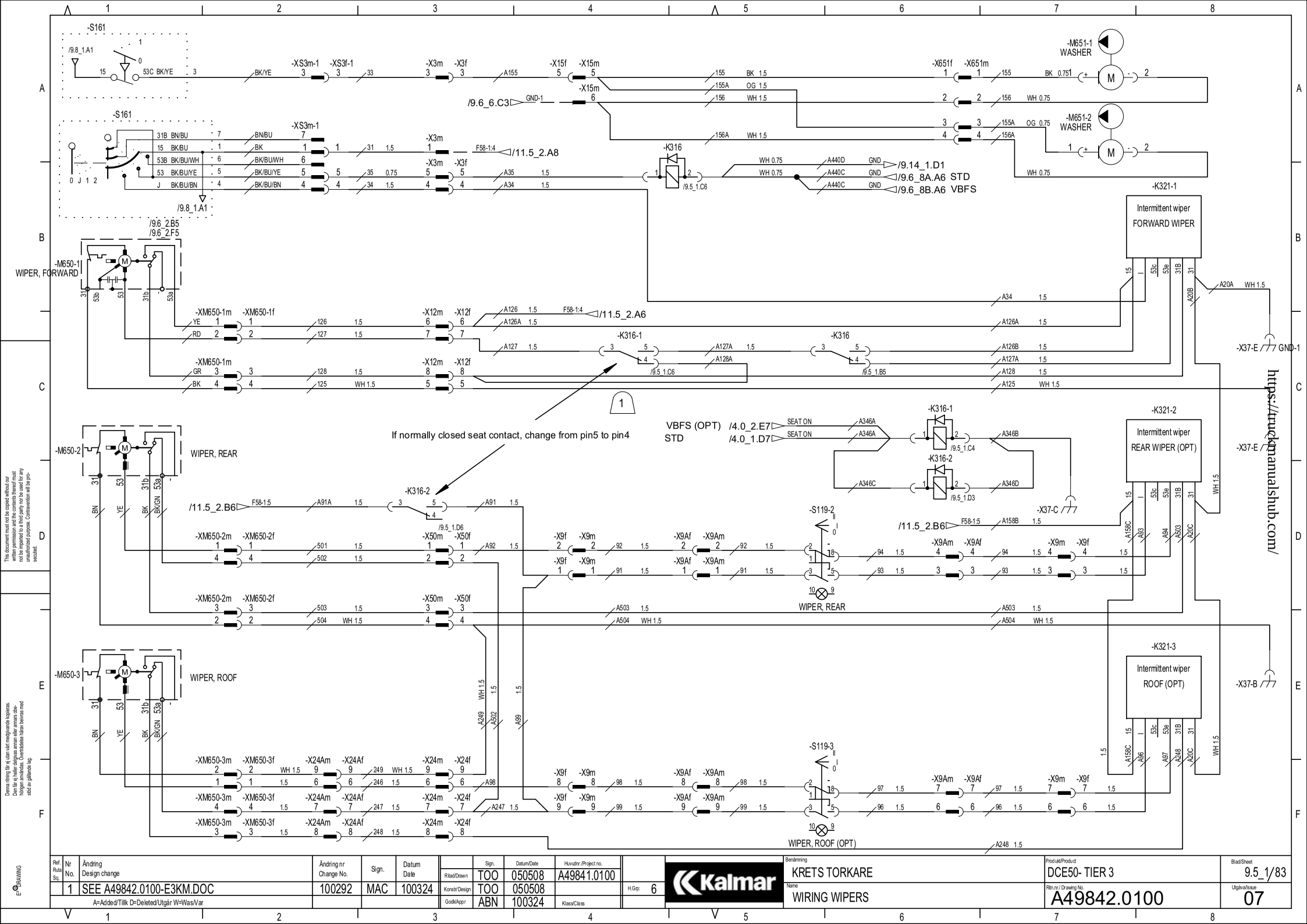
Produkt/Product: DCE 50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.4_7/83

Utgåva/Issue: 07

E DRAWING



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Godk/Appr	ABN	100324	

H.Grp: 6

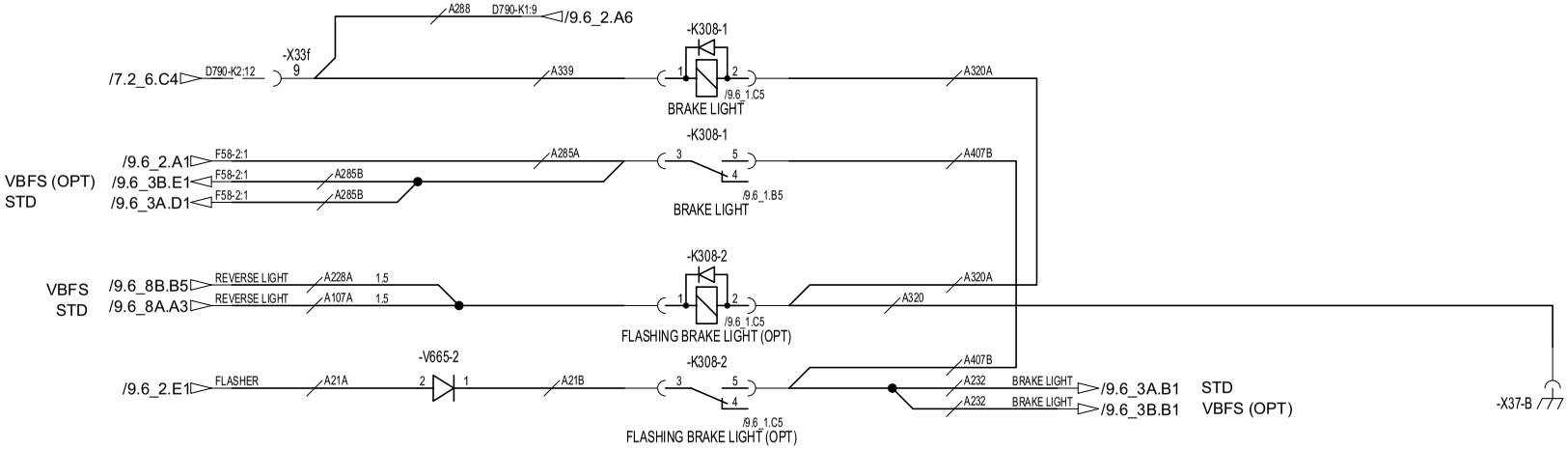
Kalmar

Benämning: KRETS TORKARE
Name: WIRING WIPERS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.5_1/83
Utgåva/Issue: 07

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Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

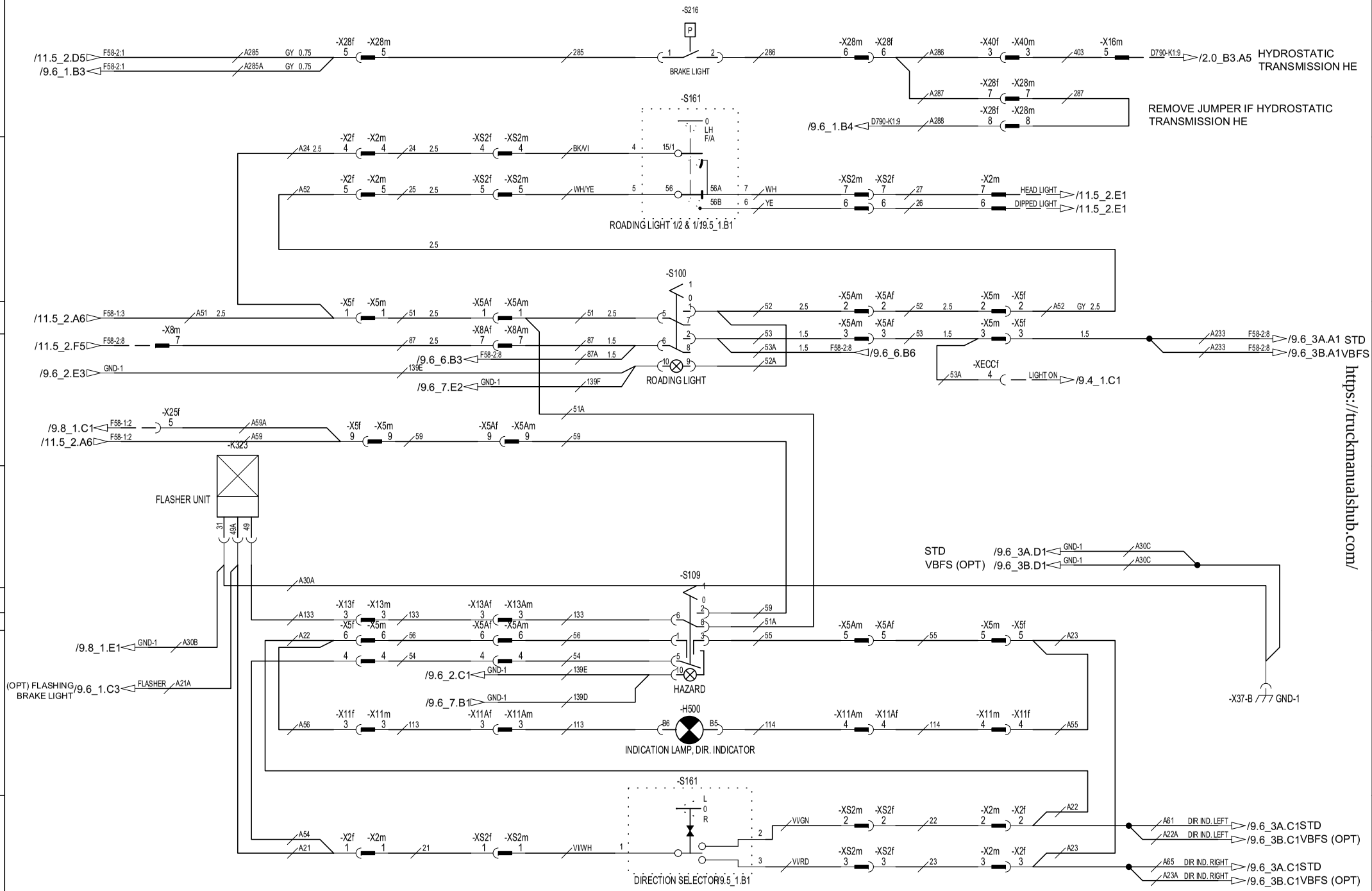
Kalmar

Benämning: KRETSFÄRD LJUS
Name: WIRING HEAD LIGHTS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.6_1/83
Utgåva/Issue: 07

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Ritad/Drawn	TOO	050508	A49841.0100
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Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

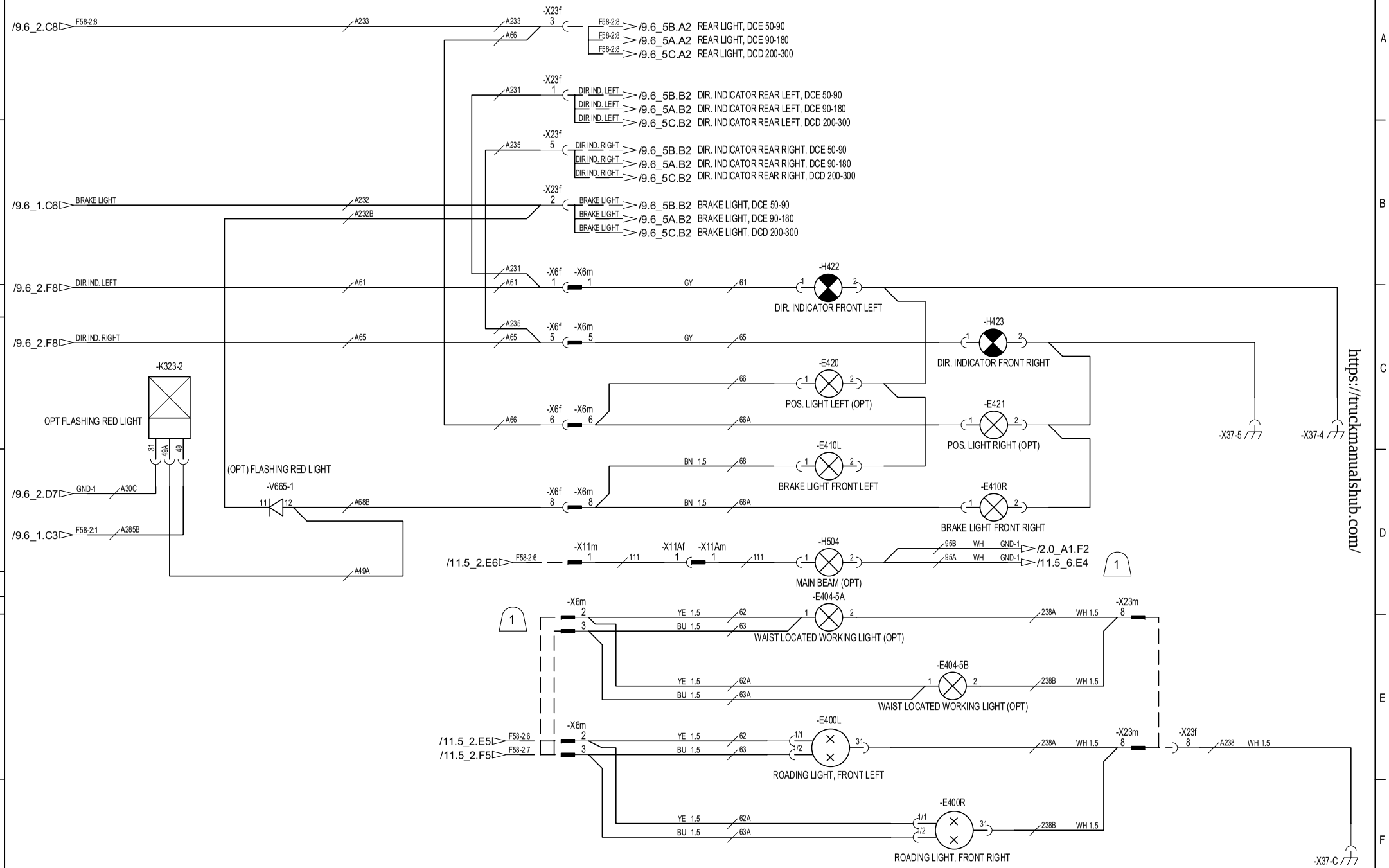
Kalmar

Benämning: KRETS FÄRDLJUS
Name: WIRING HEAD LIGHTS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.6_2/83
Utgåva/Issue: 07

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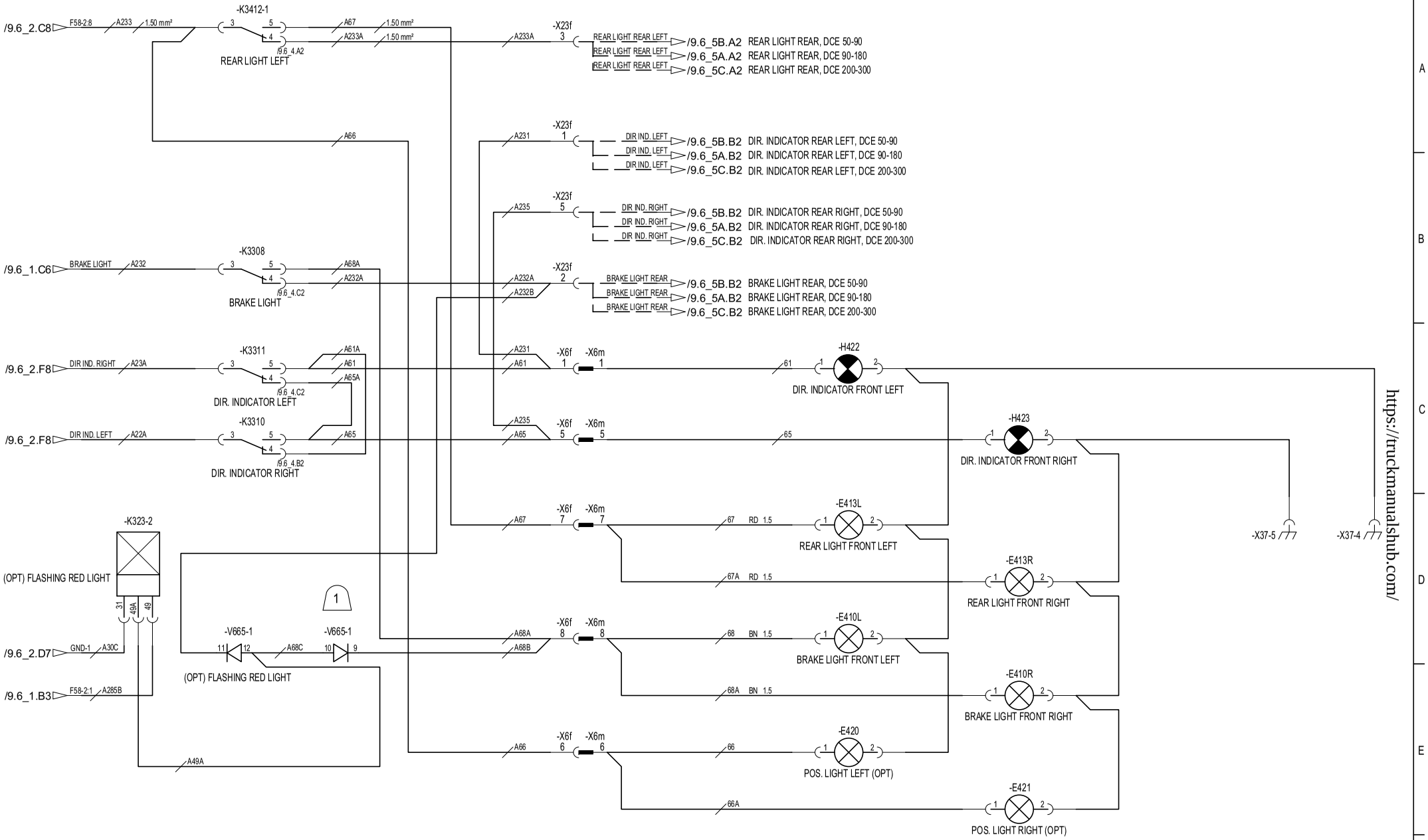
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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

Kalmar

Benämning	KRETS FÄRDLJUS
Name	WIRING HEADLIGHTS
Produkt/Product	DCE50- TIER 3
Ritn.nr / Drawing No.	A49842.0100
Blad/Sheet	9.6_3A/83
Utgåva/Issue	07

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	Sign.	Datum/Date	Huvudnr./Project no.
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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

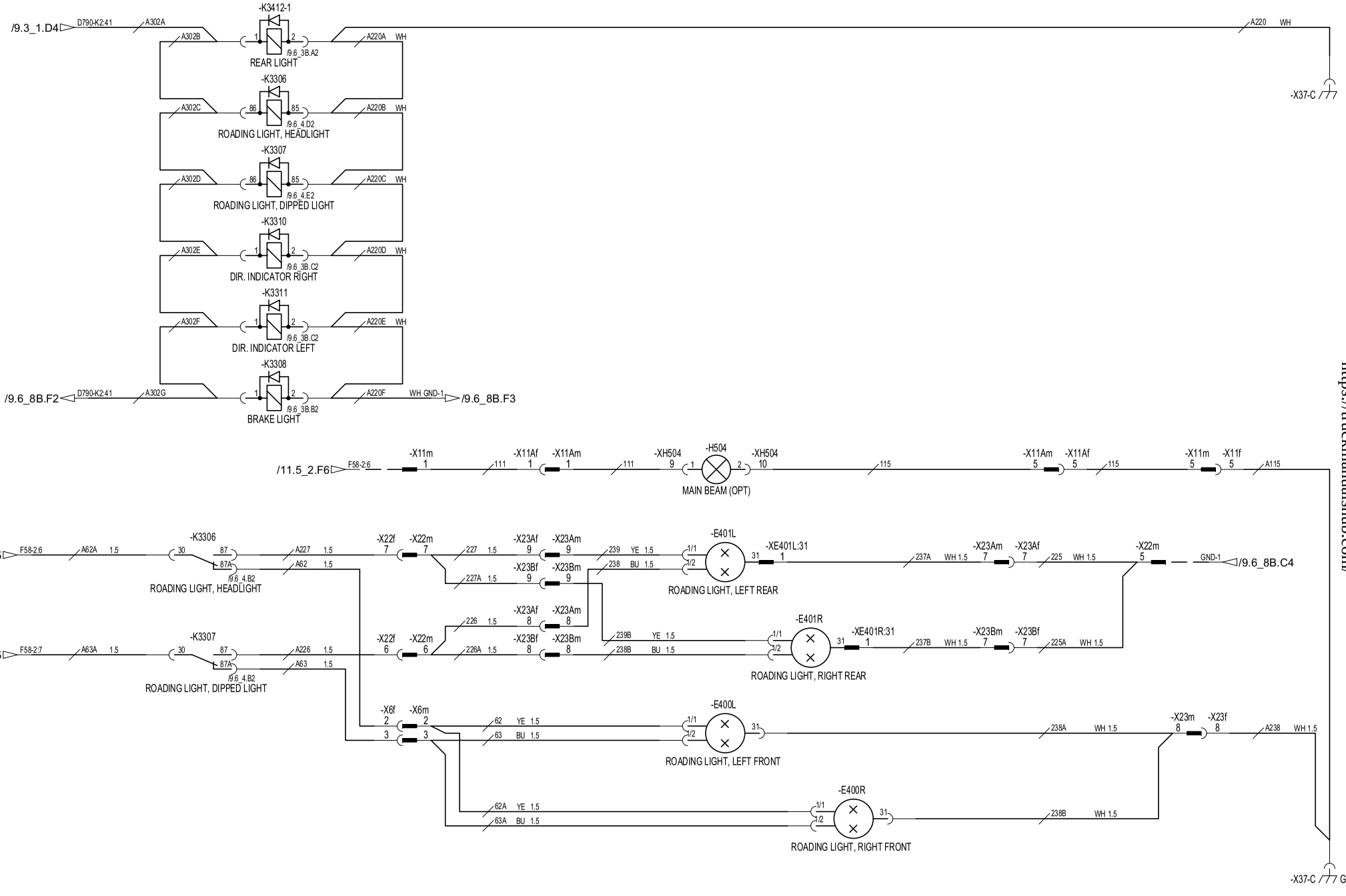
Kalmar

Benämning: KRETS FÄRDLJUS, VBFS
Name: WIRING HEADLIGHTS, TDS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.6_3B/83
Utgåva/Issue: 07

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H.Grp: 6

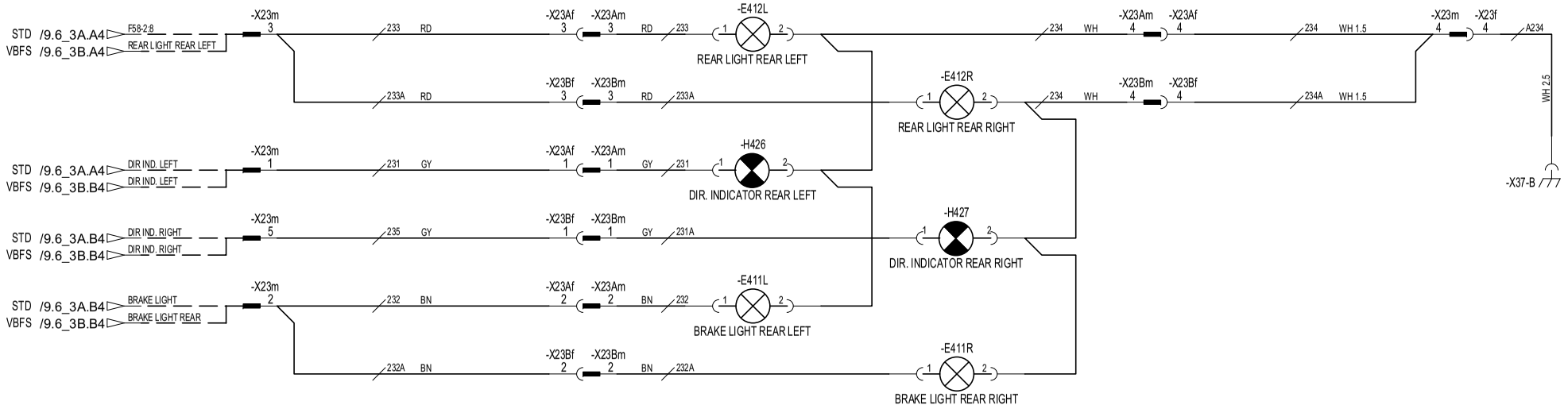
Kalmar

Benämning: KRETS FÄRDLJUS, VBFS
Name: WIRING HEAD LIGHTS TDS

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.6_4/83
Utgåva/Issue: 07

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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS FÄRDLJUS BAK, DCE90-

Name: WIRING HEAD LIGHTS REAR

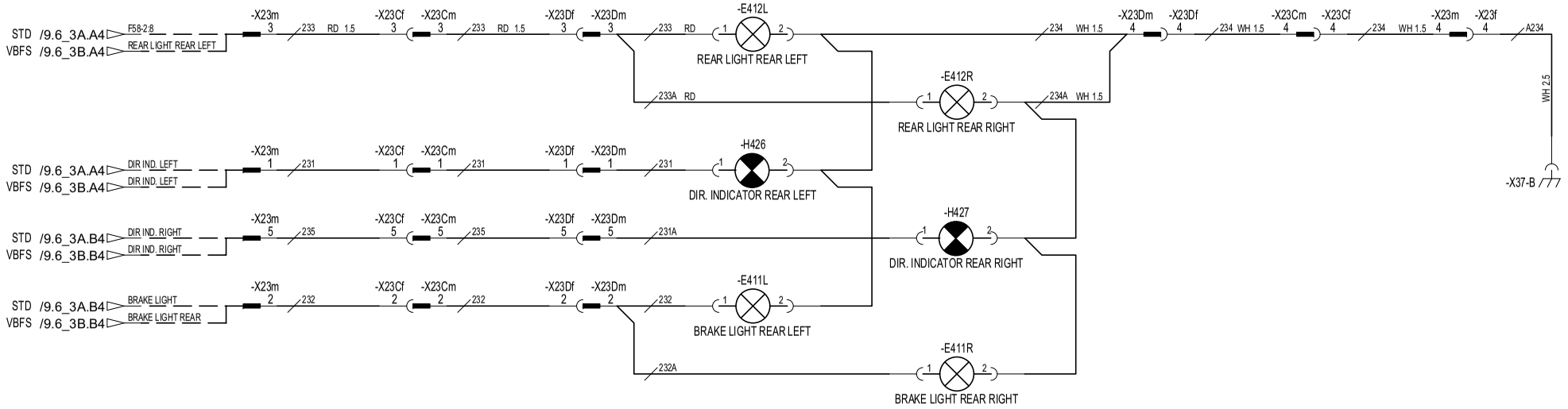
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Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.6_5A/83

Utgåva/Issue: 07

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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS FÄRDLJUS BAK, DCE50-90

Name: WIRING HEAD LIGHTS REAR

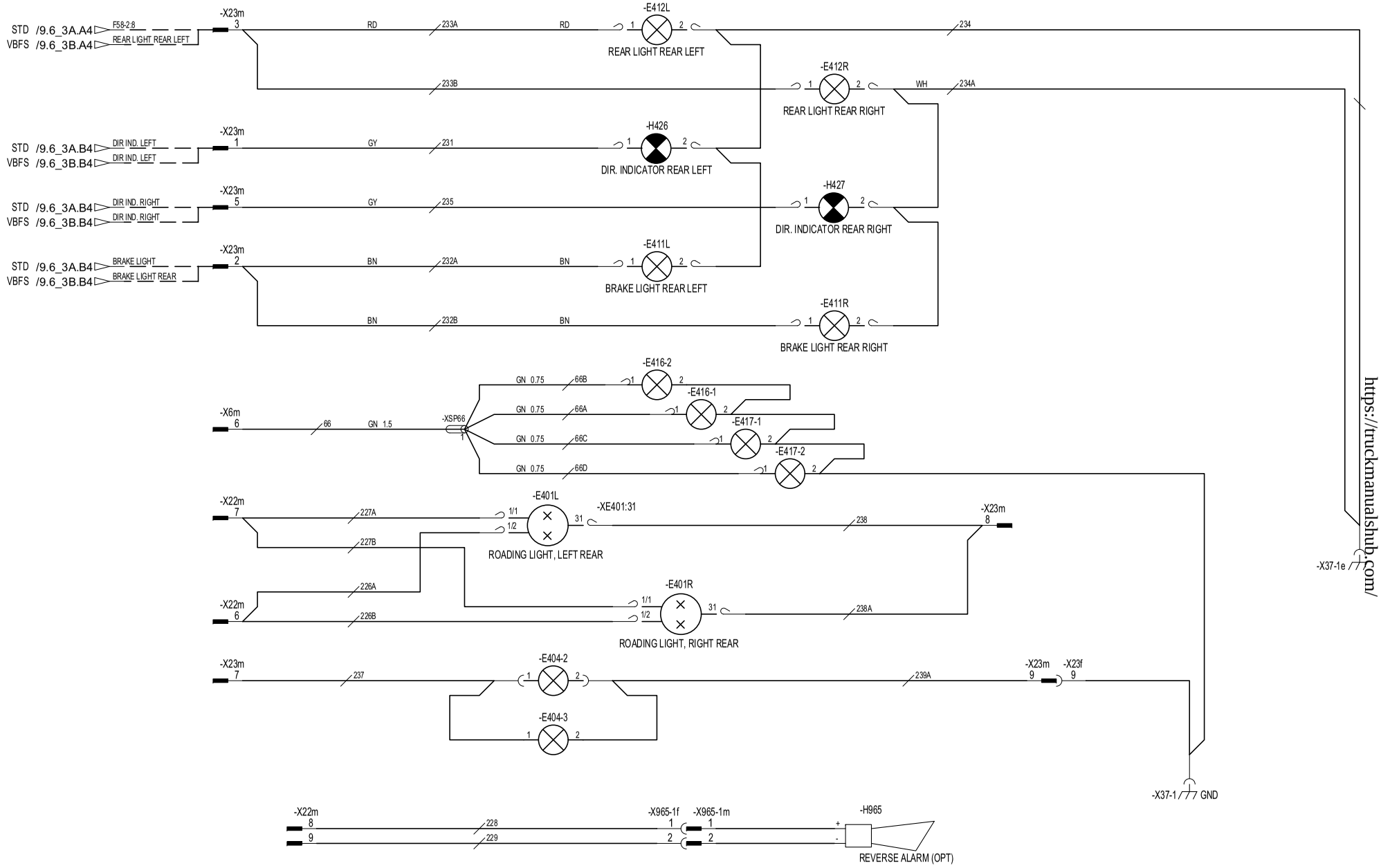
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Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

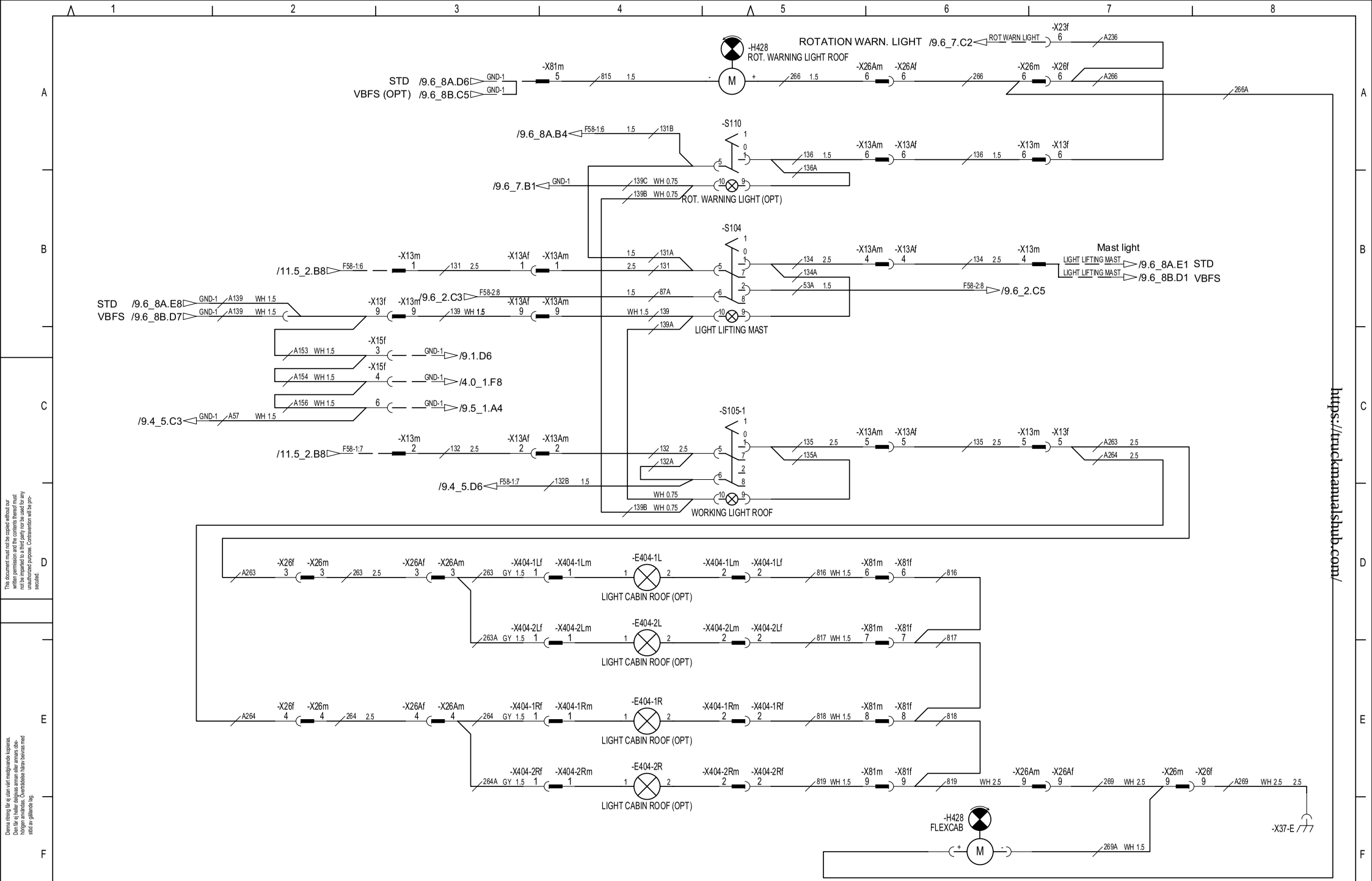
Kalmar

Benämning: KRETS FÄRDLJUS BAK
Name: WIRING HEAD LIGHTS REAR

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.6_5C/83
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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

E DRAWING

Kalmar

Benämning: KRETS ARBETSBELYSNING

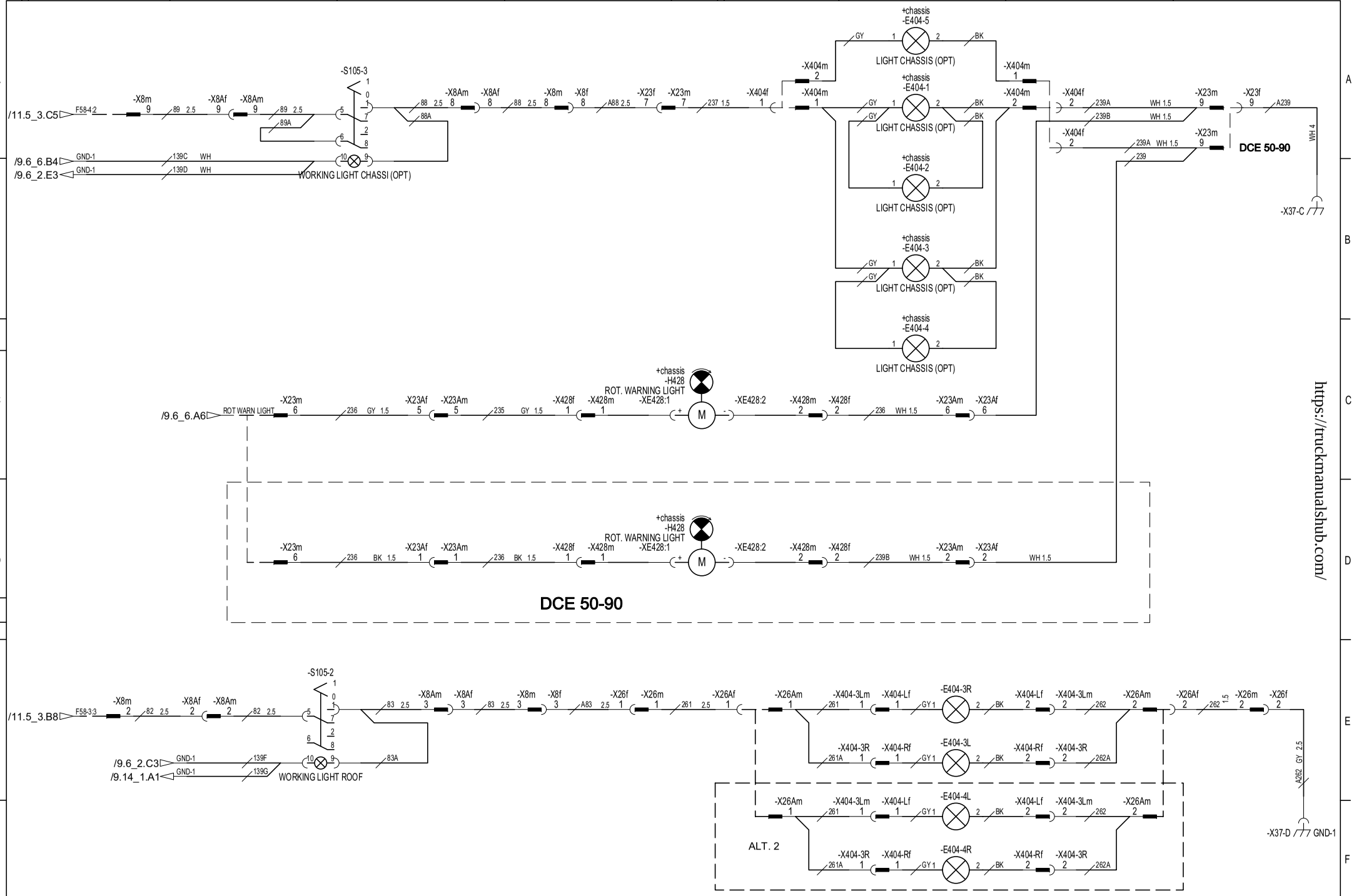
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Produkt/Product: DCE50- TIER 3

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Utgåva/Issue: 07



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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS ARBETSBELYSNING
WIRING WORKING LIGHT

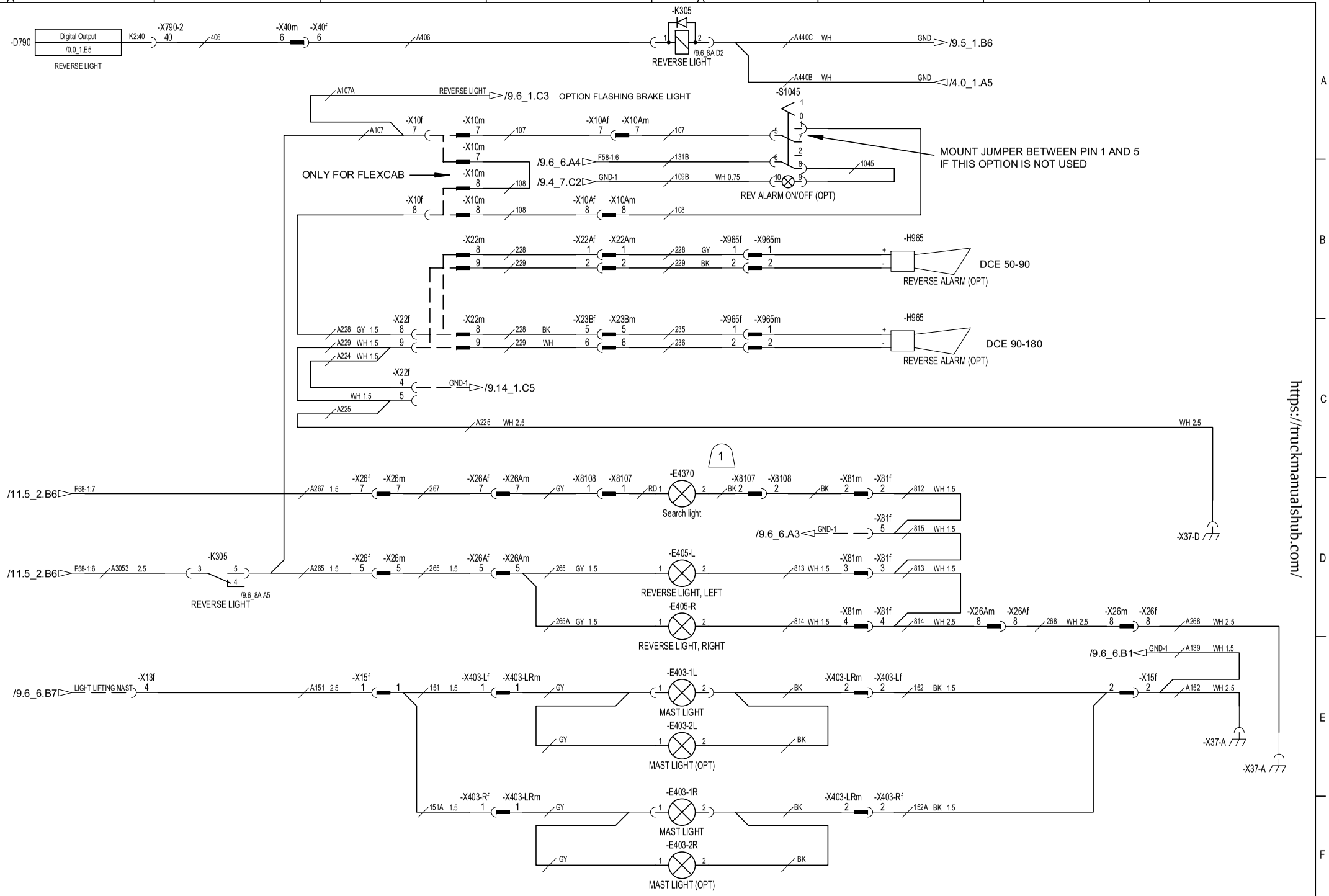
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Blad/Sheet: 9.6_7/83

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H.Grp: 6

Klass/Class

Kalmar

Benämning: KRETS ARBETSBELYSNING

Name: WIRING WORKING LIGHT

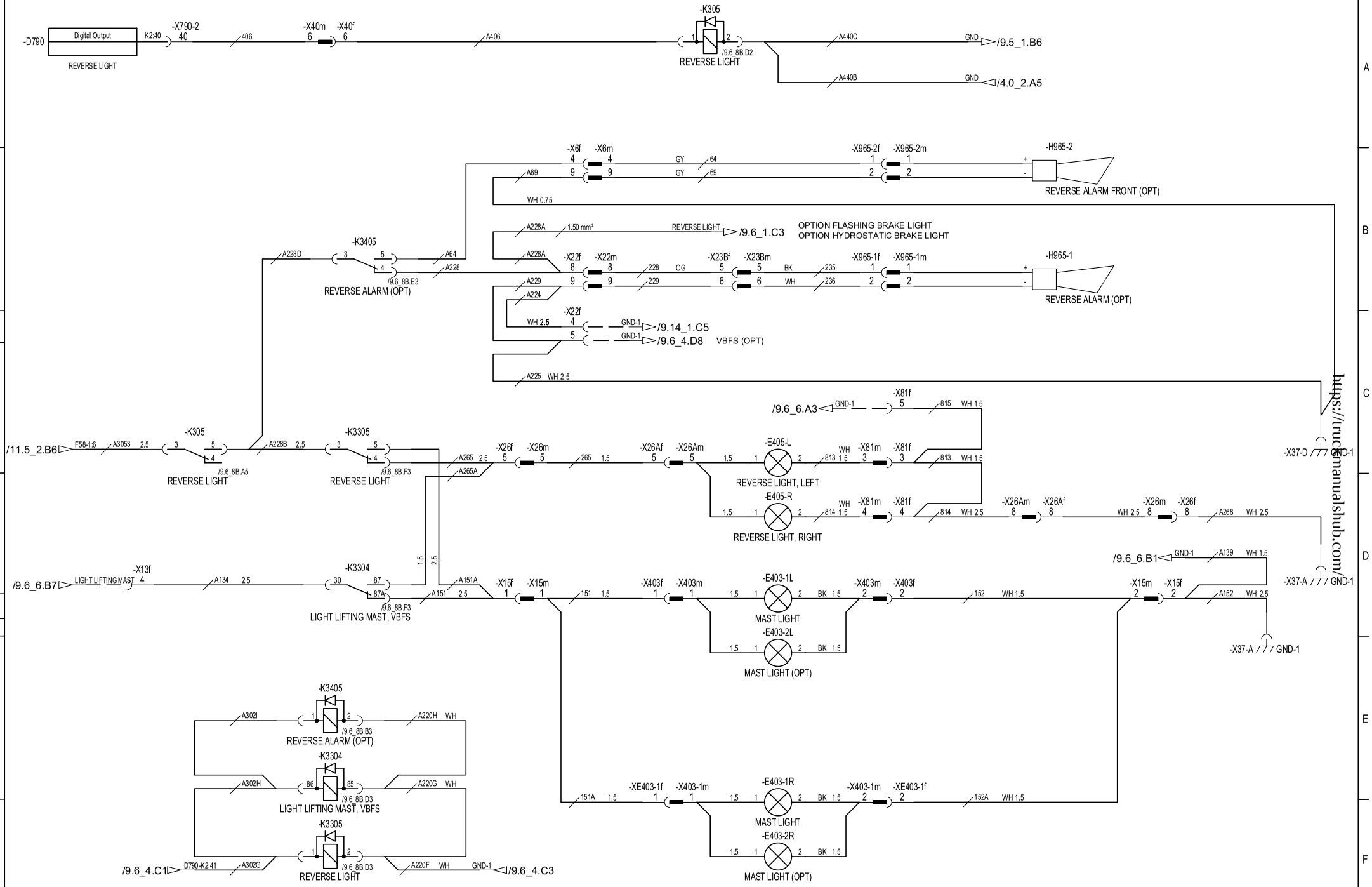
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Ritad/Drawn	TOO	050508	A49841.0100
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H.Grp: 6

Kalmar

Benämning: KRETS ARBETSBELYSING, VBFS

Name: WIRING WORKING LIGHT, TDS

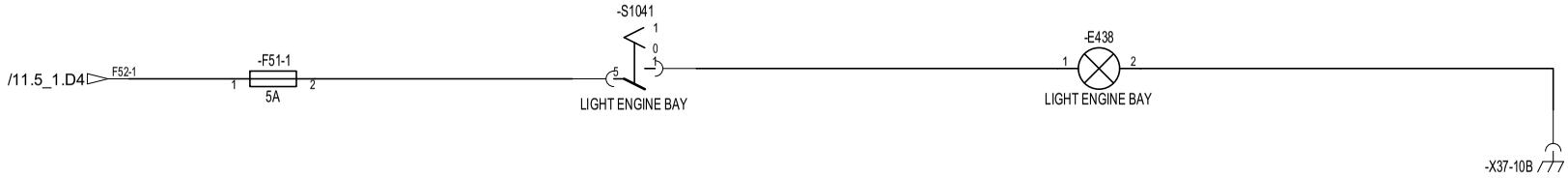
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Ritn.nr / Drawing No.: A49842.0100

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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS BELYSNING MOTORRUM
WIRING LIGHT, ENGINE BAY

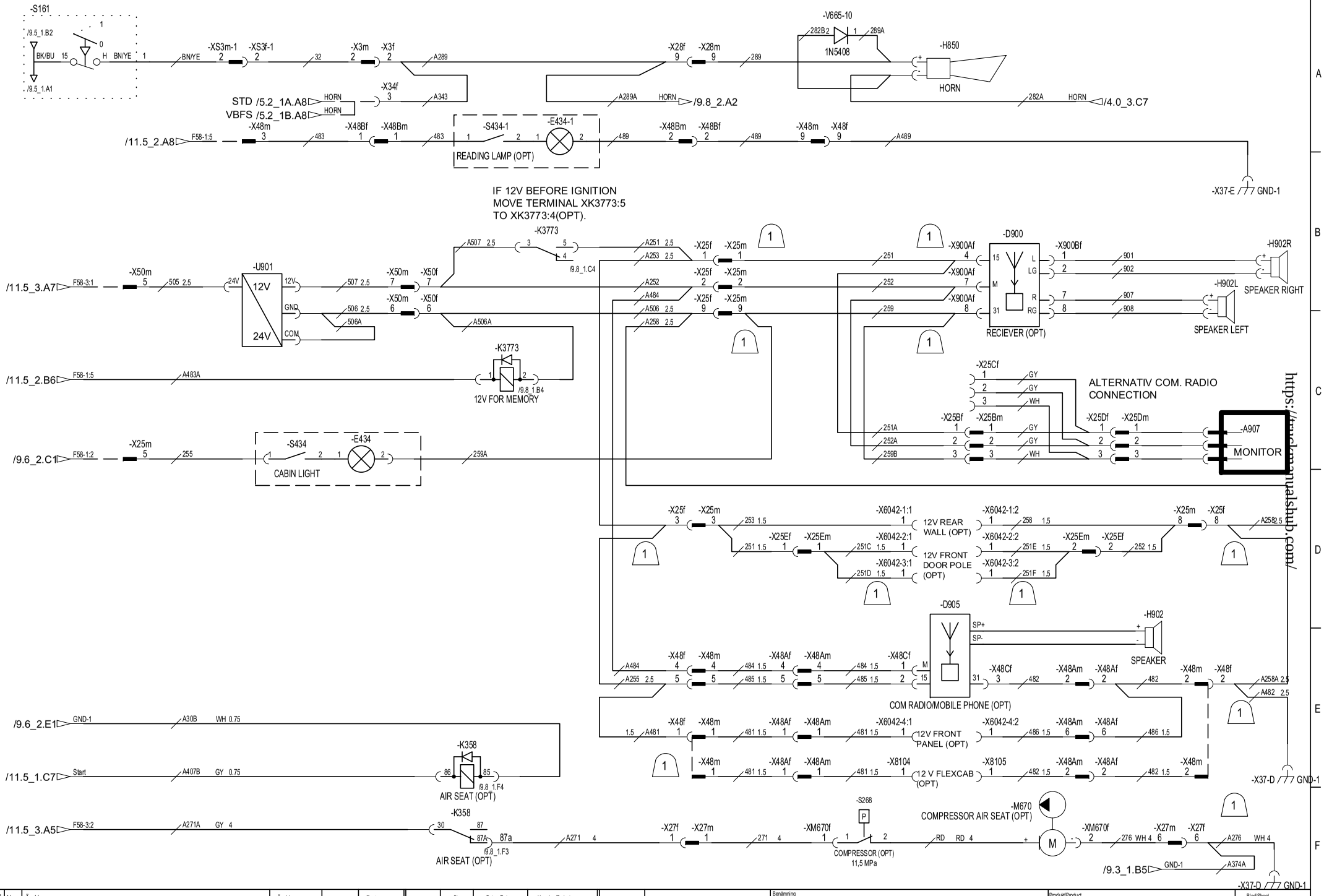
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

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Utgåva/Issue: 07

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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

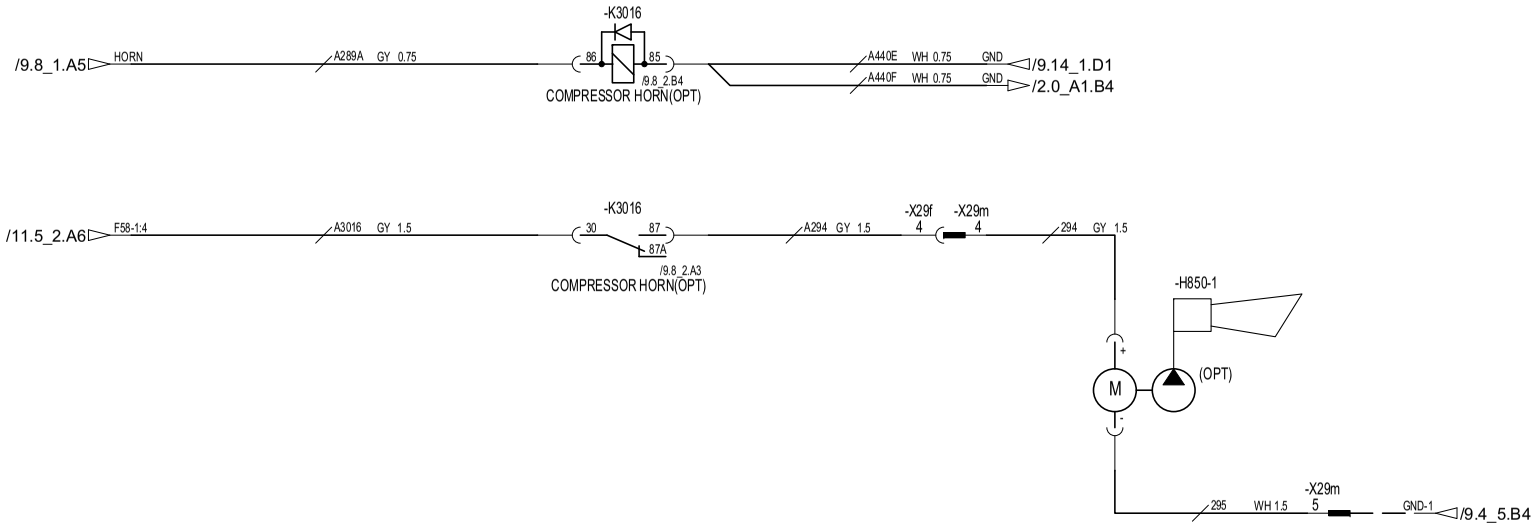
Kalmar

Benämning: KRETS HYTT
Name: WIRING CABIN

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

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Utgåva/Issue: 07

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		A=Added/Tillk D=Deleted/Utgår W=Was/Var			

	Sign.	Datum/Date	Huvudnr./Project no.
Ritad/Drawn	TOO	050610	A49841.0100
Konstr/Design	TOO	050525	
Godk/Appr	ABN	100324	
		Klass/Class	

H.Grp: 6

Kalmar

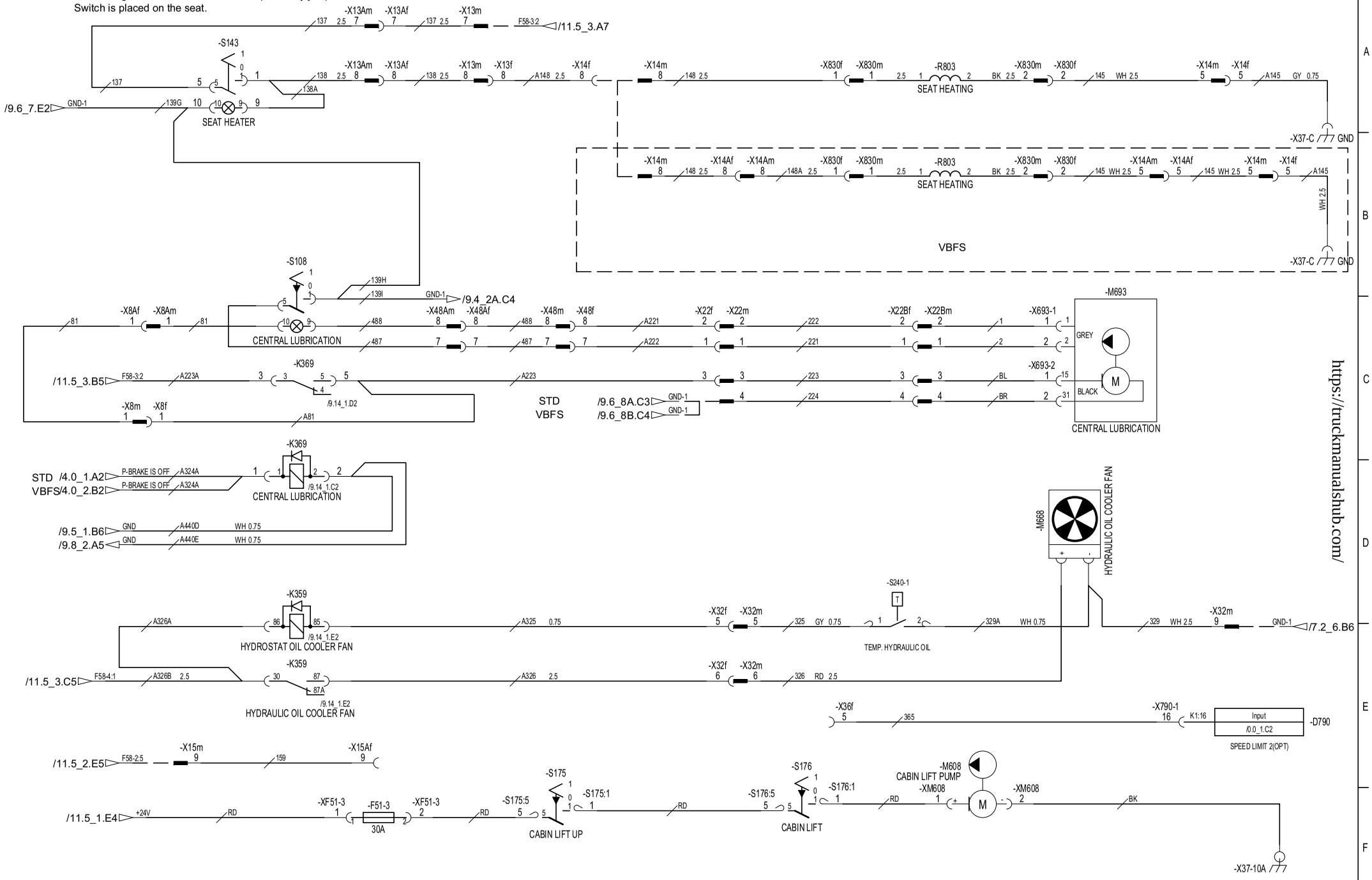
Benämning: KRETS KOMPRESSOR HORN
Name: WIRING COMPRESSOR HORN

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 9.8_2/83
Utgåva/Issue: 07

E DRAWING

When Isringhausen seat: Switch S143 replaced by jumper between 1 and 5.
Switch is placed on the seat.



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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

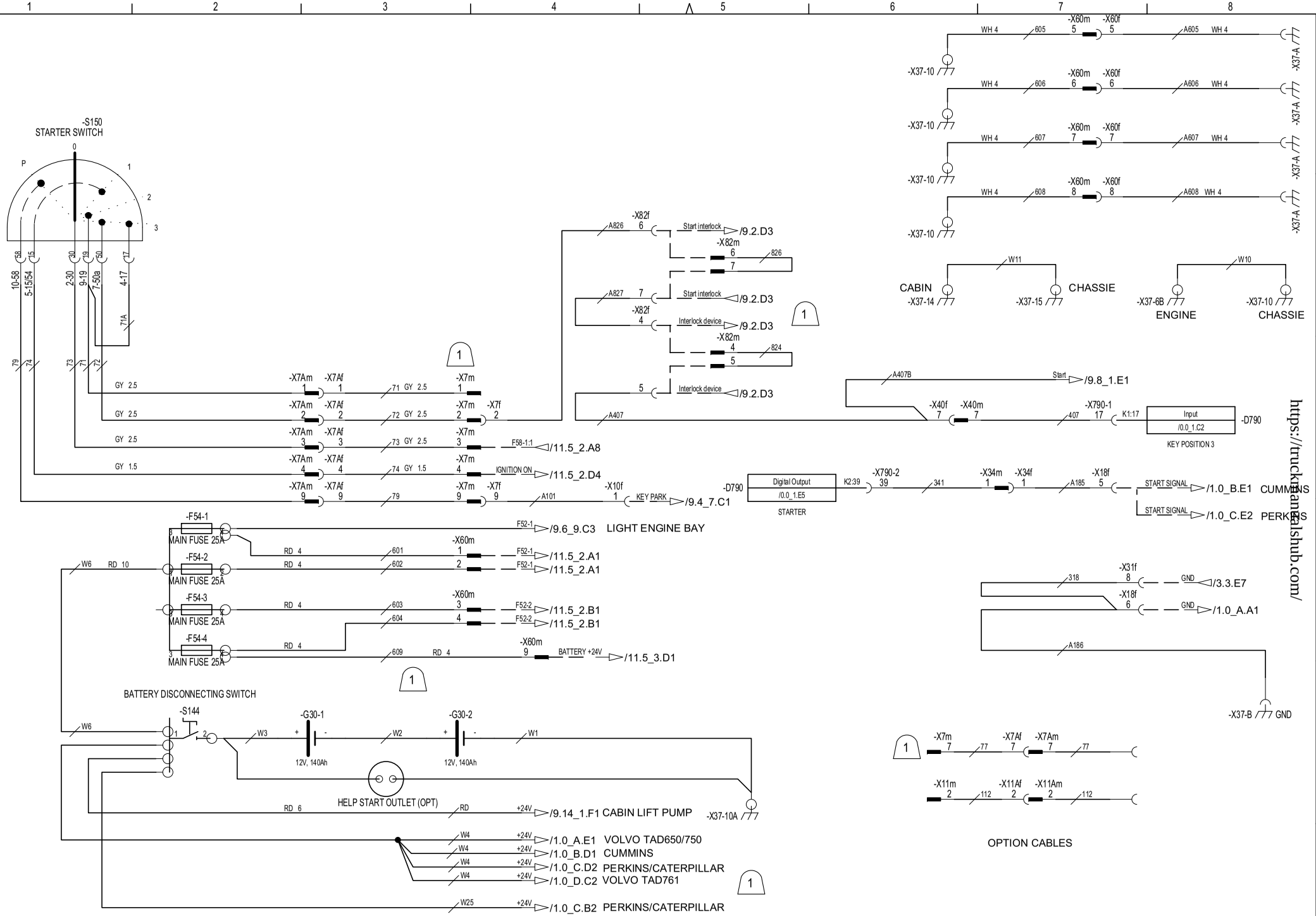
Kalmar

Benämning: KRETS, OPTION
Name: WIRING, OPTION

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

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E DRAWING



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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
Klass/Class			

H.Grp: 6

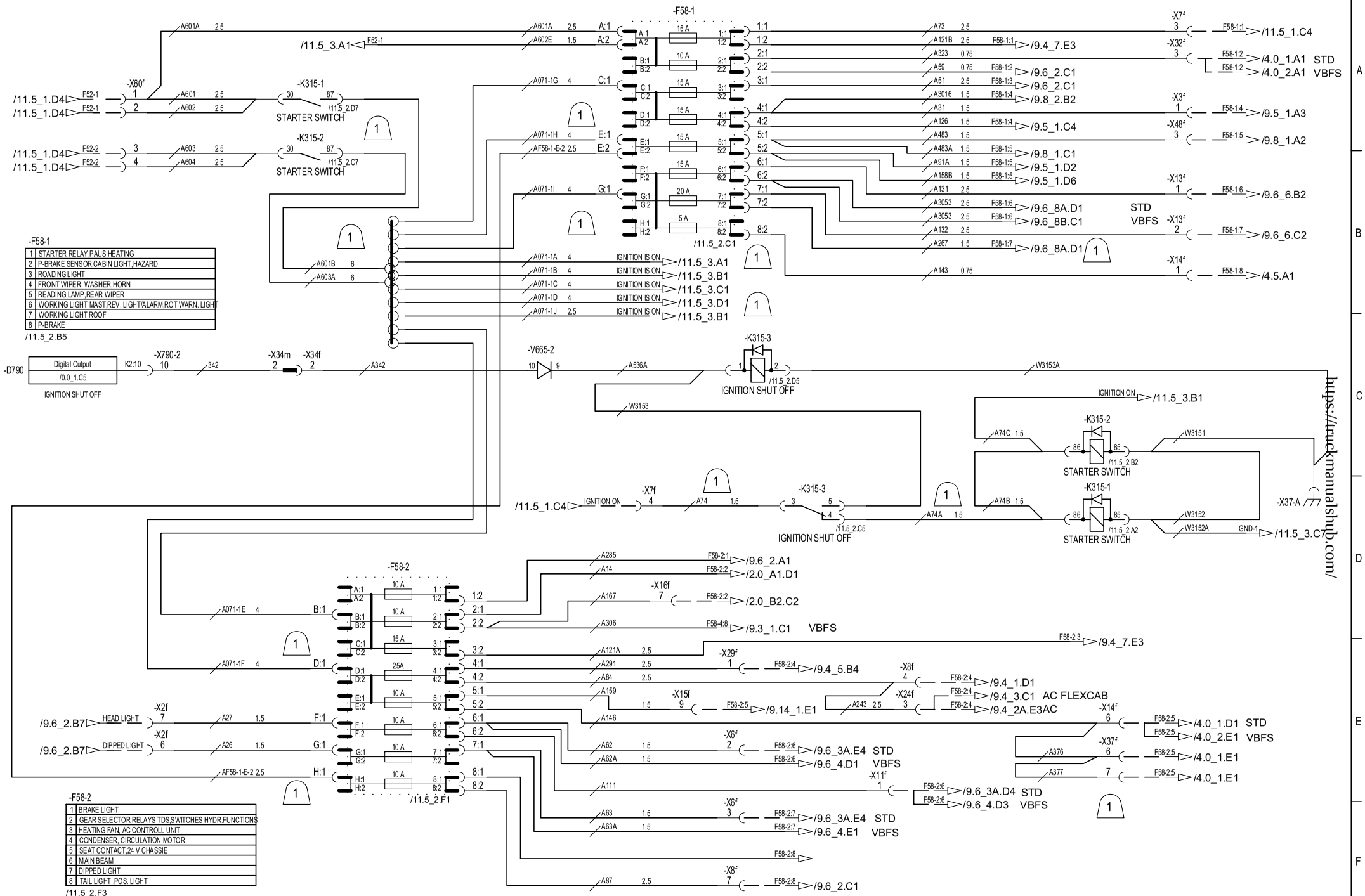
Kalmar

Benämning: KRETS STRÖM
Name: WIRING POWER SUPPLY

Produkt/Product: DCE50- TIER 3
Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 11.5_1/83
Utgåva/Issue: 07

E DRAWING



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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	

H.Grp: 6

Klass/Class

Kalmar

Benämning: KRETS STRÖM, SÄKRINGAR

Name: WIRING POWER SUPPLY, FUSES

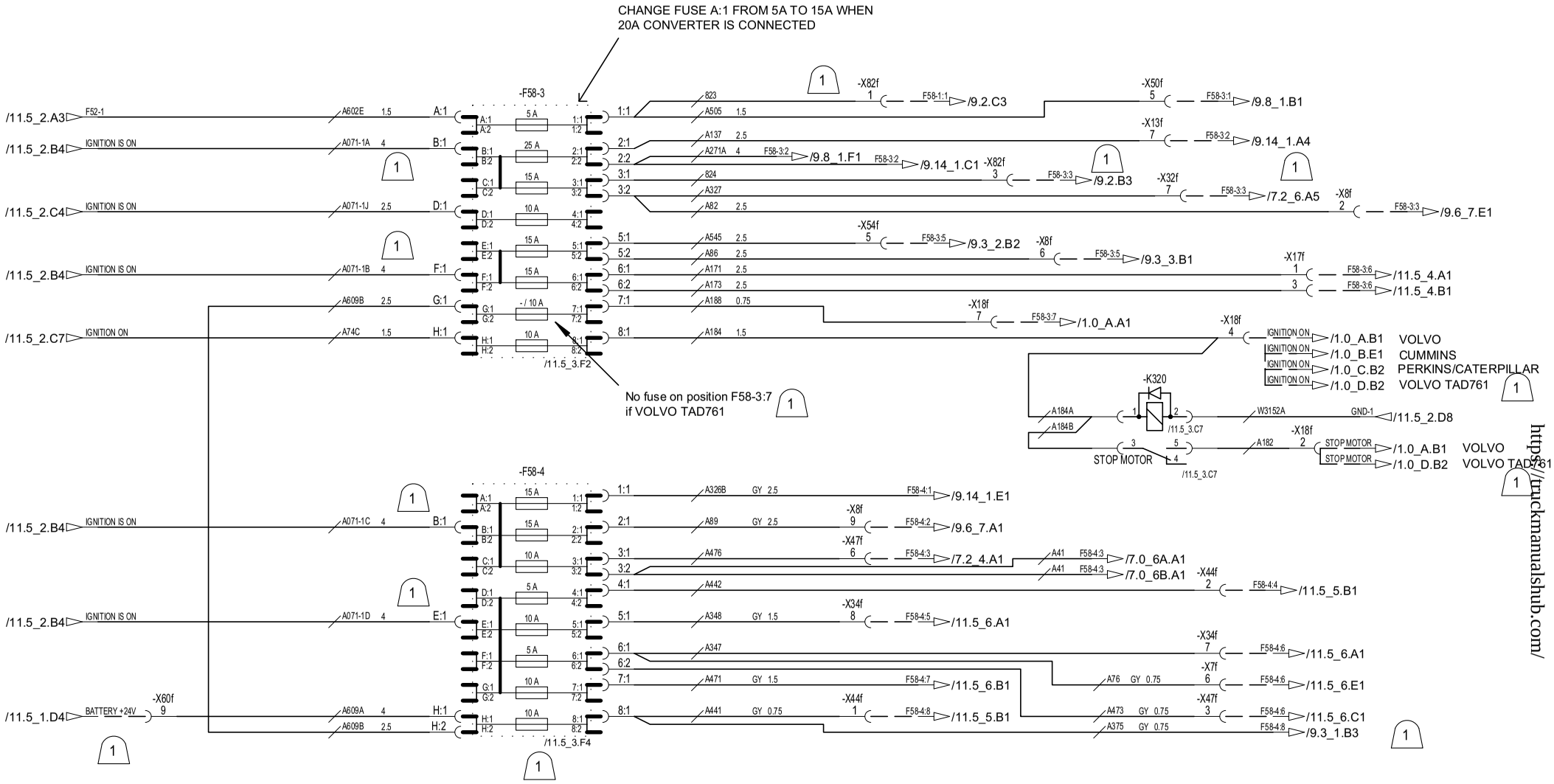
Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 11.5_2/83

Utgåva/Issue: 07

E DRAWING



-F58-3

1	12V CONVERTER
2	SEATHEATING,AIR SEAT,CENTRAL LUBRICATION
3	WORKING LIGHT EXTRA ROOF/ INTERLOCK DEVICE
4	OPTION
5	ROTATING SEAT MOTOR,SEAT UP/DOWN
6	POWER ECU 792
7	ECU 794 TAD750/650
8	ECU 794 IGNITION ON

/11.5_3.C4

-F58-4

1	HYDRALIC OIL COOLER
2	WORKING LIGHT CHASSIE
3	LIFTING FUCNCTIONS, SCALE
4	ECU793
5	ECU790
6	EDU795,ECU790,ECU796
7	ECU796,MANOEUVER STOP,PRESSURE SENSORS CLAMP
8	ECU793 / REVOLVING SEAT

/11.5_3.E4

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Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

Kalmar

Benämning: KREST STRÖM, SÄKRINGAR

Name: WIRING POWER SUPPLY, FUSES

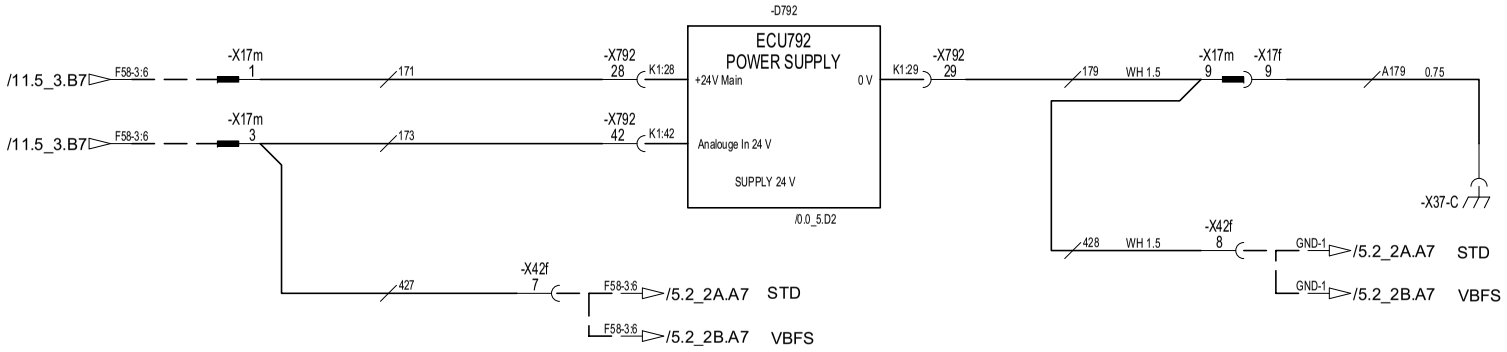
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Ritad/Drawn	TOO	050508	A49841.0100
Konstr/Design	TOO	050508	
Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

Kalmar

Benämning: KRETS MATNING ECU792

Name: WIRING POWERSUPPLY ECU 792

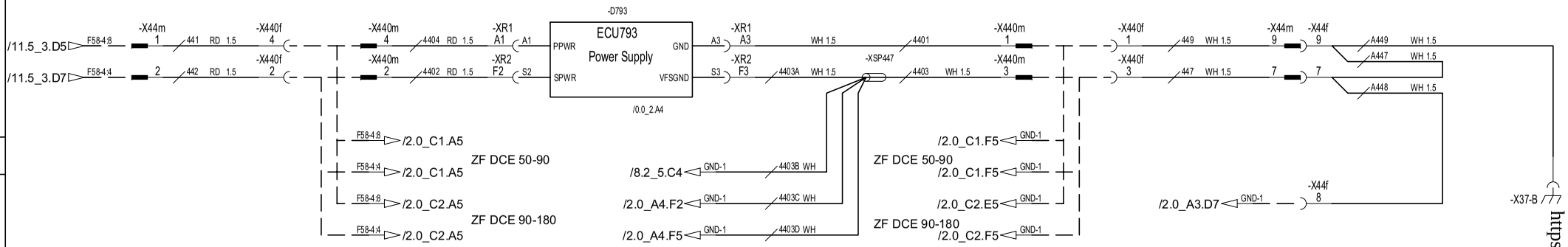
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Ritn.nr / Drawing No.: A49842.0100

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E-DRAWING



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Godk/Appr	ABN	100324	Klass/Class

H.Grp: 6

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Benämning: KRETS MATNING ECU793

Name: WIRING POWER SUPPLY, ECU793

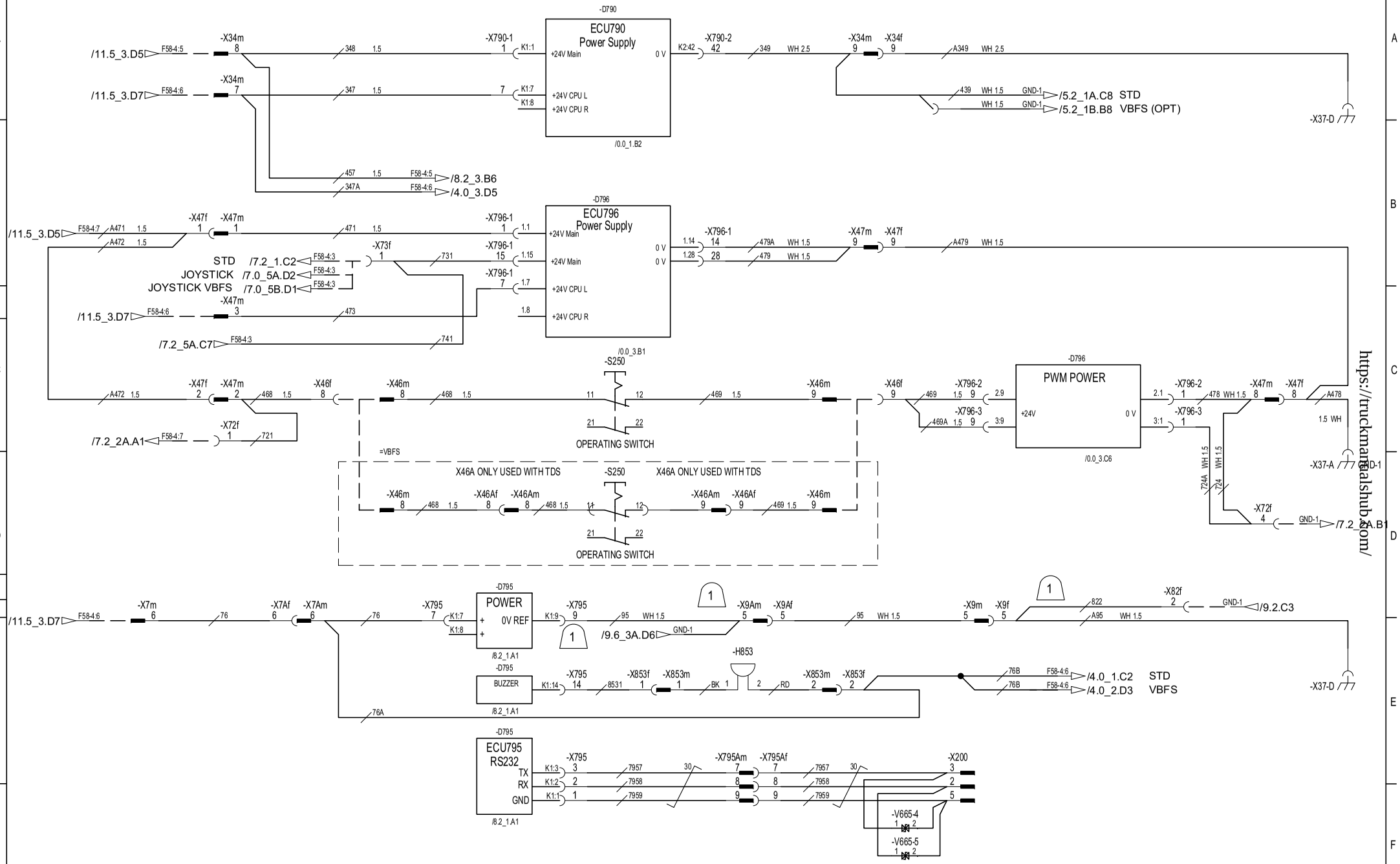
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Godk/Appr	ABN	100324	
			Klass/Class

H.Grp: 6

Kalmar

Benämning / Name: KRETS MATNING. ECU/EDU

WIRING POWER SUPPLY, ECU/EDU

Produkt/Product: DCE50- TIER 3

Ritn.nr / Drawing No.: A49842.0100

Blad/Sheet: 11.5_6/83

Utgåva/Issue: 07

E DRAWING

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NUMBER	CATEG	SVENSKA	ENGLISH
30	G	Batteri	Battery
32	A	Kretskort elcentral	Printed circuit board, Junction box
37	X	Terminal stomanslutning	Earthing terminal on chassis
39	X	Terminal minusanslutning	Terminal, negative terminal
51	F	Säkringshållare 1-polig	Fuse holder, 1-pole
52	F	Säkringshållare 2-polig	Fuse holder, 2-pole
56	F	Säkringshållare 6-polig	Fuse holder, 6-pole
58	F	Säkringshållare 8-polig	Fuse holder, 8-pole
59	F	Säkringshållare 12-polig	Fuse holder, 12-pole
62	F	Batterihandske 2-polig	Battery connector, 2-pole
64	F	Batterihandske 4-polig	Battery connector, 4-pole
72	X	Stickuttag 2-polig	Outlet, 2-pole
77	X	Stickuttag 7-polig	Outlet, 7-pole
78	X	Stickuttag extra 7-polig	Outlet, extra, 7-pole
100	S	Strömställare ljus	Switch, light
101	S	Strömställare omk hel/halvljus	Switch, main/dipped beam
102	S	Strömställare dimljus	Switch, fog light
103	S	Strömställare fjärrljus	Switch, distance light
104	S	Strömställare lastljus	Switch, mast lights
105	S	Strömställare arbetsljus	Switch, working lights
106	S	Strömställare containerljus	Switch, container light
107	S	Strömställare park broms	Switch, parking brake
108	S	Strömställare centr smörjning	Switch, central lubricator
109	S	Strömställare varningsljus	Switch, hazard lights
110	S	Strömställare rot varningsljus	Switch, rotating hazard beacon
111	S	Strömställare fönsterhiss	Switch, window regulator
112	S	Strömställare kylanläggning (AC)	Switch, air conditioner (AC)
113	S	Strömställare styrning alt	Switch, alternative steering
114	S	Strömställare läsbelysning	Switch, reading light
115	S	Strömställare instr belysning	Switch, instrument illumination
116	S	Strömställare innerbelysning	Switch, interior lighting
117	S	Strömställare värme	Switch, heating
118	S	Strömställare fläktm värme	Switch, heater fan
119	S	Strömställare vindrutetorkare	Switch, wiper
120	S	Strömställare spolare	Switch, washer
121	S	Strömställare blackout	Switch, blackout
122	S	Strömställare nöd hydraulpump	Switch, emergency hydraulic pump
123	S	Strömställare backspegel	Switch, observation mirror
124	S	Strömställare kallstart	Switch, cold start
125	S	Strömställare avgasbroms	Switch, exhaust brake
126	S	Strömställare diff spärr/broms	Switch, diff. Block
127	S	Strömställare värmesystem diesel	Switch, heating system diesel
128	S	Strömställare kraftuttag sida	Switch, power take off side
129	S	Strömställare kraftuttag bak	Switch, power take off rear
130	S	Strömställare hög/lågväxel	Switch, high/low gear
131	S	Strömställare färdväljare fram	Switch, gear selector forward
132	S	Strömställare färdväljare bak	Switch, gear selector rear
135	S	Strömställare växelväljare	Switch, gear shift
136	S	Strömställare framhjuls styrning	Switch, forward wheel steering
137	S	Strömställare 4-hjuls styrning	Switch, 4-wheel steering
138	S	Strömställare crab styrning	Switch, crab steering
139	S	Strömställare defroster	Switch, defroster
141	S	Strömställare Stegbelysning	Switch, Steplight
142	S	Strömställare fot	Switch, foot
143	S	Strömställare sitsvärme	Switch, seat heater
144	Q	Batterifrånskiljare	Battery disconnecting switch
145	S	Strömställare AT-regulator	Switch, AT-regulator
147	S	Strömställare körvisare	Switch, direction indicators
149	S	Strömställare signalhorn	Switch, horn
150	S	Strömställare startlås/ellas	Switch, main key switch
152	S	Strömställare intervalltorkare	Switch, intermittent wiper
156	S	Strömställare kupevärmare	Switch, cab heating

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NUMBER	CATEG	SVENSKA	ENGLISH
157	S	Strömställare stoltilt	Switch, seat tilt
158	S	Strömställare dimbakljus	Switch, rear fog light
159	S	Strömställare extra fram/back väljare	Switch, extra direction selector
160	S	Strömställare komb fram/back	Switch, combi-forward/reverse
161	S	Strömställare komb signal, ljus hel/halv spol,torkare m intervall körvisare	Switch, combi-horn, light main/dipped beam, washer, wiper (intermittent), direction indicator
162	S	Strömställare komb signal ljus hel/halv, spol, torkare m 2 int, fram/bacK	Switch, combi horn, light main/dipped beam, washer, wiper w 2int., forward/revers
163	S	Strömställare start på 2-an	Switch, start 2nd gear
165	S	Strömställare stolvärme	Switch, seat heater
166	S	Strömställare låsning vändskiva	Switch, interlocking of turntable
167	S	Strömställare luftfjädring	Switch, pneumatic springing
168	S	Strömställare låsn stol	Switch, interlocking of seat
169	S	Strömställare stolsvändning	Switch, reversible seat
170	S	Strömställare förångare (LPG)	Switch, evaporator (LPG)
171	S	Strömställare v-skiva upp/ner	Switch, fifth wheel up/down
172	S	Strömställare v-skiva fr/back	Switch, fifth wheel forward/reverse
173	S	Strömställare v-skiva skevning	Switch, fifth wheel, levelling
174	S	Strömställare,utskjut	Switch, projecting
175	S	Strömställare hyttlyft upp	Switch, cab hoist up
176	S	Strömställare hyttlyft ner	Switch, cab hoist down
177	S	Strömställare hyttskjutning	Switch, cab movement
178	S	Strömställare nollställning	Switch, reset
179	S	Strömställare Aut/man växling	Switch Aut/man gearshifting
180	S	Strömställare fyrhjulsdrift	Switch, 4-WD
190	S	Strömställare klimatanläggning	Switch, air conditioner
191	S	Strömställare recirkulation	Switch, re-circulation
192	S	Strömställare vattenavskiljare	
195	S	Strömställare joy-stick X	Switch, joy-stick X
196	S	Strömställare joy-stick X+Y	Switch, joy-stick X+Y
197	S	Strömställare längs/tvärskörning	Switch, length/sideways driwing
198	S	Strömställare flytläge skevning	Switch, equalizing fifth wheel
199	S	Strömställare option	Switch, option
200	S	Brytkontakt lampa park broms	Contact, breaking,warning lamp,parking brake
201	S	Brytkontakt lampa färdbroms	Contact, breaking, warning lamp, brake
202	S	Brytkontakt lampa oljetryck motor	Contact, breaking, warning lamp, oil pressure engine
204	S	Brytkontakt tryck ackumulator	Contact, breaking, pressure accumulatortank
205	S	Brytkontakt innerbelysning	Contact, breaking, interior lighting
206	S	Brytkontakt handskfack belysning	Contact, breaking, glove
207	S	Slutkontakt diff spärr	Contact, making, diff. interlock
208	S	Slutkontakt lampa temperatur spolkrets bromsar	Contact, making, warning lamp temperature brake
214	S	Slutkontakt överväxel	Contact, making, over drive
215	S	Slutkontakt temp motor	Contact, making, temperature engine
216	S	Slutkontakt bromsljus	Contact, making, brake lights
217	S	Slutkontakt backljus	Contact, making, reversing light
218	S	Slutkontakt AT-regulator	Contact, making, AT-control
219	S	Slutkontakt lampa luftfilter	Contact, making, indicating light air filter
220	S	Brytkontakt drivning	Contact, breaking, drive cut off
221	S	Slutkontakt temp växellåda	Contact, making, temperature gear box
222	S	Slutkontakt lampa temp moment - förstärkare	Contact, making, warning lamp temperature torque amplifier.
223	S	Släpkontakt signal	Contact, brush, horn
224	S	Slutkontakt insprutningspump	Contact, making, injection pump
225	S	Brytkontakt säkerhetsbälte	Contact, breaking, seat belt
228	S	Slutkontakt hyttlåsning	Contact, making, cab locking
229	S	Slutkontakt stolslåsning	Contact, making, seat locking
230	S	Brytkontakt stol	Contact, breaking, seat
231	S	Slutkontakt fotkontroll stolvändning	Contact, making, seat rotation, foot switch
232	S	Brytkontakt lampa luftanslutning släp	Contact, breaking, warning lamp air connection
233	S	Slutkontakt lampa låsning vändskiva	Contact, warning, interlocking of turntable

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NUMBER	CATEG	SVENSKA	ENGLISH
235	S	Slutkontakt sidoskjutning stol	Contact, making, side shifting of seat
236	S	Slutkontakt vattennivå	Contact, water level
239	S	Brytkontakt termisk	Contact, breaking, thermic
240	S	Slutkontakt termisk	Contact, making, thermic
241	S	Brytkontakt lampa luftmatning släp	Contact, breaking, warning lamp air supply to trailer
242	S	Slutkontakt lampa oljetryck v-låda	Contact, making, warning lamp, oil pressure gear box
243	S	Brytkontakt tryck kylmedia AC	Contact, breaking, coolant pressure (air condition)
244	S	Slutkontakt hydraulik aktiverad	Contact, making, hydraulics
245	S	Slutkontakt hydraultryck styrning	Contact, making, hydraulic pressure control
246	S	Slutkontakt tryck kylmedia	Contact, pressure refrigerant
250	S	Manöverbrytare	Operating Switch
251	S	Slutkontakt vändbar förarstol	Contact, making, VBFS
260	S	Slutkontakt lyft steg 1	Contact, making, hoist step 1
261	S	Slutkontakt lyft steg 2	Contact, making, hoist step 2
262	S	Slutkontakt tilt	Contact, making, tilting
263	S	Slutkontakt gaffelspridning	Contact, making, fork positioning
264	S	Slutkontakt sidoföring	Contact, making, sideshift
265	S	Slutkontakt stativ in/ut	Contact, making, lifting mast in-out
266	S	Brytkontakt hyttdörr	Contact, breaking cab door
267	S	Slutkontakt bromstryck	Contact, making, brake pressure
268	S	Slutkontakt kompressor	Contact, making, Compressor
269	S	Slutkontakt sax inne	Contact, making extender in
270	S	Slutkontakt överlastskydd	Contact, making, overload protection
271	S	Slutkontakt, filter växellåda	Contact, making, filter gearbox
299	S	Slut/brytkontakt option	Contact, making/braking option
300	K	Relä hel/halvljus	Relay, main/dipped beam
301	K	Relä dimljus	Relay, fog light
302	K	Relä fjärrljus	Relay, distance light
303	K	Relä lastljus	Relay, mast light
304	K	Relä arbetsljus	Relay, working light
305	K	Relä backljus	Relay, reversing light
306	K	Relä helljus	Relay, main beam
307	K	Relä halvljus	Relay, dipped beam
308	K	Relä bromsljus	Relay, brake light
309	K	Relä parkeringsbroms	Relay, parking light
310	K	Relä körvisare vä	Relay, direction indicator left
311	K	Relä körvisare hö	Relay, direction indicator right
312	K	Relä startelement	Relay,element preheater
313	K	Relä vändbar förarstol	Relay, rotating driver´s seat (VBFS)
314	K	Relä parkeringsbroms	Relay, parking brake
315	K	Relä tändningslås	Relay, ignition key
316	K	Relä torkare	Relay, wiper
317	K	Relä strålkastartorkare	Relay, roading lights wiper
318	K	Relä AT-regulator	Relay, AT-regulator
319	K	Relä varningsblinkers	Relay, hazard blinkers
320	K	Relä elektrisk stopp	Relay, electical stop
321	K	Relä intervalltorkare	Relay, intermittent wiper
322	K	Relä kylvätskenivå	Relay, coolant level
323	K	Relä blinkers	Relay, blinkers
324	K	Relä rangespärr	Relay, range interlock
325	K	Relä blinkande bromsljus (back)	Relay, flashing brake lights (reversing)
326	K	Relä blinkande bromsljus (runt)	Relay, flashing hazard brake lights
327	K	Relä växel neutral	Relay, gear neutral
328	K	Relä växelskifte	Relay, gear shift
329	K	Relä växel hög/låg	Relay, high/low gear
330	K	Relä startspärr	Relay, start interlock
331	K	Relä drivning fram	Relay, forward driving
332	K	Relä drivning bak	Relay, reversing driving
333	K	Tidrelä förvärmning	Time relay, automatically preheating
334	K	Relä frikoppling/drivbrytning	Relay, free wheel/drive disconnection
335	K	Relä växelventil 1:a (diesel, gas)	Relay, gear change valve 1-gear (diesel,LPG)

E Schema - Komponentförteckning / E Schematics - List of Components

NUMBER	CATEG	SVENSKA	ENGLISH
336	K	Relä växelventil 2:a (diesel, gas)	Relay, gear change valve 2-gear (diesel,LPG)
337	K	Relä drivriktning motor	Relay, motor drive direction
338	K	Relä kylfläkt drivmotor	Relay, cooling fan drive motor
339	K	Relä kylfläkt elskåp	Relay, cooling fan electrical box
340	K	Tidrelä fördröjt tillslag	Time relay, start delay
341	K	Tidrelä fördröjt frånslag	Time relay, stop delay
342	K	Relä drivning 2/4 hjul	Relay, switching 2/4 WD
343	K	Relä dimbakljus	Relay, fog light rear
344	K	Relä momentförstärkare	Relay, torque amplifier
345	K	Relä låsning vändskiva	Relay, interlocking of turntable
346	K	Relä frikoppling stollåsning	Relay, releasing of seat interlocking
347	K	Relä stolvändning/ljussignal	Relay, multifunction, seat rotation/light signal
348	K	Relä fläktmotor värmare	Relay, fan heating
349	K	Relä fartreglage	Relay, speed control
350	K	Relä pumpkontaktor/pumpkontroll	Relay, pump contactor/pump control
351	K	Relä hyttlyft upp	Relay, cab hoist up
352	K	Relä hyttlyft ner	Relay, cab hoist down
353	K	Relä säkerhetsslinga	Relay, safety loop
354	K	Relä styrsystem	Relay, signal control system
355	K	Relä sensorstyrning	Relay, sensor control
356	K	Skiftrelä längskörning/tvärskörning	Shift relay, length/sideways driving
357	K	Relä roterande varningsljus	Relay, hazard beacon
358	K	Relä komressor luft	Relay, compressor air
359	K	Relä Hydrauloljekylare	Relay hydraulic oil cooler
360	K	Relä startsolenoid	Relay, starting solenoid
361	K	Relä kompressor AC	Relay, compressor air conditione
362	K	Relä vattenventil AC	Relay, water valve air conditioner
363	K	Relä kondensor AC	Relay, condenser air conditione
364	K	Relä stolsbrytare	Relay seat switch
365	K	Relä fönsterhiss upp	Relay, electrical screen elevator up
366	K	Relä fönsterhiss ner	Relay, electrical screen elevator down
367	K	Relä styrning	Relay, steerin
368	K	Relä lågt bromstryck	Relay, low brake pressure
369	K	Relä centralsmörjning	Relay, central lubrication
370	K	Relä centralsmörjning, aggregat	Relay, central lubrication, attatchment
371	K	Relä lyfthöjd	Relay, liftheight
372	K	Relä blinkande varn.ljus, höjdbegränsn.	Relay, flashing beacon, lifting height limiter
373	K	Relä bakljus	Relay light
375	K	Huvudkontaktor reglersystem	Main contactor, operating control
376	K	Kontaktor fram reglersystem	Contactor, forward operating control
377	K	Kontaktor bak reglersystem	Contactor, reversing operating control
378	K	Kontaktor by-pass reglersystem/Fältförsvagning	Contactor, ¿by-pass¿ operating control/ Field weakening
379	K	Kontaktor pumpmotor	Contactor, pump motor
380	K	Kontaktor	Contactor
381	K	Kontaktor återladdning	Contactor, recharging
382	K	Relä, förbikoppling säkerhetssystem	Relay, by-pass safety system
383	K	Relä, Stolsvärme	Relay, heated seat
384	K	Relä vattenseparator	Relay, waterseparator
385	K	Relä bränslepump insprutning	Relay, fuel injection pump
386	K	Relä, hög motortemperatur.	Relay, high motor temperature
387	K	Relä alternativ gaspedal	Relay alternative throttle pedal
388	K	Relä, Extra färdriktningsväljare	Relay, Extra direction selector
389	K	Relä, Pausvärme	Relay, Paus heat
399	K	Relä option	Relay, option
400	E	G-lampa vä fram	Light bulb, roading light left hand front
400	E	G-lampa hö fram	Light bulb, roading light right hand rear
401	E	G-lampa vä bak	Light bulb, roading light left hand front
401	E	G-lampa hö bak	Light bulb, roading light right hand rear
402	E	G-lampa fjärrljus	Light bulb, distance light
403	E	G-lampa lastljus	Light bulb, mast light
404	E	G-lampa arbetsljus	Light bulb, working light

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NUMBER	CATEG	SVENSKA	ENGLISH
405	E	G-lampa backljus	Light bulb, rear light
406	E	G-lampa cont belysning vänster	Container light left-hand
406	E	G-lampa cont belysning höger	Container light right-hand
408	E	G-lampa park ljus vä fram	Light bulb, parking light, left-hand forward
408	E	G-lampa park ljus hö fram	Light bulb, parking light, right-hand forward
410	H	G-lampa broms ljus vä fram	Light bulb, brake light, left-hand forward
410	H	G-lampa broms ljus hö fram	Light bulb, brake light, right-hand forward
411	H	G-lampa broms ljus vä bak	Light bulb, brake light, left-hand rear
411	H	G-lampa broms ljus hö bak	Light bulb, brake light, right-hand rear
412	H	G-lampa bak ljus vä bak	Light bulb, rear light, left-hand rear
412	H	G-lampa bak ljus hö bak	Light bulb, rear light right-hand rear
413	H	G-lampa bak ljus vä fram (VBFS)	Light bulb, rear light, left-hand forward (VBFS)
413	H	G-lampa bak ljus hö fram (VBFS)	Light bulb, rear light,right-hand forward (VBFS)
416	H	G-lampa sidomarkering vä fram	Light bulb, side position light, left-hand forward
416	H	G-lampa sidomarkering vä bak	Light bulb, side position light, left-hand rear
417	H	G-lampa sidomarkering hö fram	Light bulb, side position light, right -hand forward
417	H	G-lampa sidomarkering hö bak	Light bulb, side position light, right-hand rear
420	H	G-lampa positionsljus vänster	Light bulb, position light, left-hand
421	H	G-lampa positionsljus höger	Light bulb, position light, right-hand
422	H	G-lampa körvisare vä fram	Light bulb, direction indicator left-hand forward
423	H	G-lampa körvisare hö fram	Light bulb, direction indicator right-hand forwrd
426	H	G-lampa körvisare vä bak	Light bulb, direction indicator left-hand rear
427	H	G-lampa körvisare hö bak	Light bulb, direction indicator right-hand rear
428	H	G-lampa roterande varningsljus	Light bulb, flashing beacon lamp
429	E	G-lampa cigarettändare belysning	Light bulb, cigarett lighter illumination
431	E	G-lampa instrument belysning	Light bulb, instrument illumination
432	E	G-lampa handsfack belysning	Light bulb, glove pocket light
433	E	G-lampa instegs belysning	Light bulb, step-in lighting
434	E	G-lampa innerbelysning	Light bulb, interior lighting
435	E	G-lampa låsbelysning	Light bulb, reading lighting
436	E	G-lampa identifikationsljus	Light bulb, identification light
437	E	G-lampa identifikationsljus/takskylt	Light bulb, identification light/roof sign
438	E	G-lampa motorrumsbelysning	Light bulb, engine compartment light
439	E	Nummerskyltsbelysning	Light license plate
440	E	G-lampa värmereglage belysning	Light bulb, heating control light
445	H	G-lampa körvisare vä (extra)	Light bulb, extra direction indicator left
446	H	G-lampa körvisare hö (extra)	Light bulb, extra direction indicator right
451	H	G-lampa dimbakljus vänster	Light bulb, fog light rear left
452	H	G-lampa dimbakljus höger	Light bulb, fog light rear right
453	H	G-lampa bromsljus/körvisare vänster	Light bulb, brake light/dir. indicator left-hand
453	H	G-lampa bromsljus/körvisare höger	Light bulb, brake light/dir. indicator right-hand
454	H	G-lampa bromsljus blackout vänster	Light bulb, brake light blackout left-hand
454	H	G-lampa bromsljus blackout höger	Light bulb, brake light blackout right-hand
456	E	G-lampa backljus blackout IR vänster	Light bulb, rear light blackout IR left-hand
456	E	G-lampa backljus blackout IR höger	Light bulb, rear light blackout IR right-hand
457	H	G-lampa positionsljus blackout vänster	Light bulb, position light blackout left-hand
457	H	G-lampa positionsljus blackout höger	Light bulb, position light blackout right-hand
458	E	G-lampa fram blackout vänster	Light bulb, roading light blackout left-hand
458	E	G-lampa fram blackout höger	Light bulb, roading light blackout right-hand
459	E	G-lampa fram blackout IR vänster	Light bulb, roading light blackout IR left-hand
459	E	G-lampa fram blackout IR höger	Light bulb, roading light blackout IR right-hand
460	E	G-lampa arb.belysning hytt blackout IR vä	Light bulb, working light cab blackout IR left
460	E	G-lampa arb.belysning hytt blackout IR hö	Light bulb, working light cab blackout IR right
461	E	G-lampa arb.bel. bom 20' blackout IR vä	Light bulb, working light boom20' b.out IR left
461	E	G-lampa arb.bel. bom 20' blackout IR hö	Light bulb, working light boom20' b.out IR right
462	E	G-lampa arb.bel. bom 40' blackout IR vä	Light bulb, working light boom40' b.out IR left

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NUMBER	CATEG	SVENSKA	ENGLISH
462	E	G-lampa arb.bel. bom 40' blackout IR hö	Light bulb, working light boom40' b.out IR right
463	H	G-lampa bak ljus vänster bak, blackout	Light bulb, rear light left-hand rear, blackout
463	H	G-lampa bak ljus höger bak, blackout	Light bulb, rear light right-hand rear, blackout
464	E	G-lampa cont belysning IR vänster	Light bulb,Container light IR left-hand
464	E	G-lampa cont belysning IR höger	Light bulb,Container light IR right-hand
465	H	G-lampa röd saxagregat ute	Light-bulb, red extender exended
466	H	G-lampa orange vertikalhålning på	Light bulb, orange vertical hold on
467	H	G-lampa grön klämtryck OK	Light bulb, green clamp pressure OK
468		G-Lampa Röd Maxlast	Light bulb,Red Overload
500	H	Kont lampa körvisare	Indicating lamp, direction indicator
501	H	Kont lampa körvisare (extra)	Indicating lamp, direction indicator extra
503	H	Varn lampa oljetryck motor	Warning lamp, oil pressure engine
504	H	Kont lampa helljus	Indicating lamp, main beam
505	H	Varn lampa laddning	Warning lamp, loading
506	H	Varn lampa laddning (extra)	Warning lamp, loading extra
507	H	Varn lampa färdbroms	Warning lamp, brake
508	H	Varn lampa parkerings broms	Warning lamp, parking brake
509	H	Varn lampa nivå kylvatten	Warning lamp, coolant level
510	H	Kont lampa diff spärr	Indicating lamp, diff. interlock
512	H	Varn lampa temp momentförst	Warning lamp, temperature converter
514	H	Kont lampa överväxel	Indicating lamp, overdrive clutch
519	H	Kont lampa halvljus	Indicating lamp, dipped lights
524	H	Kont lampa luftfilter	Indicating lamp, air filter
525	H	Kont lampa UNIKAT	Indicating lamp, UNIKAT
528	H	Kont lampa förvärmning	Indicating lamp, preheating
530	H	Kont lampa framhjuls styrning	Indicating lamp, forward wheel steering
531	H	Kont lampa 4-hjuls styrning	Indicating lamp, 4-wheel steering
532	H	Kont lampa crab styrning	Indicating lamp, crab steering
533	H	Kont lampa hyd.pump	Indicating lamp, emergency hyd. pump
547	H	Varn lampa centralvarning	Warning lamp, central warning
549	H	Varn lampa oljetryck v-låda	Warning lamp, oil pressure gear box
550	H	Varn lampa hyttlåsning	Warning lamp, cab lock
551	H	Varn lampa temp v-låda	Warning lamp, temperature gear box
552	H	Varn lampa bromstryck	Warning lamp, brake pressure
554	H	Varn lampa temp spolkrets bromsar	Warning lamp, temp. cooling system brakes
555	H	Varn lampa temp kylvatten mot	Warning lamp, temperature coolant engine
556	H	Varn lampa låsning vändskiva	Warning lamp, interlocking of turntable
560	H	Varn lampa temp drivmotor el	Warning lamp, temperature, drive motor
561	H	Varn lampa temp pumpmotor el	Warning lamp, temperature, pump motor
562	H	Varn lampa öppen twistlock	Warning lamp, unlocked twist lock
563	H	Varn lampa låst twistlock	Warning lamp, locked twist lock
564	H	Varn lampa anliggning	Warning lamp, alignement
565	H	Varn lampa temp motor el	Warning lamp ,temperature motor
569	H	Kont lampa elvärme	Indicating lamp, electric heater
569	H	Kont lampa elvärme	Indicating lamp, electric heater
570	H	Varn lampa överkoppling säkerhetssystem	Warning lamp, by-pass safety system
571	H	Kont lampa bränslenivå	Indicating lamp, fuel level
572	H	Varningslampa lyfthöjd	Warning lamp lifting height
573	H	Kontroll lampa motor information	Indicator lamp engine information
574	H	Kontroll lampa stödben nere	Indicator lamp support jacks down
575	H	Kontroll lampa stödben ur arb.läge	Indicator lamp support jacks out of working pos
576	H	Kontroll lampa anliggning främre ben	Indicator lamp, alignment front legs
577	H	Kontroll lampa anliggning bakre ben	Indicator lamp, alignment rear legs
578	H	Kontroll lampa klämläge främre ben	Indicator lamp, clamp position front legs
579	H	Kontroll lampa klämläge bakre ben	Indicator lamp, clamp position rear legs
580	H	Kontroll lampa främre ben uppe	Indicator lamp, front legs upper position
581	H	Kontroll lampa främre ben nere	Indicator lamp, front legs lower position
582	H	Varningslampa överlast	Warning lamp overload
583	H	Kontroll lampa anliggning ett ben	Indicator lamp, alignment one leg
584	H	Kontroll lampa anliggning alla ben	Indicator lamp, alignment all legs

NUMBER	CATEG	SVENSKA	ENGLISH
599	H	Kont lampa option	Indicating lamp, option
600	Y	M-ventil avgasbroms	Solenoid valve, exhaust brake
601	Y	M-ventil diff spärr	Solenoid valve, diff. interlock
602	Y	M-ventil broms	Solenoid valve, brake
603	Y	M-ventil värme	Solenoid valve, heater
604	Y	M-ventil kraftuttag sida	Solenoid valve, power take off, side
605	Y	M-ventil kraftuttag bak	Solenoid valve, power take off, rear
606	Y	M-ventil 2/4 hjulsdrift	Solenoid valve, 2/4WD
607	Y	M-ventil hög/låg växel	Solenoid valve, high/low gear
608	M	Pumpaggregat hyttlyft	Pump unit, cab hoist
609	M	Ställmotor gaspådrag	Regulating motor, throttle
610	Y	M-ventil hydraulsystem allm	Solenoid valve, hydraulics, general
611	Y	M-ventil flödesbegränsning	Solenoid valve, flow restriction
612	M	Ställmotor recirkulation	Regulating motor, re-circulation
613	Y	M-ventil momentförstärkare	Solenoid valve, torque amplifier
614	Y	M-ventil rangespärr	Solenoid valve, ranging interlock
615	Y	M-ventil hjulvridning	Solenoid valve, wheel turning
616	Y	M-ventil kallstart	Solenoid valve, cold start aid
617	Y	M-ventil AT-regulator by-pass	Solenoid valve, AT-regulator ¿by-pass¿
618	Y	M-ventil vatten klimatanläggning	Solenoid valve, water air conditioner
620	Y	M-ventil vändskiva upp	Solenoid valve, fifth wheel up
621	Y	M-ventil vändskiva ner	Solenoid valve, fifth wheel down
622	Y	M-ventil vändskiva fram	Solenoid valve, fifth wheel forward
623	Y	M-ventil vändskiva bak	Solenoid valve, fifth wheel rear
624	Y	M-ventil skevning hö	Solenoid valve, levelling right hand
625	Y	M-ventil skevning vä	Solenoid valve, levelling left hand
626	Y	M-ventil AT-regulator	Solenoid valve, AT-regulator
627	Y	M-ventil vakuum	Solenoid valve vacuum
628	Y	M-ventil bränsleblandning	Solenoid valve fuelmixture
630	Y	M-ventil v-låda fram	Solenoid valve, gear box, forward gear
631	Y	M-ventil v-låda back	Solenoid valve, gear box, rear gear
632	Y	M-ventil v-låda spole 1	Solenoid valve, gear box, 1 gear
633	Y	M-ventil v-låda spole 2	Solenoid valve, gear box, 2 gear
634	Y	M-ventil v-låda spole 3	Solenoid valve, gear box, 3 gear
635	Y	M-ventil klämtryck	Solenoid valve, clamping pressure
636	Y	M-ventil styrning	Solenoid valve, steering
637	Y	M-ventil flytläge skevning	Solenoid valve, equalizing fifth wheel
638	Y	M-ventil stopp insprut pump	Solenoid valve, stop injection pump
639	Y	M-ventil låsning orbitrol ls	Solenoid valve, locking LS orbitrol
640	Y	M-ventil gasol	Solenoid valve, LPG
641	Y	M-ventil förångare (LPG)	Solenoid valve, evaporator (LPG)
642	Y	M-ventil park broms	Solenoid valve, parking brake
643	Y	M-ventil låsning stol (VBFS)	Solenoid valve, seat locking (VBFS)
644	Y	M-ventil låsning vändskiva	Solenoid valve, fifth wheel locking
645	Y	Magnetkoppling komp AC	Magnetic clutch, compressor AC
646	Y	M-ventil stolsvändning	Solenoid valve, seat rotation
647	Y	M-ventil stolstilt	Solenoid valve, seat tilt
648	Y	M-ventil luftfjädring	Solenoid valve, pneumatic springing
649	B	Termostat klimatannläggning	Thermostat, air condition
650	M	Torkarmotor fram	
650	M	Torkarmotor fram	
650	M	Torkarmotor fram	
650	M	Torkarmotor fram	
651	M	Vindrutespolarmotor	Washer motor
652	M	Strålkastarmotor	Light motor
653	M	Strålkastarspolarmotor	Light washer motor
654	M	Startmotor	Starter motor
655	M	Kylfläkt drivmotor (EC)	Cooling fan, main motor (EC)
656	M	Kylfläkt elskåp (EC)	Cooling fan, electrical box (EC)
657	M	Fläktmotor värme	Heating fan
658	G	Generator (extra)	Alternator extra
659	G	Generator utan laddregulator	Alternator without loading regulator

NUMBER	CATEG	SVENSKA	ENGLISH
660	G	Generator med laddregulator	Alternator with loading regulator
661	M	Fönsterhissmotor	Screenelevator motor
662	G	Laddregulator	Loading regulator
663	M	Doseringspump klimatanläggning	Dosage pump, air condition
664	M	Cirk pump klimatanläggning	Circulating pump, air condition
665	V	Diod	Diode
666	M	Fläktmotor cirkulation	Circulation fan
667	M	Cirkulationspump värmesystem	Circulation pump heating system
668	M	Kylfläkt hydraulolja	Cooling fan, hydraulic oil
669	E	Värmare kupe/ motor diesel	Heater compartment/engine diesel
670	M	Kompressor	Compressor
671	M	Doseringspump diesel	Dosage pump diesel
672	M	Spjäll motor, ECC	Draught valve motor, ECC
673	Y	Vatten ventil motor, ECC	Water valve motor, ECC
674	M	Kylfläkt bromsolja	Cooling fan, brake fluid
675	M	Motor, Stolsvändning	Motor, Seat rotation
676	Y	M-ventil Broms stolsvändning	Solenoid valve Brake seat turning
677	M	Motor Låsning stolsvridning	Motor Locking revolving seat
685	A	Reglerenhet termostat AC	Control unit, termostat AC
690	B	Fartreglage (EC)	Speed control (EC)
693	M	Pump centralsmörjning	Pump, central lubrication
694	M	Styrmotor	Steering motor
695	M	Drivmotor (EC)	Drive motor (EC)
696	M	Pumpaggregate nödstyrning	Pump, emergency steering
697	B	Elbroms	Electric brake
698	M	Pumpmotor (EC)	Pump motor (EC)
699	Y	M-ventil option	Solenoid valve, option
700	P	Hastighetsmätare	Speedometer
701	P	Mätare oljetemp v-låda	Gear box oil temperature gauge
702	P	Klocka	Clock
703	P	Varvtalsmätare	Engine rev meter
704	P	Tryckluftsmätare	Air pressure gauge
705	P	Mätare oljetryck v-låda	Gear box oil pressure gauge
706	P	Termometer temp kylvätska motor	Temperature gauge, engine coolant
707	P	Bränslemätare	Fuel gauge
708	P	Timräknare	Hour meter
709	P	Kapacitetsmätare batteri	Capacity gauge, battery
710	P	Tidur motor/kupevärmare	Timer, engine- and cab heater
711	P	Räknare, impuls	Counter, impulse
712	P	Mätare oljetryck motor	Motor oil pressure gauge
714	P	Mätare, temp. Hydraulolja	Hydraulic fluidtemperature, guage
715	P	Extra instrument allm	Extra instrument, general
720	S	Givare vändbar förarstol	Transmitter, revolving driver´s seat (VBFS)
740	D	FleetManager kontrollenhet	FleetManager control unit
741	U	FleetManager batterifilter	FleetManager battery filter
742	D	FleetManager kortläsare	FleetManager card device
743	D	FleetManager accelerations givare	FleetManager acceleration sensor
744	D	Galvaniskt isolerad CAN brygga	Galvanic insulated CAN bridge
751	B	Givare varvtal turbin	Transmitter, speed turbin
752	B	Givare varvtal inre växellåda	Transmitter, speed internal gear chain
753	B	Varvtalsgivare motor	Transmitter, engine revolution
754	B	Givare lufttryck	Transmitter, air pressure
755	B	Givare hydraulfilter indikering	Transmitter, hydraulics filter indication
756	B	Temperatur kylvätska motor	Transmitter, engine coolant temperature
757	B	Bränslenivågivare	Transmitter, fuel level
758	B	Varvtalsgivare v-låda	Transmitter, gear box revolution
759	B	Nivåindikator kylvätska	Transmitter, coolant level
760	B	Givare rev-spärr/aut-vxl trans	Transmitter, reversing interlock / automatic gear change system (on gearbox output shaft)
761	B	Givare rev-spärr/aut-vxl motor	Transmitter, reversing interlock / automatic gear changing system (engine speed)
762	B	Givare temp,spolkrets bromsar	Transmitter, brake flushing circuit

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NUMBER	CATEG	SVENSKA	ENGLISH
763	B	Givare nivå hydraulolja	Transmitter, hydraulic fluid level
764	B	Givare servotryck växellåda	Transmitter, gear box servo pressure
765	B	Givare oljetryck v-låda	Transmitter, oil pressure gear box
766	B	Givare oljetemp. v-låda	Transmitter, oil temperature gear box
767	B	Givare oljetryck motor	Transmitter, oil pressure engine
768	B	Givare oljetryck hydraulik	Transmitter, hydraulic pressure
769	B	Givare ändläge	Transmitter, end position
770	B	Givare rattutslag	Transmitter, steering wheel angle
771	B	Givare vinkel	Transmitter, angle
772	B	Givare temp bromsolja	Transmitter, temperature brake fluid
773	B	Givare närvaro	Transmitter, presence
774	B	Givare utomhustemp	Transmitter, ambient temperature
775	B	Givare temp klimatanläggning	Transmitter, temperature air condition
776	B	Givare temp hydraulolja	Transmitter, hydraulic temperature
777	B	Givare läge	Transmitter, position
778	B	Givare drivbrytning	Transmitter, drive break
779	A	Reglersystem återladdning (EC)	Control system, recharging (EC)
780	D	Reglersystem drivmotor	Control system traction motor
781	D	Reglersystem pumpmotor	Control system pump motor
782	A	Logik interface 2 drivmotorer	Logic (interface) two main motors (EC)
783	A	Logik interface gaspådrag	Logic (interface) throttle
784	A	Logik interface bromsregl	Logic (interface) brake control
785	A	Logik interface styrsystem	Logic (interface) control system
786	A	Servoförstärkare styrsystem	Servo amplifier steering system
789	B	Givare allmän	Transmitter, common
790	D	Elektronisk kontrollenhet ECU, hytt	Electronic Control Unit ECU, cab
791	D	Elektronisk kontrollenhet aggregat	Electronic Control Unit, attachment
792	D	Elektronisk kontrollenhet styrning	Electronic Control Unit, steering system
793	D	Elektronisk kontrollenhet växellåda	Electronic Control Unit, gearbox
794	D	Elektronisk kontrollenhet motor	Electronic Control Unit, engine
795	P	Display	Display
796	D	Elektronisk kontrollenhet, lasthantering	Electronic Control Unit, Loadhandling
797	D	Elektronisk kontrollenhet, ram	Electronic Control Unit, frame
798	D	Elektronisk kontrollenhet, stolvändning	Electronic Control Unit, seat rotation
799	A	Logik allm (option)	Logic, general (option)
800	S	Startelement	Start element
802	E	Eluppvärmd backspegel	Electrical heated observation mirror
803	E	Eluppvärmd stol	Electrical heated seat
804	E	Cigarettändare	Cigarett lighter
805	E	Elvärme hytt	Electrical heating cab
806	A	Aggregat klimatanläggning	Aggregate, air conditioner
807	R	Potentiometer	Potentiometer
808	E	Eluppvärmd lufttorkare	Electrical heater air dryer
810	A	Kondensor AC, fläkt	Condensor AC, fan
815	S	Manöverspak	Control lever
820	R	Motstånd	Resistor
821	C	KONDENSATOR	CAPACITOR
822	Z	Signalfilter	Signal filter
823	U	Signalomvandlare höger	Signal amplifier, right
824	U	Signalomvandlare vänster	Signal amplifier, left
825	R	Reglage spakstyrning	Controls, (steering with control levers).
826	Y	Ventil spakstyrning	Valve, (steering with control levers).
827	A	Växellåda	Gearbox
828	R	Shuntmotstånd	Shunt-resitor
830	L	Tändspole	Ignition coil
835	E	Tändstift	Ignition plug
840	S	Strömfördelare	Distributor
850	H	Signalhorn	Horn
853	H	Summer	Buzzer
888	E	Lufttork, kompressor	Air Dryer, Compressor
900	A	Radio/bandspelare	Radio/tape recorder
901	U	Spänningsomvandlare	Voltage converter

E Schema - Komponentförteckning / E Schematics - List of Components

NUMBER	CATEG	SVENSKA	ENGLISH
902	B	Högtalare	Loud speaker
903	W	Antenn radio	Aerial, radio
905	A	Kommunikationsradio	Communication radio
906	W	Antenn kommunikationsradio	Aerial, communication radio
907	A	Monitor	Monitor
908	A	Kamera	Camera
909	A	Skrivare	Printer
910	U	Spänningsomvandlare 80V/24V	Voltage converter 80 V / 24 V
911	A	Dataterminal	Dataterminal
912	A	Alkolås	Interlock device
940	A	Logik batterivakt	Logic switch , battery watch
941	U	Laddningsutjämnare	Even charger
950	A	Logik transistortändning	Logic transistor ignition
955	A	Logik övervarvningsskydd (LPG)	Logic overspeed protection (LPG)
960	A	Logik rev-spärr/aut-vxl	Logic unit, reversing interlock/automatic gear changing
961	A	Motor/kupevärmare	Engine- and cab heater
962	E	Logik slitageind kol elmotor	Logic indication of wear, brush electrical motor
965	H	Backvarnare	Reversing alarm
1001	S	Strömställare, TW	Switch, TW
1002	S	Strömställare, lossa TW	Switch, unlocking of TW
1003	S	Strömställare, låsa TW	Switch, locking of TW
1004	S	Strömställare, stopp vid 30'-35'	Switch, stop at 30 -35¿
1005	S	Strömställare, förbikoppling av säkerhetssystem	Switch, overriding of the safety system
1006	S	Strömställare, fällning främre ben	Switch, front legs down
1007	S	Strömställare, fällning bakre ben	Switch, rear legs down
1008	S	Strömställare, klämma/lossa ben	Switch, clamping/-releasing legs
1009	S	Strömställare, Motor information	Switch, Engine information
1010	S	Srömställare, tilt av hytt	Switch, tilt of cab
1011	S	Strömställare IR ljus	Switch IR light
1012	S	Strömställare utskjut 20¿-40¿	Switch, Extension 20¿-40¿
1013	S	Strömställare stödben	Switch, Support jacks
1014	S	Strömställare förbikoppling rotationstopp	Switch, over ride rotation stop
1015	S	Strömställare förbikoppling höjdbeg/tp-beg	Switch, over ride height limit/tp-limit
1016			
1017	S	Strömställare diagnostik öka/minska	Switch, diagnostics increase/decrease
1018	S	Strömställare diagnostik on/off	Switch, diagnostics on/off
1019	S	Strömställare rastvärme	Switch, paus heat
1020	S	Strömställare automatisk släpp/kläm funktion	Switch automatic release/clamp funktion
1021	S	Strömställare sax	Switch extender
1022	S	Strömställare vertikalhållning	Switch, vertical position
1023	S	Strömställare låsning övre arm	Switch, lock upper arm
1024	S	Strömställare Korta Armen av/på	Switch, Short Arm on/off
1025	S	Strömställare pappersfunktioner av/på	Switch, paper funktions on/off
1026	S	Strömställare omkoppling pappers/klämmagregat	Switch, switch papper/bale clamp
1027	S	Strömställare lyfthöjdsförval	Switch, lift height selection
1028	S	Strömställare lyfthöjdsförval öka	Switch, lift height selection increase
1029	S	Strömställare lyfthöjdsförval minska	Switch, lift height selection decrease
1030	S	Strömställare läraringång givare ultraljud	Switch, teaching ultrasonic sensor
1031	S	Strömställare, Over Height Upp/Ned	Switch, Over Height Up/Down
1032	S	Brytare backljus	Switch reverse light.
1033	S	Flytta korta armen	Move short arm
1034	S	Strömställare förbikoppling startspärr	Switch Override Start interlock
1035	S	Strömställare Val av klämtryck	Switch, Clamp pressure selection
1036	S	Strömställare Korta Armen av/på	Switch , Short Arm on/off
1037	S	Strömställare låsning skevning	Switch, lock levelling

E Schema - Komponentförteckning / E Schematics - List of Components

NUMBER	CATEG	SVENSKA	ENGLISH
1038	S	Strömställare Övre armpar/Sidoföring	Switch Upper arms/Sideshift
1039	S	Strömställare Inching	Switch, Inching
1040	S	Switch stopp motor	Switch, Stop engine
1041	S	Strömställare motorrumsbelysning	Switch, light engine compartment
1042	S	Strömställare höjdjustering stol	Switch, Seat height level
1043	S	Strömställare längdjustering stol	Switch, Seat for/aft adjustment
1044	S	Strömställare Tankväljare	Switch, Tankselector
1045	S	Strömställare Avstängning backalarm	Switch, Rev. Alarm on/off
1046	S	Strömställare eluppvärmd ruta	Switch electrical heated shield
1047	S	Henrik testar en brytare!	
1048	S	Strömställare fjärrstyrning	Switch remote control
1049	S	Strömställare styrning spegel	Switch mirror control
1440	S	Huvudströmbrytare	
2000	D	Elektronisk kontrollenhet, proportionalventil	Electronic control unit, propotional valve
3001	K	Relä rotation	Relay, rotation
3002	K	Relä tilt	Relay, tilt
3003	K	Relä sidoföring	Relay, side shifting
3004	K	Relä längdinställning	Relay, length adjustment
3005	K	Relä twist lock	Relay, twist lock
3006	K	Relä spridning	Relay, spreading
3007	K	Relä lyft/sänk	Relay, lifting/lowering
3008	K	Relä hydraulfunktion extra	Relay, extra hydraulic function
3009	K	Relä manöverbrytare hydr	Relay, operating switch
3010	K	Relä bromsljus vxl std/blackout	Relay, brake light shift std/blackout
3011	K	Relä backljus vxl std/blackout	Relay, reversing light shift std/blackout
3012	K	Relä arb.bel hytt vxl std/blackout	Relay, working light cab, shift std/blackout
3013	K	Relä arb.bel. bom 20' vxl std/blackout	Relay,working light boom20' shift std/b.out
3014	K	Relä arb.bel. bom 40' vxl std/blackout	Relay,working light boom40' shift std/b.out
3015	K	Relä vxl bromsljus/blinkers vä	Relay, shift brake light/direction indicator left
3015	K	Relä vxl bromsljus/blinkers hö	Relay, shift brake light/direction indicator right
3016	K	Relä signalhorn	relay, horn
3017	K	Relä containerbelysning	Relay, Container light
3018	K	Relä containerbelysning IR	Relay, Container light IR
3305	K	Relä VBFS, backljus	Relay, rotating driver´s seat, reversing light
3306	K	Relä VBFS, helljus	Relay, rotating driver´s seat, main beam
3307	K	Relä VBFS, halvljus	Relay, rotating driver´s seat, dipped beam
3308	K	Relä VBFS, bromsljus	Relay, rotating driver´s seat, brake light
3310	K	Relä VBFS, körvisare vä	Relay, rotating driver´s seat, direction indicator left
3311	K	Relä VBFS, körvisare hö	Relay, rotating driver´s seat, direction indicator right
3330	K	Relä, säkerhetsbälte	Relay, seat belt
3331	K	Relä VBFS, drivning fram	Relay, rotating driver´s seat, forward driving
3332	K	Relä VBFS, drivning bak	Relay, rotating driver´s seat, reversing driving
3349	K	Relä VBFS, fartreglage	Relay, rotating driver´s seat, speed control
3404	K	Relä VBFS, mastljus	Relay, rotating driver´s seat, mast light
3405	K	Relä,backalarm	Relay,reversealarm
3412	K	Relä bak ljus	Relay, rotating driver´s seat, rear light
3500	A	Head up display lasthantering	Head up display load handling
3768	K	Relä oljetryck hydraulik	Relay, hydraulic pressure
3769	K	Relä, blockering av hyttilt	Relay, blocking of cab tilt
3770	K	Relä anliggning	Relay, alignment
3771	K	Relä Krok	Relay, Hook
3772	K	Relä laddsignal (D+)	Relay, charge signal (D+)
3773	K	Relä 12V för minne radio	Relay 12V for radio memory
3774		Relä kylfläkt olja	Relay, cooling fan oil
3775			
3776	K	Relä värmare ruta	Relay heated window
4370	E	Sökljus	Search light
5000	H	Kont lampa tryck lyfttång	Indicating lamp, pressure lift tong
5001	H	Varn lampa, Over Height ben uppe	Warn. Lamp, Over Height leg upper pos
6001	Y	M-ventil blockering höger	Solenoid valve, blocking right
6002	Y	M-ventil blockering vänster	Solenoid valve, blocking left

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NUMBER	CATEG	SVENSKA	ENGLISH
6003	Y	M-ventil inkoppling av hydraulik till topplyft	Solenoid valve, activation of toplift hydraulics
6004	Y	M-ventil sänk	Solenoid valve, lower
6005	Y	M-ventil lyft	Solenoid valve, lift
6006	Y	M-ventil bom ut	Solenoid valve, boom out
6007	Y	M-ventil bom in	Solenoid valve, boom in
6008	Y	M-ventil vridning medsols	Solenoid valve, rotation clockwise
6009	Y	M-ventil vridning motsols	Solenoid valve, rotation counter-clockwise
6010	Y	M-ventil tilt ut	Solenoid valve, tilt out
6011	Y	M-ventil tilt in	Solenoid valve, tilt in
6012	Y	M-ventil tilt	Solenoid valve, tilt
6013	Y	M-ventil fällning främre ben	Solenoid valve, lowering front legs
6014	Y	M-ventil fällning bakre ben	Solenoid valve, lowering rear legs
6015	Y	M-ventil klämma/lossa ben	Solenoid valve, clamping/releasing legs
6016	Y	M-ventil Hyttskjutning fram	Solenoid valve, cab movement forward
6017	Y	M-ventil Hyttskjutning bak	Solenoid valve, cab movement reverse
6018	Y	M-ventil spridning ut	Solenoid valve, spreading out
6019	Y	M-ventil spridning in	Solenoid valve, spreading in
6020	Y	M-ventil sidoföring vänster	Solenoid valve, side shift left
6021	Y	M-ventil sidoföring höger	Solenoid valve, side shift right
6022	Y	M-ventil extra hydraulfunktion ut	Solenoid valve, extra hydraulic function out
6023	Y	M-ventil extra hydraulfunktion in	Solenoid valve, extra hydraulic function in
6024	Y	M-ventil stativ ut	Solenoid valve, mast out
6025	Y	M-ventil stativ in	Solenoid valve, mast in
6026	Y	M-ventil höger framhjul styrning vänster	Solenoid valve, right front wheel, steering left
6027	Y	M-ventil höger framhjul styrning höger	Solenoid valve, right front wheel, steering right
6028	Y	M-ventil vänster framhjul styrning vänster	Solenoid valve, left front wheel, steering left
6029	Y	M-ventil vänster framhjul styrning höger	Solenoid valve, left front wheel, steering right
6030	Y	M-ventil höger bakhjul styrning vänster	Solenoid valve, right rear wheel, steering left
6031	Y	M-ventil höger bakhjul styrning höger	Solenoid valve, right rear wheel, steering right
6032	Y	M-ventil vänster bakhjul styrning vänster	Solenoid valve, left rear wheel, steering left
6033	Y	M-ventil vänster bakhjul styrning höger	Solenoid valve, left rear wheel, steering right
6034	Y	M-ventil skevning	Solenoid valve, levelling
6035	Y	M-ventil skevning höger	Solenoid valve, levelling right
6036	Y	M-ventil skevning vänster	Solenoid valve, levelling left
6037	Y	M-ventil kylfläkt	Solenoid valve, Cooling fan
6038	Y	M-ventil frikoppling koppling	Solenoid valve, lockup clutch
6039	Y	M-ventil öppna twistlock	Solenoid valve, unlocked twist lock
6040	Y	M-ventil låsa twistlock	Solenoid valve, locked twist lock
6041	Y	M-ventil nöd, twistlock	Solenoid valve, emergency, twistlock
6042	Y	M-ventil mellan bom	Solenoid valve, middle boom
6043	Y	Magnetventil, fällning torn (RTCH)	Solenoid valve, boom lowering (RTCH)
6044	Y	M-ventil blockering twistlock	Solenoid valve, blocking twistlock
6045	Y	M-ventil blockering lyft	Solenoid valve, blocking lift
6046	Y	M-ventil utskjut	Solenoid valve, projecting
6047	Y	M-ventil, hyttilt upp	Solenoid valve, cab tilt up
6048	Y	M-ventil, hyttilt ner	Solenoid valve, cab tilt down
6049	Y	M-ventil, kylkrets broms	Solenoid valve, cooling cicuit brake
6050	Y	M-ventil blockering utskjut	Solenoid valve, blocking projecting
6051	Y	M-ventil, regenerering höger	Solenoid valve, regeneration right
6052	Y	M-ventil, regenerering vänster	Solenoid valve, regeneration left
6053	Y	M-ventil, körläge	Solenoid valve, driving position
6054	Y	M-ventil, klämma ihop	Solenoid valve, clambing in
6055	Y	M-ventil, klämma isär	Solenoid valve, clambing out
6056	Y	M-ventil, främre knä ut	Solenoid valve, front knee out
6057	Y	M-ventil, främre knä in	Solenoid valve, front knee in
6058	Y	M-ventil, bakre knä ut	Solenoid valve, rear knee out
6059	Y	M-ventil, bakre knä in	Solenoid valve, rear knee in
6060	Y	M-ventil, främre ben upp	Solenoid valve, front legs up
6061	Y	M-ventil, bakre ben upp	Solenoid valve, rear legs up

E Schema - Komponentförteckning / E Schematics - List of Components

NUMBER	CATEG	SVENSKA	ENGLISH
6062	Y	M-ventil, urkoppling hydraulpump	Solenoid valve interruption hydraulic pump
6063	Y	M-ventil, stödben upp	Solenoid valve, brace up
6064	Y	M-ventil, stödben ner	Solenoid valve, brace down
6065	Y	M-ventil, frikoppling vridbroms	Solenoid valve, lockup rotation brake
6066	Y	M-ventil, v-låda, drivning	Solenoid valve, gearbox, drive
6067	Y	M-ventil, v-låda, oljetryck till 1:a/3:e växeln	Solenoid valve, gearbox,oilpressure to 1st/3rd gear
6068	Y	M-ventil sax/rotation	Solenoid valve externder/rotation
6069	Y	M-ventil, v-låda, oljetryck till 2:a/4:e växeln	Solenoid valve, gearbox,oilpressure to 2nd/4th gear
6070	Y	M-ventil Over Height upp	Solenoid valve, Over Height up
6071	Y	M-ventil Over Height ner	Solenoid valve, Over Height down
6072	Y	M-ventil klämtryck	Solenoid valve clamp pressure
6073	Y	Propertional ventil, Opti speed	Proportional valve, Opti speed
6074	Y	M-ventil, v-låda, växelväljare för 2:a/4:e växeln	Solenoid valve, gearbox, gearswitch for 2nd/4th gear
6075	Y	M-ventil, v-låda, växelväljare för 1:a/3:e växeln	Solenoid valve, gearbox, gearswitch for 1st/3rd gear
6076	Y	M-ventil blockering sänk	Solenoid valve, blocking lower
6077	Y	M-ventil Inching	Solenoid valve, Inching
6078	Y	M-ventil,Avstängning Övre klämarm	Solenoid valve, upper arm off
6079	Y	M-Ventil, Sidoföring/Övre armar	Solenoid valve, Sideshift/Upper arms
6080	Y	M-ventil, aktivering hyttkörning	Solenoid valve, activate sliding cab
6081	Y	M-ventil, ackumulatorladdning	Solenoid valve, accumulator charge
6082	Y	M-ventil tryckbegränsning	Solenoid valve, pressure restriction
7200	S	Givare, axeltryck höger	Sensor, axle pressure right
7201	S	Givare, axeltryck vänster	Sensor, axle pressure left
7202	S	Givare, anliggning vänster fram	Sensor, alignment left front
7202	S	Givare, anliggning höger fram	Sensor, alignment right front
7203	S	Givare, anliggning vänster bak	Sensor, alignment left rear
7203	S	Givare, anliggning höger bak	Sensor, alignment right rear
7204	S	Givare, öppen vänster twistlock	Sensor, unlocked twistlock left
7204	S	Givare, öppen höger twistlock	Sensor, unlocked twistlock right
7205	S	Givare, låst vänster twistlock	Sensor, locked twistlock left
7205	S	Givare, låst höger twistlock	Sensor, locked twistlock right
7206	S	Givare, gaffel aggregat	Sensor, fork attachment
7207	S	Givare, 2WD/4WD	Sensor, 2WD/4WD
7208	S	Givare, hytt i körläge	Sensor, Cab in drive position
7209	S	Givare, oljefilter indikering	Sensor, Oil filter indication
7210	S	Givare, hytt i transportläge	Sensor, Cab in transportation position
7211	S	Givare, lyfthöjd	Sensor, lifting height
7212	S	Givare, körläge	Sensor, driving position
7213	S	Givare, Anliggning främre ben	Sensor, Alignment front legs
7214	S	Givare, Anliggning bakre ben	Sensor, Alignment rear legs
7215	S	Givare, kläm främre ben	Sensor, Clamp front legs
7216	S	Givare, kläm bakre ben	Sensor, Clamp rear legs
7217	S	Givare, främnre knä	Sensor, front knee
7218	S	Givare, bakre knä	Sensor, rear knee
7219	S	Givare, främre ben	Sensor, front legs
7220	S	Givare, bakre ben	Sensor, rear legs
7221	S	Givare, styraxel	Sensor, steering axle
7222	S	Givare, stödben uppe	Sensor, brace up
7223	S	Givare, stödben nere	Sensor, brace down
7224	B	Givare, mätläge våg	Sensor, measurepoint scale
7225	B	Givare, rotationsstopp	Sensor, rotation stop
7226	B	Givare, tryck lyftcylinder	Sensor, pressure lift cylinder
7227	B	Givare, tryck klämma	Sensor, pressure clamp
7228	B	Givare lyfthöjd analog	Sensor lift height analogue
7229	B	Givare tiltvinkel analog	Sensor tilt angle analogue
7230	B	Givare ultraljud last position	Sensor, ultrasonic load position
7231	B	Givare, Over Height, Ben uppe	Sensor, Over Height, Leg upper position
7232	B	Givare,IR Last position	Givare,IR Load position

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NUMBER	CATEG	SVENSKA	ENGLISH
7233	B	Givare lambda sond	Sensor lambda sond
7234	B	Givare vatten i bränsle	Transmitter water in fuel
7235	B	Givare temp avgaser	Sensor exhaust temperature
7236	B	Givare tryck avgaser	Sensor exhaust pressure
7651	B	Givare oljetryck v-låda 1:a/3e	Transmitter oil pressure gearbox 1st/3rd
7652	B	Givare oljetryck v-låda 1/3	
7751	B	Givare temperatur inne	Sensor temp indoor
7753	B	Sensor temperatur avisning	Sensor temperatur deicing
7901	D	d	
8071	R	Potentiometer lyft/sänk	Potentiometer lift/lower
8072	R	Potentiometer tilt	Potentiometer tilt
8073	R	Potentiometer sidoföring	Potentiometer side shifting
8074	R	Potentiometer spridning	Potentiometer spreading
8075	R	Potentiometer extra	Potentiometer extra
8076	R	Potentiometer mast in/ut	Potentiometer reach in/out
8077	R	Potentiometer höger framhjul	Potentiometer right front wheel
8078	R	Potentiometer vänster framhjul	Potentiometer left front wheel
8079	R	Potentiometer höger bakhjul	Potentiometer right rear wheel
8080	R	Potentiometer vänster bakhjul	Potentiometer left rear wheel
8081	R	Potentiometer tiltvinkel	Potentiometer tilt angle
8082	R	Potentiometer fläkthastighet, ECC	Potentiometer fan speed, ECC
8083	R	Potentiometer temperatur, ECC	Potentiometer temperature, ECC
8084	R	Potentiometer spjäll, ECC	Potentiometer draught valve, ECC
8085	R	Potentiometer rotation	Potentiometer rotation
8086	R	Potentiometer sax	Potentiometer extender
8087	R	Potentiometer klämma	Potentiometer clamp
8088	R	Potentiometer skevning	Potentiometer levelling
8089	R	Potentiometer kroklåsning	Potentiometer flaps
8090	V	Laser, pappersaggretgat	Lase, Pulp an Paper
8091			
8092	E	Eluppvärmd ruta	Electrical heated window
8093	W	Genomföring, kablage	Lead-through, harness
9000	M	Motor höj/sänkbar stolspelare	Motor rise/lower seat column
9001	D	Åkerströms fjärrkontroll	Åkerströms Remote Control
9002			
9003	H	Varningssignal aut. rörelse	Warning alarm aut. movement
9888	A	test	
93774	K	Relä hållkrets	Relay, Holdcircuit

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Technical data

Specifications for data and volume

Data

1 Engine	Volvo TAD650VE	Volvo TAD660VE	Volvo TAD750VE	Volvo TAD760VE	Cummins QSB6.7	Caterpillar C6.6
Power acc. to ISO 3046 (net power)	147 kW at 2300 rpm 136 kW at 2000 rpm	147 kW at 2300 rpm 145 kW at 2000 rpm	181 kW at 2300 rpm 181 kW at 2000 rpm	181 kW at 2300 rpm 184 kW at 2000 rpm	164 kW at 2200 rpm or 129 kW at 2200 rpm	136 kW at 2200 rpm
Torque ISO 3046	750 Nm at 1600 rpm	800 Nm at 1600 rpm	1050 Nm at 1500 rpm	1100 Nm at 1500 rpm	949 Nm at 1500 rpm or 799 Nm at 1400 rpm	802 Nm at 1400 rpm
Alternator	2240 W				1960 W	2100 W
Start battery, voltage – capacity	2x12V - 140 Ah					

1.3 Engine, device for extra exhaust cleaning		
Particle filter	K 18	S 18
Voltage	400 V	400 V
Output	3.3 kW	13.5 kW

2 Transmission	Dana-Spicer Off Highway		ZF
	TE13000	TE17000	3WG161
Number of gears, forward - reverse	3 - 3	3 - 3	3 - 3
Stall speed	1805 rpm (engine: TAD650VE, TAD660VE) 1926 rpm (engine: C6.6) 1891 rpm (engine: QSB6.7, 129 kW)	1914 rpm (engine: TAD750VE, TAD760VE) 1879 rpm (engine: QSB6.7, 164 kW)	1964 rpm (engine: TAD650VE, TAD660VE)

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3.3 Driveline/axle, drive axle	DCE90-180/DCE70-32E3	DCE70-35E4
Drive axle, type	Kessler D81	Kessler D81
Drive axle, mounting	Tightening torque 650 Nm	
Propeller shaft, mounting	Tightening torque 98 Nm	

4 Brakes	
Service brake system - affected wheels	Wet Disc Brake - Drive wheels
Parking brake system - affected wheels	Spring brake - Drive wheels
Brake pedal – pedal pressure	27 bar (with half depressed pedal) 100 bar (with fully depressed pedal)

4.3 Servo brake system, Accumulator	
Precharge pressure nitrogen gas	70 bar
Max. accumulator pressure	165 bar

5 Steering	
Steering system	Hydraulic servo
Mini-wheel – Incremental sensor	2-channel potentiometer
Joystick – Resistance	5 kOhm

6 Suspension	DCE 90-6	DCE 100 - 6	DCE 120 - 6	DCE 140 - 6	DCE 150 - 6	DCE 100 - 12	DCE 120 - 12	DCE 150 - 12	DCE 160 - 6	DCE 160 - 9	DCE E160-12	DCE 180 - 6	DCE 70-32E3	DCE 70-35E4
Dimension, front and rear	11.00 - 20/16PR			12.00 - 20/20PR								12.00 - 20/20PRHD	12.00 - 20/20PR	
Ring pressure, see also pressure plate	0.9 MPa										1.0 MPa		0,9 MPa	
	Note: Michelin tyres must have ring pressure 1.0 MPa.													
Tyre type, front and rear	Air inflated. Spare and replacement tyres shall be from a manufacturer approved by Kalmar Industries.													

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Wheel nuts, tightening torque	650 Nm

9 Frame, body, cab and accessories	Spirit Delta	Spirit Delta Space	FlexCab	FlexGuard
Equivalent sound pressure level in cab according to EN12053. LpAz (Internal).	max. 73 dB(A)	max. 73 dB(A)	max. 78 dB(A)	max. 85 dB(A)

9.4 Frame, body, cab and accessories, heating, ventilation and air conditioning	Spirit Delta	Spirit Delta Space	FlexCab	FlexGuard
Stated heat output	10 kW at -10 °C	10 kW at -10 °C	5.5 kW at -10 °C	-

9.6 Lighting system		
Bulb	**Output (W)**	**Socket**
Instruments	3	Ba7s
Control lights	1.2	W2x4.6d
Interior lighting	10	S8.5
Tail light, red	5	BA15s
Brake light	21	BA15s
Driving direction indicator	21	BA15s
Running lights	5	SV8.5
Headlights (high/low beam)	75/70	P43t-38 (H4)
Reversing light, white	70	PK22s (H3)
Working lights	70	PK22s (H3)
Xenon working lights ⊕	35	D1S Xenon tubes. The insert and ballast must be changed as a unit.
Rotating beacon	70	PK22s (H1)

10. Common hydraulics	
Hydraulic pressure	See data plate (located on left-hand front mudguard)

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Volumes

For oil types see *Recommended oils and lubricants page 11*.

1.2 Engine, fuel system	DCE 90-6	DCE 100 - 6	DCE 120 - 6	DCE 140 - 6	DCE 150 - 6	DCE 100 - 12	DCE 120 - 12	DCE 150 - 12	DCE 160 - 6	DCE 160 - 9	DCE 160 -12	DCE 180 - 6	DCE 70-32E3	DCE 70-35E4
Fuel tank, capacity	140 l	200 l												
Fuel quality	Diesel, according to EN590													

1.7 Engine, cooling system	Volvo TAD650VE, TAD660VE	Volvo TAD750VE, TAD760VE	Cummins QSB6.7	Caterpillar C6.6
Coolant volume	35 l	40 l	40 l (164 kW) 40 l (129 kW)	40 l
Coolant, filling and changing	Volvo Penta Coolant VCS, ready-mixed		ES Compleat, Premix	Cat ELC 50/50 Premix
	BEWARE! Different types of coolant must not be mixed. Risk of engine damage if different types of coolant are mixed. When changing and topping up coolant, only use coolant of the same type that was used before.			

1.8 Engine, lubrication system	Volvo TAD650VE, TAD660VE	Volvo TAD750VE, TAD760VE	Cummins QSB6.7	Caterpillar C6.6
Oil type, quality	See *Recommended oils and lubricants page 11*.			
Oil volume	16 l at first filling 15.5 l at replacement including filter	23 l at first filling 21.5 l at replacement including filter	20 l	17,4 l at first filling 15.5 l at replacement including filter

2.6 Transmission, lubrication system	Dana TE13000	Dana TE17000	ZF 3WG161
Oil type, quality	See *Recommended oils and lubricants page 11*		
Oil volume	35 l		33 l

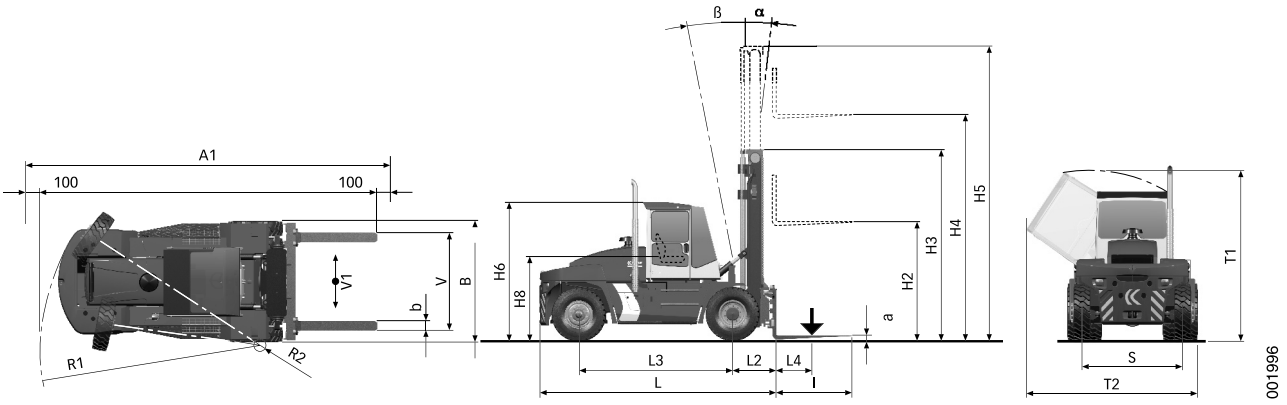
3.3 Driveline/axle, drive axle	DCE90-180/DCE70-32E3	DCE70-35E4
Oil quality	See *Recommended oils and lubricants page 11*.	
Oil volume, differential	17.5 l	18.5 l
Oil volume, hub reduction	2x2 l	

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9 Frame, body, cab and accessories	FlexCab	Spirit Delta and Spirit Delta Space
Refrigerant air conditioning	R134a	
Volume refrigerant	1200 g (see plate for air conditioning)	2200 g (see plate for air conditioning)
Lubricant in air conditioning	ZXL100PG	
Volume lubricant	0.15 l	0.32 l
Volume washer fluid	2.0 l	

10 Common hydraulics	DCE 90-6	DCE 100-6	DCE 120-6	DCE 140-6	DCE 150-6	DCE 100-12	DCE 120-12	DCE 150-12	DCE 160-6	DCE 160-9	DCE E160-12	DCE 180-6	DCE 70-32E3	DCE 70-35E4
Oil quality	See *Recommended oils and lubricants page 11*.													
Oil additive	Lubrizol 3%													
Hydraulic system volume	205 l	225 l												

Specifications for lift capacity and dimensions



	DCE 90-6	DCE 100-6	DCE 120-6	DCE 140-6	DCE 150-6	DCE 100-12	DCE 120-12	DCE 150-12	DCE 160-6	DCE 160-9	DCE 160-12	DCE 180-6	DCE 70-32E3	DCE 70-35E4
Lifting capacity														
Classed (kg x 10^3)	9	10	12	14	15	10	12	15	16	16	16	18	7	7

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	DCE 90- 6	DCE 100-6	DCE 120-6	DCE 140-6	DCE 150-6	DCE 100-12	DCE 120-12	DCE 150-12	DCE 160-6	DCE 160-9	DCE 160-12	DCE 180-6	DCE 70-32E3	DCE 70-35E4
Centre of gravity distance (L4 [mm])	600					1200			600	900	1200	600	1220	
Dimensions														
Truck length without forks (L [mm])	4470	4720	4725	4985	5055	5065	5315	5325	5305	5315	5575	5065	5595	5845
Truck width (B [mm])	2480			2540										2900
Height, basic machine Spirit Delta (H6 [mm])	2895			2920										
Height, basic machine FlexCab (H6 [mm])	2995			3020										
Seat height (H8 [mm])	1770			1790										
Wheelbase (L3 [mm])	2750	3000		3250			3500				3750	3250		3500
Distance drive axle - fork front shank surface (L2 [mm])	895		900	910	980	990		1000	980	990	1000	990	1265	1265
Track width (front - rear) (S [mm])	1840 - 1960			1855 - 1960										2210 - 1960

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	DCE 90- 6	DCE 100-6	DCE 120-6	DCE 140-6	DCE 150-6	DCE 100-12	DCE 120-12	DCE 150-12	DCE 160-6	DCE 160-9	DCE 160-12	DCE 180-6	DCE 70-32E3	DCE 70-35E4
Turning radius, outer (R1 [mm])	3950	4180		4360			4785				5175	4360		4785
Turning radius, inner (R2 [mm])	75			125			420				600	125		420
Ground clearance, min. [mm]	250			250										
Height at cab tilt, max. (OHG) (T1 [mm])	3370 (3450)			3395 (3475)										
Width at cab tilt, max. (OHG) (T2 [mm])	3350 (3440)			3380 (3470)										
Minimum track width for 90° stacking with forks (A1 [mm])	6240	6470	6475	6665	6735	7945	8370	8380	7160	8160	8770	6745	8900	9200
Operating weight [kg x 10^3]	15.2	15.6	16.2	16.9	19.8	18.6	19.7	21.4	19.2	20.6	22.4	21.1	22.9	23.9
Axle pressure front, (without load) [kg]	7800	8100	8300	8400	10300	10000	10100	9400	10000	9600	10500	9800	14700	15600

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	DCE 90- 6	DCE 100-6	DCE 120-6	DCE 140-6	DCE 150-6	DCE 100-12	DCE 120-12	DCE 150-12	DCE 160-6	DCE 160-9	DCE 160-12	DCE 180-6	DCE 70-32E3	DCE 70-35E4
Axle pressure front, (with classed load) [kg]	21700	23100	26500	28900	32650	26700	29600	33800	33200	34200	35800	36600	27100	27600
Axle pressure rear, (without load) [kg]	7400	7500	7900	8500	9500	8600	9600	12000	9200	11000	11900	11300	8200	8300
Axle pressure rear, (with classed load) [kg]	2500	2500	1900	2000	2150	1900	2100	2600	2000	2400	2600	2500	2800	3300

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Recommended oils and lubricants

The service intervals indicated by Cargotec in the maintenance manual only apply if oils are selected according to the table below. The table indicates recommended viscosity for different oil types and grades depending on the ambient temperature.

Any deviation from this table must be approved in writing by Cargotec, and may mean changed service intervals.

Oil type, quality	°C / °F	-30 / -22	-20 / -4	-10 / +14	0 / +32	+10 / +50	+20 / +68	+30 / +86	+40 / +104	+50 / +122
1.8 Engine, lubrication system *) **Volvo:** VDS-2, VDS-3 API: CH-4, CI-4 ACEA: E4-99, E4-99 (Synthetic), E5, E7			-15°C	SAE 15W/40						
		-25°C	SAE 10W/30							
		SAE 5W/30								
Cummins: CES-20071, CES-20072, CES-20076, CES-20077, CES-20078 API: CH-4/SJ, CI-4/SK ACEA: E5, E7			-15°C	SAE 15W/40						
		-25°C	SAE 10W/30							
		SAE 5W/30								
Caterpillar: **) EMA: DHD-1				SAE 15W/40						
			SAE 10W/30							
		SAE 5W/30								
2.6 Transmission, lubrication system Dana: Transmission oil ATF		DEXRON III (trade mark)								
ZF: API: CD/CE/CF-4/CF/CG-4/ CH-4/CI-4/SF/SG/SH/SJ/SL ACEA: Categories A, B, E			SAE 10W, 10W/30, 10W/40							
		-25°C	SAE 15W/30, 15W/40							
			SAE 20W/20, 20W/40							
				SAE 30						
3.3 Power transmission, drive shaft Hypoid oil, API GL-5 and MIL-L-2105B			SAE 80W140							
			SAE 80W90							
			SAE 90							
					SAE 85W140					

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10 Common hydraulics	
Hydraulic oil	AV 32
SS 155434	AV 46
Hydraulic oil	HVLP 46
DIN 51524	HLP 68
Hydraulic oil	ISO - LHV 46
ISO 6743/4	ISO - LHM 68

NOTE

Oil filters shall always be changed in connection with oil change.

The change interval for engine oil is conditional on the sulphur content in the fuel not exceeding 0.5%.

*) API CH-4 or CI-4 are approved for markets outside the EU/EES.

**) API CH-4 and CI-4 oils are acceptable, if the requirements in Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are fulfilled. CH-4 and CI-4 oils that do not meet the requirements in Caterpillar's ECF-1 specification may result in shortened service life of the engine.

ACEA = Association des Constructeurs Européenne d'Automobiles

API = American Petroleum Institute

CES = Cummins Engine Standard

EMA = Engine Manufacturer's Association

VDS = Volvo Drain Specification

Grease

Use a universal grease type EP according to NLGI Grade 2 (EP2) for all grease points except for slide plates lifting equipment and slide plates.

For lifting equipment, use a universal grease type EP according to NLGI Grade 2 (EP2) with 3.5% Molybdenum disulfide intermix.

Cargotec approved lubricant must be used for slide plates. Obtained from Cargotec Spare Parts Dept. 0.65 kg cartridge for grease gun part no. 923110.0360, and 5 kg can part no. 923595.0003

Electrical connector grease

Use electrical contact grease part no. 923836.0552.

Sealant silicone

Use silicone part no. 923107.0308.

Silicone adhesive

Use silicone adhesive part no. 923854.0100.

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Coolant

Use ready-mixed coolant. Choose the mixture of coolant that is adapted for the correct temperature.

CAUTION

Different types of coolant must not be mixed.

Risk of engine damage if different types of coolant are mixed.

When changing and topping up coolant, only use coolant of the same type that was used before. See Spare parts catalogue for correct part number.

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Tightening torques, recommendations

The tightening torques in the following table are recommendations when tightening bolts and nuts.

When torquing using a machine, for example, bolt runner, the tightening torque should be reduced by approx. 5%.

For mild surfaces (hardness below 200 HB), washer shall be used under both bolt head and nut. Alternatively, use flange bolt or flange nut.

Tighten to the prescribed torque without stopping.

Recommended tightening torque may vary depending on surface treatment. Certain combinations of nut and bolt require lubrication according to the table below.

State	Bolt	Nut	Lubrication
1	untreated	untreated	oil
2	bright-galvanized	untreated or bright-galvanized	dry or oil
3	hot-galvanized	untreated	dry or oil

Quality	8.8			10.9	12.9
State	1	2	3	1	1
Fine M-thread					
M81	27 Nm	24 Nm	30 Nm	39 Nm	46 Nm
M101,25	54 Nm	48 Nm	61 Nm	78 Nm	91 Nm
M121,25	96 Nm	85 Nm	108 Nm	135 Nm	162 Nm
M161.5	230 Nm	205 Nm	260 Nm	323 Nm	388 Nm
M181.5	330 Nm	294 Nm	373 Nm	466 Nm	559 Nm
M-thread					
M4	3.2 Nm	2.9 Nm	3.6 Nm	4.6 Nm	5.5 Nm
M5	6.4 Nm	5.7 Nm	7.2 Nm	9.1 Nm	11 Nm
M6	11 Nm	9.8 Nm	12.5 Nm	16 Nm	19 Nm
M8	26 Nm	24 Nm	30 Nm	38 Nm	45 Nm
M10	52 Nm	47 Nm	59 Nm	74 Nm	89 Nm
M12	91 Nm	81 Nm	103 Nm	128 Nm	154 Nm
M16	220 Nm	198 Nm	250 Nm	313 Nm	375 Nm
M20	430 Nm	386 Nm	490 Nm	620 Nm	732 Nm
M24	750 Nm	668 Nm	848 Nm	1050 Nm	1270 Nm
M30	1480 Nm	1317 Nm	1672 Nm	2080 Nm	2500 Nm
UNC-thread					

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Quality	8.8			10.9	12.9
1/4	12.5 Nm	11.1 Nm	14.1 Nm	17.6 Nm	20 Nm
5/16	25 Nm	22.3 Nm	28.3 Nm	35 Nm	42 Nm
3/8	44 Nm	39 Nm	50 Nm	62 Nm	73 Nm
7/16	70 Nm	62 Nm	79 Nm	100 Nm	118 Nm
1/2	107 Nm	95 Nm	121 Nm	151 Nm	178 Nm
9/16	153 Nm	136 Nm	173 Nm	216 Nm	255 Nm
5/8	210 Nm	187 Nm	237 Nm	298 Nm	353 Nm
3/4	370 Nm	390 Nm	418 Nm	524 Nm	619 Nm
7/8	594 Nm	528 Nm	671 Nm	839 Nm	990 Nm
1	889 Nm	791 Nm	1005 Nm	1260 Nm	1480 Nm
1 1/8	1260 Nm	1120 Nm	1424 Nm	1780 Nm	2100 Nm
1 1/4	1760 Nm	1565 Nm	1990 Nm	2490 Nm	2940 Nm
1 3/8	2320 Nm	2065 Nm	2620 Nm	3280 Nm	3870 Nm
1 1/2	3060 Nm	2720 Nm	3455 Nm	4320 Nm	5100 Nm

Tightening torques, ORFS-couplings

Pipe and hose coupling

Pipe diameter		Tightening torques
mm	inch	Nm
6	1/4	23-25
8	5/16	33-38
10	3/8	
12	1/2	51-57
14	-	80-90
15	-	
16	5/8	
18	3/4	120-130
20	-	
22	7/8	150-170
25	1"	

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Pipe diameter		Tightening torques
mm	inch	Nm
28	-	180-200
30	-	
32	1"1/4	
35	-	200-240
38	1"1/2	

Socket width		Tightening torques
mm	inch	Nm
17	11/16	23-25
22	13/16	33-38
24	15/16	51-57
36	1 3/8	120-130
41	1 5/8	150-170

Flange coupling

UNF-UN		Metric-ISO		BSSP	
Thread (inch)	Tightening torques (Nm)	Thread (mm)	Tightening torques (Nm)	Thread (inch)	Tightening torques (Nm)
7/16-20	21	10x1	20	1/8-28	20
1/2-20	27	12x1,5	35	1/4-19	35
9/16-18	40	14x1,5	45	3/8-19	70
3/4-16	78	16x1.5	55	1/2-14	100
7/8-14	110	18x1.5	68	3/4-14	190
1"1/16-12	180	20x1.5	80	1"-11	300
1"3/16-12	230	22x1.5	98	1"1/4-11	330
1"5/16-12	285	26x1.5	170	1"1/2-11	400
1"5/8-12	320	27x2	180		
1"7/8-12	400	33x2	310		
		42x2	330		
		48x2	400		

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Tightening torque, climate control system connections

O-rings, radiator hoses

Hose diameter		Thread	Tightening torques
mm	inch	inch	**Nm**
6	1/4"	7/16"	7-14 Nm
10	3/8"	5/8"	14-20 Nm
10	3/8"	11/16"	14-20 Nm
12	1/2"	3/4"	14-27 Nm
16	5/8"	7/8"	27-41 Nm
19	3/4"	1 1/16"	34-47 Nm
Pressure switch		3/8"	7-14 Nm

The above values are to be considered guidelines and may vary depending on installation.

Unit explanations

Unit	Abbreviation
Newton metre	Nm
Kilo pound metre	kpm
Kilo Pascal	kPa
Mega Pascal	MPa
Kilowatt	kW
kilojoule	kJ
British thermal unit	Btu
Calorie	ca
Inch	in
Feet	ft
Yard	yd
Mile	mile
Centimetre	cm
Metre	m
Kilometre	km

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Conversion table, SI-units

SI-unit	Recalculation factor	Non-SI	Recalculation factor	SI
Torque				
Nm	x 10,2	= kg·cm	x 0,8664	= lb·in
Nm	x 0,74	= lbf·ft	x 1,36	= Nm
Nm	x 0,102	= kg·m	x 7,22	= lb·ft
Pressure (Pa = N/m ^{2})				
kPa	x 4,0	= in.H_2O	x 0,249	= kPa
kPa	x 0,30	= in.Hg	x 3,38	= kPa
kPa	x 0,145	= psi	x 6,89	= kPa
bar	x 14,5	= psi	x 0,069	= bar
kp/cm ^{2}	x 14,22	= psi	x 0,070	= kp/cm ^{2}
N/mm ^{2}	x 145,04	= psi	x 0,069	= bar
MPa	x 145	= psi	x 0,00689	= MPa
Power (W = J/s)				
kW	x 1,36	= hp (cv)	x 0,736	= kW
kW	x 1,34	= bhp	x 0,746	= kW
kW	x 0,948	= Btu/s	x 1,055	= kW
W	x 0,74	= ft·lb/s	x 1,36	= W
Energy (J = Nm)				
kJ	x 0,948	= Btu	x 1,055	= kJ
J	x 0,239	= calorie	x 4,19	= J
Speed and acceleration				
m/s^2	x 3,28	= ft/s ^{2}	x 0,305	= m/s ^{2}
m/s	x 3,28	= ft/s	x 0,305	= m/s
km/h	x 0,62	= mph	x 1,61	= km/h
Horsepower/torque				
Bhp x 5252 rpm= TQ (lb·ft)			TQ x rpm 5252 = bhp	
Temperature				
ºC = (ºF – 32)/1,8	ºF = (ºC x 1,8) + 32			
Flow factor				
l/min (dm ^{3} /min)	x 0,264	= US gal/min x 3,785		= litre/min

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Conversion table, length

Unit	cm	m	km	in	ft	yd	mile
cm	1	0,01	0,00001	0,3937	0,03281	0,01094	0,000006
m	100	1	0,001	39,37	3,2808	1,0936	0,00062
km	100000	1000	1	39370,7	3280,8	1093,6	0,62137
in	2,54	0,0254	0,000025	1	0,08333	0,02777	0,000015
ft	30,48	0,3048	0,000304	12	1	0,3333	0,000189
yd	91,44	0,9144	0,000914	36	3	1	0,000568
mile	160930	1609,3	1,6093	63360	5280	1760	1
1 mm = 0,1 cm - 1 mm = 0,001 m							

Conversion table, area

Unit	cm^2	m^2	km^2	a	ft^2	yd^2	in^2
cm^2	1	0,0001	-	0,000001	0,001076	0,000012	0,155000
m^2	10000	1	0,000001	0,01	10,764	1,1958	1550,000
km^2	-	1000000	1	10000	1076400	1195800	-
a	0,01	100	0,0001	1	1076,4	119,58	-
ft^2	-	0,092903	-	0,000929	1	0,1111	144,000
yd^2	-	0,83613	-	0,008361	9	1	1296,00
in^2	6,4516	0,000645	-	-	0,006943	0,000771	1
1 ha = 100 a - 1 $mile^2$ = 259 ha = 2,59 km^2							

Conversion table, volume

Unit	cm^3 = cc	m^3	l	in^3	ft^3	yd^3
cm^3 = ml	1	0,000001	0,001	0,061024	0,000035	0,000001
m^3	1000000	1	1000	61024	35,315	1,30796
dm^3 (l)	1000	0,001	1	61,024	0,035315	0,001308
in^3	16,387	0,000016	0,01638	1	0,000578	0,000021
ft^3	28316,8	0,028317	28,317	1728	1	0,03704
yd^3	764529,8	0,76453	764,53	46656	27	1
1 gal (US) = 3785,41 cm^3 = 231 in^3 = 0,83267 gal (UK)						

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Conversion table, weight

Unit	g	kg	t	oz	lb
g	1	0,001	0,000001	0,03527	0,0022
kg	1000	1	0,001	35,273	2,20459
t	1000000	1000	1	35273	2204,59
oz	28,3495	0,02835	0,000028	1	0,0625
lb	453,592	0,45359	0,000454	16	1
1 ton (metric) = 1,1023 ton (US) = 0,9842 ton (UK)					

Conversion table, pressure

Unit	kp/cm^2	bar	$Pa = N/m^2$	kPa	lbf/in^2	lbf/ft^2
kp/cm^2	1	0,98067	98066,5	98,0665	14,2233	2048,16
bar	1,01972	1	100000	100	14,5037	2088,6
$Pa = N/m^2$	0,00001	0,001	1	0,001	0,00015	0,02086
kPa	0,01020	0,01	1000	1	0,14504	20,886
lbf/in^2	0,07032	0,0689	6894,76	6,89476	1	144
lbf/ft^2	0,00047	0,00047	47,88028	0,04788	0,00694	1
kg/cm^2 = 735,56 Torr (mmHg) = 0,96784 atm						

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Terminology and index

Explanation

Term	Description
AC	Air Conditioning. Heating unit with manual control of heating, cooling, dehumidification and air flow.
Accumulator	Reservoir that stores (accumulates) pressure for hydraulic functions for example.
Attachment	The part of the machine that grips the load when lifting.
Anti-corrosion agent	Prevents oxidising, in daily use rust inhibitor.
Operating hydraulics	All load handling functions, i.e. lift and lower, tilt, side shift, spreading and levelling.
Wheelbase	Distance between the drive and steering axles.
Bar	Unit for measuring pressure.
Battery disconnect switch	Interrupts the current from the battery.
Central lubrication	An automatic system for lubricating a preselected number of lubrication points.
Daily inspection	Those actions that must be carried out every day to ensure the functionality of the machine.
Decitonne	A tenth of a tonne, unit of measurement of the machine's lifting capacity.
Displacement	The oil volume that the pump can supply per pump revolution.
Display	"Window" that shows digital information on the steering wheel panel in the cab (with KCS).
Operating time	Number of hours that the machine has been operating, shown on the operating time gauge in the cab.
Drive axle	Driving axle which receives torque from the drive line.
Drive line	Parts of the machine that contribute to the power transmission; engine, torque converter, gearbox, propeller shaft and driving axle with differential and hub reduction.
ECC	Electronic Climate Control. Climate control system with automatic control of heating, cooling, dehumidification and air flow.
ECU	Electronic Control Unit
EDU	Electronic Display Unit
Electrolyte level	Fluid level in the battery cells.
Electric servo	Load handling hydraulic components receive control signals from electro mechanical controls.
Expansion tank	Reservoir for coolant.
Fixed displacement	Pump with fixed pump volume.
FlexCab	Protective cage with a strong protective frame construction. Enclosed.
FlexGuard	Protective cage with a strong protective frame construction. Open.
FMI	Fault Message Identifier.
Forks	Lifting device that lifts the loads.
Fork mountings	Mountings for forks, mounted on the lift assembly.
Main fuse	Located beside the battery. Interrupts the current to every system in the machine.
Hydraulic oil	Oil for hydraulic system. See specifications in the Operator's manual.

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Term	Description
Hydraulic oil pump	Pump in the hydraulic system.
Hydraulic system	System that uses oil pressure to transfer power to different functions.
Hydraulic servo	Load handling hydraulic components receive control signals from mechanical controls.
Hanging load	Raised load.
Indicator	Manual “sensor”, indicates, for example, if a filter is blocked and needs replacing.
KCS	Kalmar Control System. An electronic control system that monitors and handles certain systems in the machine which require KCS, e.g., certain engine and transmission alternatives.
Piston	The bar that slides into the piston cylinder and is affected by hydraulic pressure.
Refrigerant	Liquid/gas in the Air conditioning. May only be handled by authorised trained personnel.
Lifting capacity	Indicates how great a load the machine can lift.
Lifting point	Attachment point for lifting device when lifting objects.
Lift assembly	Lifts the load, located on the mast.
Low emission engine	Engine with low emissions of dangerous substances. Manufactured according to regulations.
Solenoid	An electro magnetically controlled valve. See also proportional valve.
Control valve	Valves that can be used for controlling items, for example, releasing pressure and thereby lowering a mast or a fork. See also control valve.
Machine model	Machine type. Given as, for example: DCD 90-180. See also type designation.
Environmental waste	Used oil filters etc. must be handled according to applicable national laws and regulations.
Torque converter	Hydraulic, stepless clutch.
Counterweight	Weights adapted to the machines lifting capacity to provide counter weight when lifting.
Hub reduction	Type of final drive (often with drive wheels) that reduces the speed and increases the torque from the driveline.
Optimum drive	Function for simulated hydrostatic control.
Optimum rev	KCS function which optimises lift speed using an extra variable hydraulic pump, at the same time as the engine speed is as low as possible.
Optimum speed	KCS function that optimises the lift speed using an extra variable hydraulic pump.
Pilot oil pressure	A low control pressure, for example, to a valve.
Planetary gear	Type of gearbox with the gears in constant mesh.
Product alternative	One of several alternatives selected for the machine, i.e. engine alternative.
Progressive steering	Faster steering wheel movements give greater steering response.
Proportional valve	An electro magnetically controlled valve. If a current is applied, the valve is activated proportionally to the size of the current. In everyday speech, a stepless valve, as opposed to an on/off valve. On the gearbox valve housing for example.
Frame members	Bearing members of the frame.
Recirculation	Circulation in a closed system.
Serial number	Unique machine designation. On the machine plate.
Service position	How the machine must stand securely before service is started.
Servo	A small movement by the user gives a greater effect, i.e. power steering.

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Term	Description
Servo pressure	A low control pressure to control a higher pressure, for example to a valve.
Side shift	The forks are moved parallel sideways.
Levelling	The forks are inclined if the load is on an uneven surface.
SmartLink	Software for handling KCS (Kalmar Control System).
Spirit Delta	Enclosed type of cab.
SPN	Suspect Parameter Number.
Spreading	Spreading of forks, that is, changing the internal distance between the forks.
Mast	Carriers of unit and load.
Dust reservoir	The air filter collects the coarsest particles in a dust reservoir, which empties automatically while driving.
Steering axle	Wheel axle with steering.
Buzzer	Audible alarm for gaining the driver’s attention.
Option	Optional equipment for the machine.
Tilt	The mast is tilted forwards or backwards.
Top-lift	Attachment. See attachment.
Transmission oil	Oil for the gearbox and torque converter. See specifications.
Transport safety for the vehicle	Precautions before machine transport.
Twistlocks	Two detent bolts, one in each corner of the unit, which slide into corresponding holes in the container and are twisted to lock the container into position when lifting.
Type designation	Indicates type of machine and capacity. See also machine model.
Maintenance	Periodic maintenance operations so that the machine functions safely and lasts well.
Variable pump	Pump with adjustable flow speed
Variable displacement	Controllable volume (capacity) in a pump.
Valve slide	Moveable section of the valve. Determines the path of the oil.
Wet brakes	Brake friction plates in an oil bath.

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