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NOTICE

The information contained is for **DEALER REFERENCE PURPOSES ONLY**.
MANUALS ARE MODEL AND SERIAL NUMBER SPECIFIC.

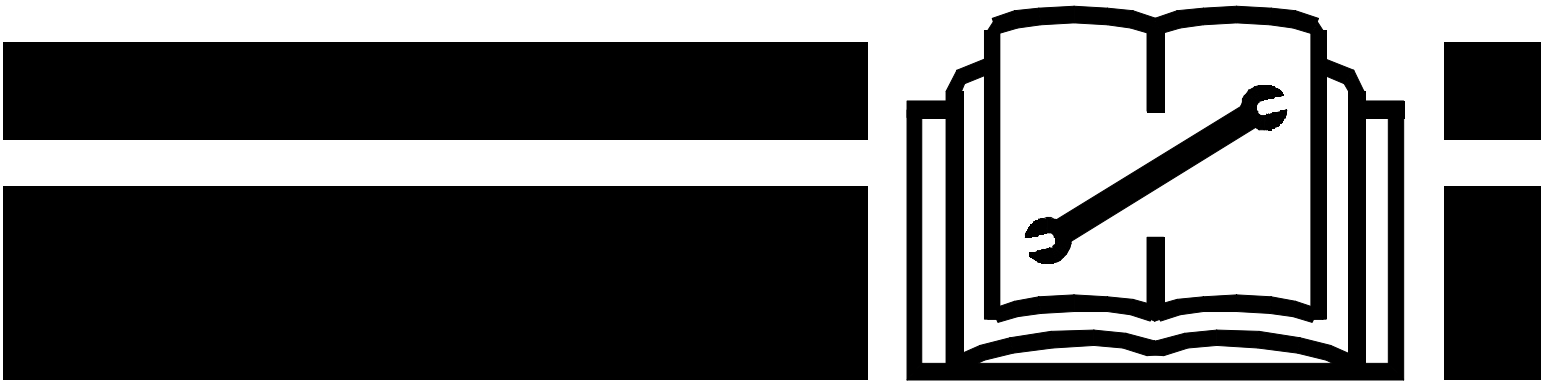
If additional printed manuals are required for your shop/office location, order by part number through the factory's Parts Center.

If a retail customer needs replacement manual(s) for a specific unit, contact the factory's Customer Data Center at: 800-829-0051 or customerdata@vermeermfg.com

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Vermeer®

D33x44 NAVIGATOR™
Horizontal Directional Drill



Service Manual

D33x44_SM1_R01
SERIAL NO. 101 -
ORDER NO. 105400-S23

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INTRODUCTION

This manual contains service requirements and procedures needed by an experienced service person to complete necessary service and repairs on the machine. Study and understand these requirements and procedures thoroughly before servicing or repairing the machine. There are also many components which are not user-serviceable. Do not attempt any service which you do not fully understand, nor any service that you cannot do adequately and safely with the tools and equipment available to you. Failure to do so could result in personal injury or equipment damage. If you encounter a problem that you do not understand or cannot solve, contact your Vermeer service representative.

The instructions, illustrations and specifications in this manual are based on the latest information available at the time of publication. Your machine may have product improvements and options not yet contained in this manual.

Vermeer Manufacturing Company reserves the right to make changes at any time without notice or obligation.

Additional copies of this manual are available. When ordering, use the part number on the front cover.

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This machine may be covered by one or more of the following U.S. and foreign patents. (Other U.S. and foreign patents pending.)			
Canadian Des. Pat. #79,593	US Pat. #5,219,380	US Pat. #5,588,474	US Pat. #5,720,354
US Des. Pat. #308,682	US Pat. #5,291,964	US Pat. #5,590,041	US Pat. #5,746,278
US Des. Pat. #396,837	US Pat. #5,355,965	US Pat. #5,607,280	US Pat. #5,768,811
UK Regd. Pat. #2,053,636	US Pat. #5,394,583	US Pat. #5,611,496	US Pat. #5,778,991
US Pat. #4,848,423	US Pat. #5,507,441	US Pat. #5,647,803	US Pat. #5,803,380
US Pat. #4,961,542	US Pat. #5,509,220	US Pat. #5,659,985	US Pat. #5,819,859
US Pat. #5,074,063	US Pat. #5,544,055	US Pat. #5,687,807	US Pat. #5,845,689
US Pat. #5,088,532	US Pat. #5,553,407	US Pat. #5,692,548	
US Pat. #5,129,336	US Pat. #5,556,253	US Pat. #5,692,549	
US Pat. #5,205,181	US Pat. #5,574,642	US Pat. #5,704,142	

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1210 Vermeer Road East, P.O. Box 200
Pella, Iowa 50219-0200, USA

Contents Overview

NOTE: The following is the general table of contents for the manual. A detailed table of contents is located at the beginning of each section.

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General Information ..... Section 20

Engine System ..... Section 30

Common Hydraulic System ..... Section 40

Common Electrical System ..... Section 50

(Not available at time of publication) ..... Section 60

Rotation System ..... Section 70

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Water System ..... Section 100

Ground Drive ..... Section 110

Stakedown & Rack ..... Section 120

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Section 10-0: Safety

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Section 10-1: Safety Messages

General safety messages appear in this Safety Messages section. Specific safety messages are located in appropriate sections of the manual where a potential hazard may occur if the instructions or procedures are not followed.

UNDERSTAND SAFETY ALERT SYMBOL



This is the safety alert symbol. This symbol placed on your machine or in the manual is used to alert you to the potential for bodily injury or death.

UNDERSTAND SIGNAL WORDS



A signal word "**DANGER"**, "**WARNING"**, or **"CAUTION"** is used with the safety alert symbol.

Safety signs with the signal word **"DANGER"**, "**WARNING"** or **"CAUTION"** are located near specific hazards.

DANGER—Imminent hazards which, if not avoided, will result in serious personal injury or death.

WARNING—Potential hazards or unsafe practices which, if not avoided, could result in serious injury or death.

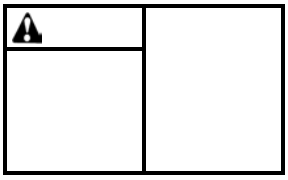
CAUTION—Potential hazards or unsafe practices which, if not avoided could result in minor personal injury or product or property damage.

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READ, UNDERSTAND, AND FOLLOW INSTRUCTIONS





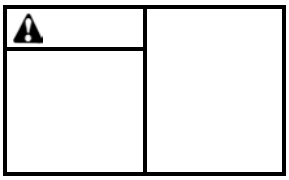
Read, understand, and follow all safety instructions and safety messages included in this manual and on decals attached to the machine. These instructions and safety messages contain important information.

Allow only responsible, properly instructed individuals to operate and service the machine.

Failure to follow the instructions and safety messages in this manual and on the decals attached to the machine could result in serious injury or death.

Keep all safety decals and instruction decals in good condition. Replace any missing or damaged decals.

SAFETY DECALS



Safety decals located on your machine contain important and useful information that will help you operate your equipment safely. Each of these safety decals is shown in the Operator's Manual and in the Parts Manual under Decal Assembly. All safety decals also appear elsewhere in the parts manual with other assemblies of which they are a part.

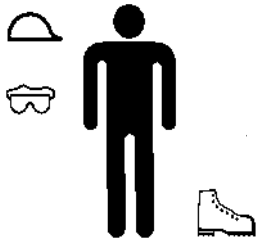
To assure that all decals remain in place and in good condition, follow these instructions:

- Keep decals clean. Use soap and water—not mineral spirits, abrasive cleaners, or other similar cleaners that will damage the decal.
- Replace any damaged or missing decals. When applying decals, the surface temperature of the metal must be at least 40°F (5°C). The metal must also be clean and dry.
- When replacing a machine component with a decal attached, replace the decal also.
- Purchase replacement decals from your Vermeer dealer.

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PERSONAL PROTECTIVE EQUIPMENT



Wear required personal equipment

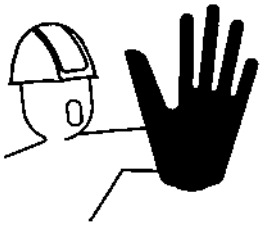
Wear close fitting clothing and confine long hair.

Avoid wearing jewelry such as rings, wrist watches, necklaces or bracelets.

Always wear:

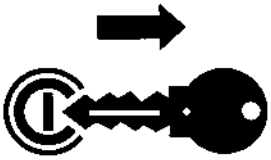
- a hard hat
- safety glasses
- work shoes

KEEP SPECTATORS AWAY FROM MACHINE



Make sure all spectators and other workers are clear of the machine before starting the engine.

USE SHUTDOWN PROCEDURE



Before working on the machine for any reason, including servicing, repairing, inspecting, lubricating, fueling, or transporting the machine, refer to the Shutdown Procedure section, page **10-2-1,** for proper instructions.

DO NOT MODIFY MACHINE

Make no modifications to your equipment unless specifically recommended or requested by Vermeer Manufacturing Company.

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MAINTAIN OPERATOR PRESENCE SYSTEM

This machine is equipped with an operator presence system. This system is intended for your safety and must be maintained in good, functional condition.

AVOID MOVING PARTS



Keep hands, feet and clothing away from power-driven parts.

Keep shields in place and properly secured.

AVOID ENTANGLEMENT - STAY AWAY



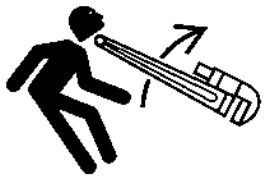
Entanglement in the rotating drill rod and cutting tool can cause death or serious injury.

Stay away from rotating drill rod and cutting tool.

Do not wear loose clothing that could catch on rotating equipment.

Boring and thrust control levers must self-center to NEUTRAL and stop rod motion.

ROTATING WRENCH CONTACT



Serious injury or death could result if struck by a wrench on the drill rod if rotation is started. Never use hand wrenches to break rod joints. Break rod joints only with the power vises on the machine.

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AVOID FLUID UNDER PRESSURE



Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

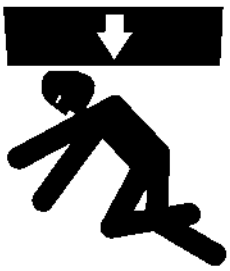
WORK IN VENTILATED AREA



Exhaust fumes can be fatal.

If operating the machinery in an enclosed area, remove the exhaust fumes with an exhaust pipe extension to the outside.

RAISED MACHINE CAN FALL



Never allow anyone to work under a raised machine unless mechanically supported with suitable blocking.

REPLACE SHIELDS

Be sure that all safety devices, including shields, are installed and functioning properly after servicing the machine.

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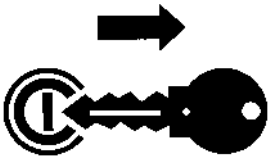
WARNING: Failure to follow any of the preceding safety instructions, or those that follow within this manual, could result in serious injury or death. This machine is to be used only for those purposes for which it was intended as explained in the Operator's Manual.

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Section 10-2: Shutdown Procedure

STOPPING THE MACHINE



For longest engine life, idle engine without load for several minutes before shutting it off.

For your safety and the safety of others, use the Shutdown Procedure before working on the machine for any reason, including servicing, cleaning, unclogging, or inspecting the machine.

A variation of the following procedure may be used if so instructed within this manual or if an emergency requires it.

To shutdown the machine:

1. Shut off the drilling fluid pump.
2. Reduce engine speed to idle.
3. Shut off the engine and remove ignition key.

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Section 20-0: General Information

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Section 20-1: Manuals, Warranties, and Parts

ABOUT THIS MANUAL

This 1st edition of the *D33x44 Navigator Horizontal Directional Drill Service Manual* contains instructions, illustrations, and specifications based upon latest information available at the time of publication. Your machine may have product improvements and options not yet contained in this manual. Procedures provided in this manual provide one method for completing a given task. Additional information may be available through the *Trenchless Service Department*.

Primary Sections

This manual has taken a ***functional systems approach*** to presenting service information for the machine. As a result, the manual is divided into several primary sections—each covering a different "system" on the machine. The sections, or systems, covered in this manual include:

- safety
- general information
- engine
- common hydraulic
- common electrical
- rotation
- thrust/pullback
- rod loader & vise
- water
- ground drive
- stakedown & rack

Sub-sections

Each section is broken into sub-sections. Each section begins with a detailed table of contents to help you find the information or procedures you need.

Bleed Tabs

Bleed tabs at the edge of the page aid in quickly locating information.

Operation and Maintenance Manuals

Operating instructions for the D33x44 are found in the *D33x44 Operator's Manual*. Lubrication and routine maintenance procedures are found in the *D33x44 Maintenance Manual*.

Ordering Manuals

Additional copies of this manual are available through the Vermeer Parts Center. When ordering, use the part number on the front cover.

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REFERENCE PUBLICATIONS

Vermeer Publications

The following Vermeer D33x44 Navigator Horizontal Directional Drill publications are necessary for reference:

- *Operator's Manual* (P/N 105400-R41)
- *Maintenance Manual* (P/N 105400-R43)
- *Parts Manual* (P/N 105400-R44)

Contact the Vermeer Parts Center to order these publications.

Vendor Publications

The following vendor publications are optional reference materials:

- *Cummins Engine Service Manual* for the 4BTA 3.9 engine.

Contact the appropriate local dealer for this information. Vermeer Manufacturing Company does not verify the validity of vendor information within the context of the D33x44 machine configuration.

WARRANTIES

Vermeer Warranty

Vermeer's 1 year limited warranty is printed inside the front cover of the *D33x44 Operator's Manual*. The warranty requires that all service work be conducted by an authorized Vermeer dealership or the warranty shall become void.

Cummins Engine Warranty

The engine is covered by **Cummins' 2 year limited warranty**, and is printed in the *Cummins Engine Operation and Maintenance Manual*.

While the engine warranty is in effect, only an authorized Cummins Service Facitity may work on the engine (including the engine wire harness). Unauthorized service on the engine will void the warranty.

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REPLACEMENT PARTS

Part Numbers, Hose Lengths, & Fitting Orientations

Refer to the most current *D33x44 Parts Manual* for part numbers, hose lengths and fitting orientations.

Parts Ordering

Refer to the most current *D33x44 Parts Manual* for part number information.

Contact the Vermeer Parts Center to order replacement parts.

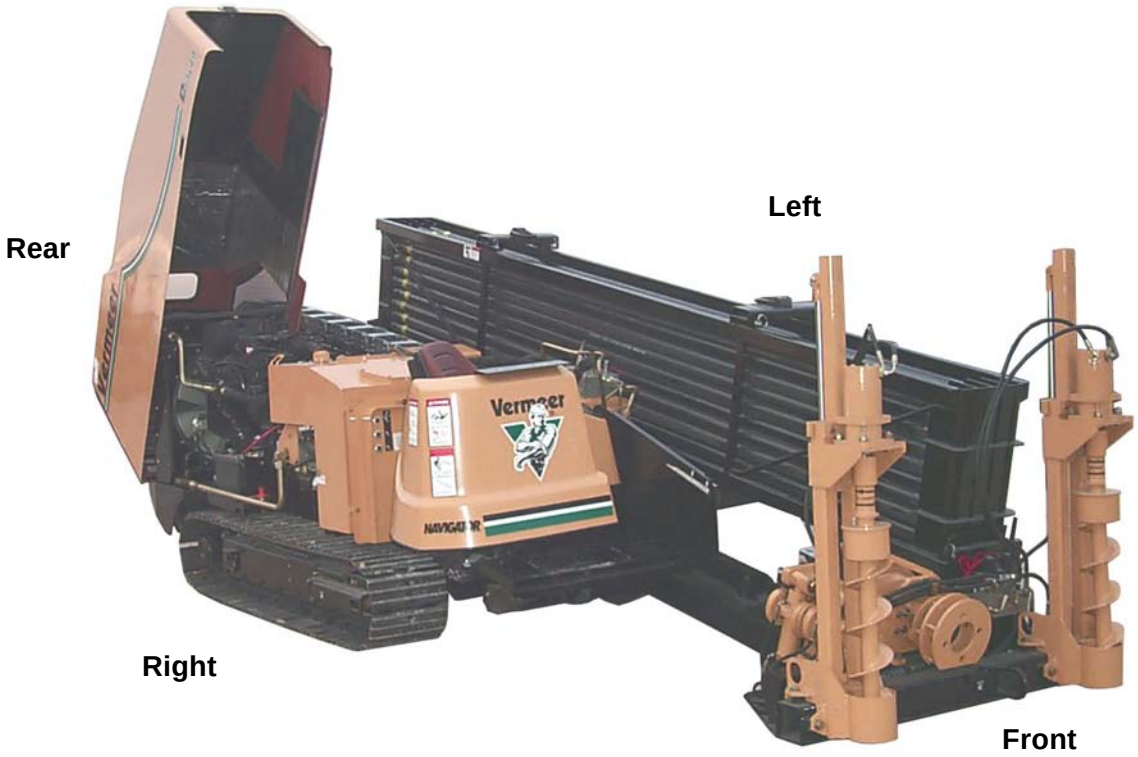
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Section 20-2: General Specifications

MACHINE ORIENTATION



NOTE: Right, left, front and rear are determined on the D33x44 when facing the power vises while seated at the controls.

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MACHINE SPECIFICATIONS

Specification	Value
Machine Dimensions	
weight empty	14,200 lb (6,441 kg)
weight with rod box	19,000 lb (8,618 kg)
overall length	245" (622 cm)
overall width	80" (203 cm)
overall height (at top of rod box)	83" (211 cm) with rack down 78" (198 cm) with rack up
Engine	
make / model	Cummins 4BTA 3.9-C125
maximum horsepower	125 hp (93.25 kW) at 2200 rpm
rated engine RPM	2200 rpm
fuel capacity	29 gal (110 L)
oil capacity	with filter: 11.5 qt (10.9 L) without filter:10.0 qt (9.5 L)
maximum engine inclination	30° all directions
coolant	mixture of 50% water and 50% ethylene glycol base antifreeze to -34°F (-37°C) protection
engine coolant capacity	11.0 gal (42 L)
electrical system	12-volt
alternator	63-amp
Battery	
required	1
BCI group size	31
cold cranking amps (CCA)	950 cold cranking amps, 30 seconds, 0°F (-18°C)
reserve capacity	185 min, 25 amp output at 80°F (27°C)
length	13" (33 cm)
width	6-3/4" (17 cm)
height	9-3/8" (24 cm)

Continued on next page...

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Specification	Value
Thrust / Pullback System	
maximum thrust at rated pressure	20,000 lb (9070 kg)
maximum pullback force at rated pressure	33,000 lb (14,970 kg)
pump make / model	Sundstrand 90 series
pump pressure limiter setting (multifunction valve) for PULLBACK	4900 psi (338 bar)
pump multifunction valve pressure setting for THRUST	3100 psi (214 bar)
thrust limiter setting (Rockfire mode) for THRUST	400-3000 psi (28-207 bar)
pump nominal flow @ 2200 rpm	32 gpm (121 L/min)
Rotation System	
maximum torque @ rated pressure @ low speed	4400 ft-lb
low rotation speed @ 2200 engine rpm	117 rpm
medium rotation speed @ 2200 engine RPM	156 rpm
high rotation speed @ 2200 engine rpm	234 rpm
pump make / model	Sundstrand 90 series
pump pressure limiter setting (multifunction valve) for FORWARD rotation	6090 psi (420 bar)
pump pressure limiter setting (multifunction valve) for REVERSE rotation	6090 psi (420 bar)
torque limiter setting for FORWARD rotation	4100 psi (280 bar)
torque limiter setting for REVERSE rotation	1500 psi (105 bar)
pump nominal flow @ 2200 rpm	32 gpm (121 L/min)
PFC (implement) System	
pump make / model	Sundstrand 45 series
pressure compensator setting	3000 psi (210 bar)
pump nominal flow @ 2200 rpm	42 gpm (159 L/min)
Water System	
pump make / model	FMC L0918HD
pump maximum nominal flow	50 gpm (189 L/min)
pump maximum rated pressure	1300 psi (90 bar) maximum discharge

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FUELS AND LUBRICANTS

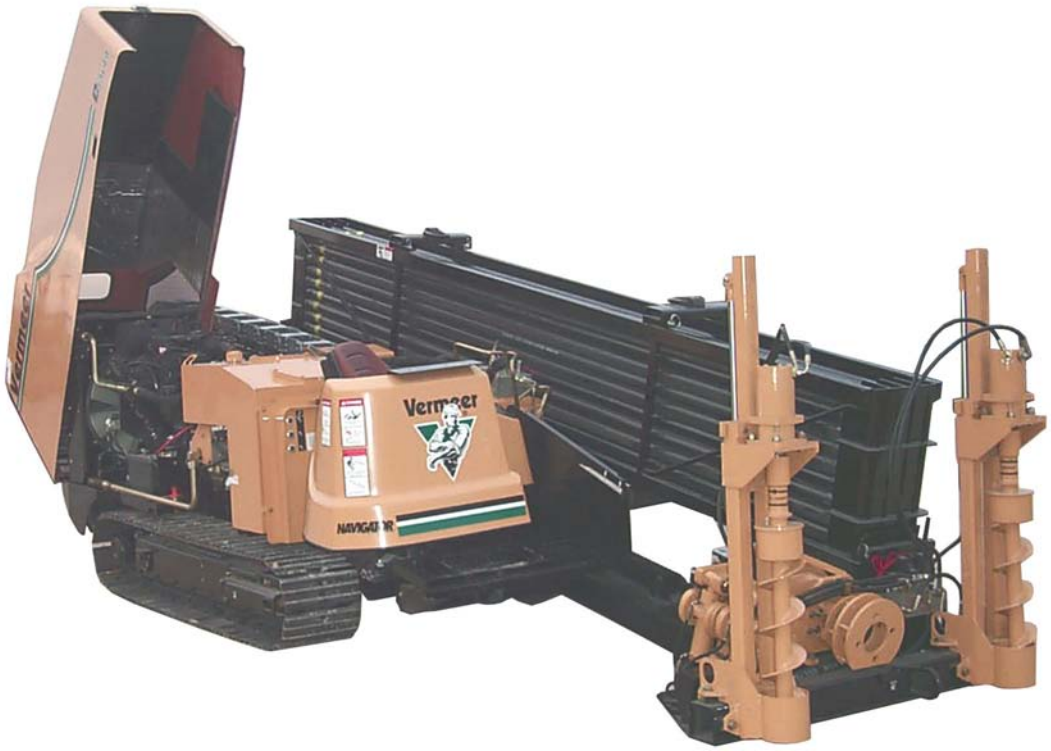
Lubricant	Capacity	Specifications / Notes
Fuel	29 gal (110 L)	An engine operation manual is supplied with each machine. Refer to the manual for engine service requirements.
Engine Oil	refer to engine specifications	
Hydraulic Fluid *Vermeer HyPower 46 or* *Vermeer HyPower 68 or* *Vermeer HyPower 100*	60 gal (227 L)	**ISO 46:** -13° to 86°F (-25° to 30°C) **ISO 68:** -4° to 104°F (-20° to 40 °C) **ISO 100:** 14° to 122°F (-10° to 122°C) Use caution not to get dirt or other contaminants into the system(s). Filter all fluid through a 10-micron filter before adding. **IMPORTANT:** Use of any oils other than those recommended, without written factory approval, will jeopardize the warranty.
All-Purpose Gear Lube	maintain check plug level	Oils must conform to API GL5 or MIL-L-2105D specifications. -20° to 100°F (-30° to 40°C): 80W-90 20° to 120°F (-10° to 50°C): 85W-140
General Lubricating Oil *Vermeer Xtra Gold 10W30*	as required	**SAE10W30**
Grease *Vermeer Ultra LC Grease*	as required	**Lithium complex, extreme pressure NLGI Grade 2** To minimize condensation in bearings, grease machine after it is shut down for the day. Fittings and grease applicator nozzle must be clean before applying grease. Replace all missing fittings.
Drilling Fluid Pump Crankcase *Vermeer Xtra Gold 40*	4.5 qt (4.3 L)	**SAE40** (classification MM or better)
Drill Rod Thread Compound	as required	Plusco Thread Compound (P/N 235983-001) API Bulletin 7A1 (tentative). This requires the compound to contain a copper base to withstand high pressures and remain in the threads.

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Section 20-4: Routine Maintenance

PERIODIC MAINTENANCE



Maintenance intervals are provided for reference only. Before performing any maintenance procedures, consult the *D33x44 Maintenance Manual* and the *Cummins Engine Operation and Maintenance Manual* for safety guidelines and instructions.

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Every 10 Service Hours or Daily

Machine

- Hydraulic Fluid Level—Check
- Fuel Tank—Fill
- Drill Rods—Inspect and Care For
- Front Roller Guides—Grease
- Rotation Gearbox Guide Rollers—Grease
- Rotation Gearbox Position Bars—Grease

Engine

- Cooling System—Check
- Fan and Drive Belt—Check
- Fuel/Water Separator—Drain
- Fluid Levels—Check
- Air Cleaner and Restriction Indicator—Check

Every 50 Service Hours or Weekly

Machine

- Front Track Roller and Upper Rear Idler—Grease
- Track Gearbox Oil Level—Check
- Rack Frame Pivot—Grease
- Rack Frame Pivot Cylinders—Grease
- Fluid Pump Crankcase Oil Level—Check
- Rear Stabilizer—Grease
- Track Drive Control Levers' Linkage—Oil
- Power Vise—Grease
- Power Vise Clamp Cylinders—Grease
- Power Vise Rotation Cylinder—Grease

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Every 100 Service Hours

Machine

- Drilling Fluid System—Check
- Overall Machine—Check
- Control Levers—Check
- Hydraulic Enable and Operator Presence System—Check
- Battery Voltage—Check
- Hydraulic System—Check
- Ground Drive System—Inspect

Engine

- Radiator and Oil Cooler—Clean

Every 250 Service Hours

Machine

- Hydraulic Fluid Filters Initially—Change

Engine

- Engine Oil and Filter—Change
- Cooling System Additive—Add

Every 500 Service Hours

Machine

- Battery Electrolyte Level—Check
- Battery Terminals—Clean
- Drilling Fluid Pump Oil —Change (Initial)
- Hydraulic Fluid Filter—Change

Engine

- Cooling System—Check
- Fuel Filter—Change
- In-line Fuel Filter—Change

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Every 1000 Service Hours

Machine

- Drilling Fluid Pump Crankcase Oil—Change
- Track Gearbox Oil—Change
- Hydraulic Fluid—Change
- Hydraulic Fluid Strainer—Remove and Inspect

Engine

- Engine System—Check
- Drive Belt Wear—Check

Every 2000 Service Hours

Engine

- Cooling System—Drain and Clean

Maintenance as Required

Machine

- Battery—Replace
- Track Tension—Adjust
- Vise Jaw Grips—Replace
- Rod Guide Rollers—Replace

Engine

- Engine System—Check
- Air Cleaner Element—Replace

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Section 20-5: Machine Performance Checks

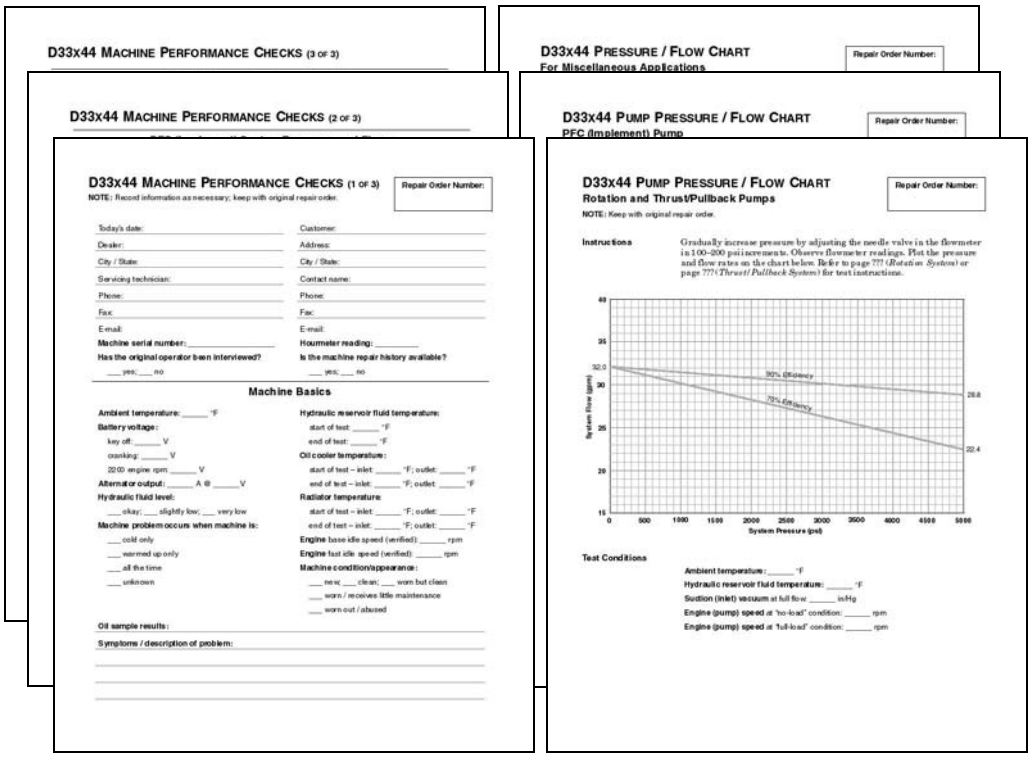
CHECKING AND RECORDING MACHINE PERFORMANCE INFORMATION

Use the following worksheets to record diagnostic observations. The first worksheet ("*Machine Performance Checks*") is intended to provide a place to record machine conditions and simple flow and pressure test results. This will allow for systematic troubleshooting while isolating the problem to a specific system. The second worksheet ("*Pump Pressure/Flow Chart*") provides a graph to record a detailed plot of pump *flow* compared to pump *pressure*. This information is essential for accurate diagnosis of suspected pump or motor failures.

It is very important to follow a systematic procedure to capture accurate test information. Refer to the sections for the individual systems such as *Rotation*, *Thrust/Pullback*, etc. The individual system sections contain procedures and important safety considerations that must be followed whenever performing hydraulic diagnostic procedures. A copy of each report should be kept with the repair order or machine file for future reference and, when appropriate, forwarded to the factory for warranty documentation.

- The *Machine Performance Checks* and the *Pump Pressure/Flow Chart* worksheets will look similar to the forms shown below.
- You will be prompted, by the pencil location, where to record information onto a **copy** of the worksheet(s) whenever you see the icon to the left.





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D33X44 MACHINE PERFORMANCE CHECKS (1 OF 3)

NOTE: Record information as necessary; keep with original repair order.

Repair Order Number:

Today's date:

Customer:

Dealer:

Address:

City / State:

City / State:

Servicing technician:

Contact name:

Phone:

Phone:

Fax:

Fax:

E-mail:

E-mail:

Machine serial number: _____

Hourmeter reading: _____

Has the original operator been interviewed?

___ yes; ___ no

Is the machine repair history available?

___ yes; ___ no

Machine Basics

Ambient temperature: _____ °F

Battery voltage:

key off: _____ V

cranking: _____ V

2200 engine RPM: _____ V

Alternator output: _____ A @ _____V

Hydraulic fluid level:

___ okay; ___ slightly low; ___ very low

Machine problem occurs when machine is:

___ cold only

___ warmed up only

___ all the time

___ unknown

Hydraulic tank fluid temperature:

start of test: _____ °F

end of test: _____ °F

Oil cooler temperature:

start of test – inlet: _____ °F; outlet: _____ °F

end of test – inlet: _____ °F; outlet: _____ °F

Radiator temperature:

start of test – inlet: _____ °F; outlet: _____ °F

end of test – inlet: _____ °F; outlet: _____ °F

Engine base idle speed (verified): _____ rpm

Engine fast idle speed (verified): _____ rpm

Machine condition/appearance:

___ new; ___ clean; ___ worn but clean

___ worn / receives little maintenance

___ worn out / abused

Oil sample results:

Symptoms / description of problem:

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D33X44 MACHINE PERFORMANCE CHECKS (2 OF 3)

PFC (Implement) System Pressures and Flows

Pressures:

standby: _____ psi (300)

compensator: _____ psi (3000

transport pressure relief _____ psi (3500)

Load sense pressure:

with functions in NEUTRAL: _____ psi

with function activated: _____ psi

Suction (inlet) vacuum at full flow: _____ in/Hg

at full flow: _____ in/Hg (6.8-0)

cold start (reduced flow): _____ in/Hg (15.2 max)

Pump flow

_____ gpm (43) @ standby _____ psi

_____ gpm @ max. _____ psi

Case drain flow:

system @ standby pressure: _____ gpm

system @ compensator pressure:_____ gpm

Thrust/Pullback System Pressures and Flows

Charge pressure @ 1750 rpm:

NEUTRAL: _____ psi (350 +/-25)

FORWARD: _____ psi (>300)

REVERSE: _____ psi (>300)

Suction (inlet) vacuum

at full flow: _____ in/Hg (9.8)

at cold start (reduced flow): _____ in/Hg (24)

Charge Pump Flow @ 2200 rpm

no-load: _____ gpm @ nominal psi (9.3)

loaded: _____ gpm @ 300 psi (8.4)

System pressure in THRUST:

(limiter off): _____ psi (4100)

(limiter on): _____ psi (3100)

System pressure in PULLBACK: ____ psi (4900)

2-speed shift pressure:

LOW: _____ psi (<50)

HIGH: _____ psi (>100)

Pump flow in THRUST @ 2200 rpm:

no-load: _____ gpm @ _____ psi @ _____ rpm

loaded: _____ gpm @ _____ psi @ _____ rpm

Pump flow in PULLBACK @ 2200 rpm:

no-load: _____ gpm @ _____ psi @ _____ rpm

loaded: _____ gpm @ _____ psi @ _____ rpm

Pump case pressure: _____ psi

cold _____ psi (73)

normal _____ psi (25)

Pump case flow: _____ gpm

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D33X44 MACHINE PERFORMANCE CHECKS (3 OF 3)

Rotation System Pressures and Flows (at 2200 rpm unless noted)

Suction (inlet) vacuum

at full flow: _____ in/Hg (9.8)

at cold start (reduced flow): _____ in/Hg (24)

Shuttle / front motor (port ‘D1’) shift pressure:

NEUTRAL: _____ psi (<50)

LOW: _____ psi (<50)

MEDIUM: _____ psi (<50)

HIGH: _____ psi (>300)

Shuttle / rear motor (port ‘D2’) shift pressure:

NEUTRAL: _____ psi (<50)

LOW: _____ psi (<50)

MEDIUM: _____ psi (>250)

HIGH: _____ psi (>250)

Shuttle pressure (port ‘G’):

NEUTRAL: _____ psi (300)

LOW: _____ psi (300)

MEDIUM: _____ psi (300)

HIGH: _____ psi (300)

Shuttle flow:

NEUTRAL: _____ gpm (2.0)

LOW: _____ gpm (2.0)

MEDIUM: _____ gpm (2.0)

HIGH: _____ gpm (2.0)

Gearbox pressure:

cold _____ psi (max 100)

normal _____ psi (25)

Charge pressure @ 1750 rpm:

NEUTRAL: _____ psi (350 +/- 25)

FORWARD: _____ psi

REVERSE: _____ psi

System pressure in FORWARD:

(limiter off): _____ psi (6090)

(limiter on): _____ psi (4100)

System pressure in REVERSE:

(limiter off): _____ psi (6090)

(limiter on): _____ psi (1500)

Pump flow in FORWARD:

no-load: _____ gpm (32) @ _____ psi @ _____ rpm

loaded: _____ gpm (28.8) @ _____ psi (5000) @ _____ rpm

Pump flow in REVERSE @ 2200 rpm:

no-load: _____ gpm (32) @ _____ psi @ _____ rpm

loaded: _____ gpm (30.8)@ _____ psi (1500) @ _____ rpm

Pump case pressure:

cold _____ psi (73)

normal _____ psi (25)

Pump case flow: _____ gpm

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D33X44 PUMP PRESSURE / FLOW CHART

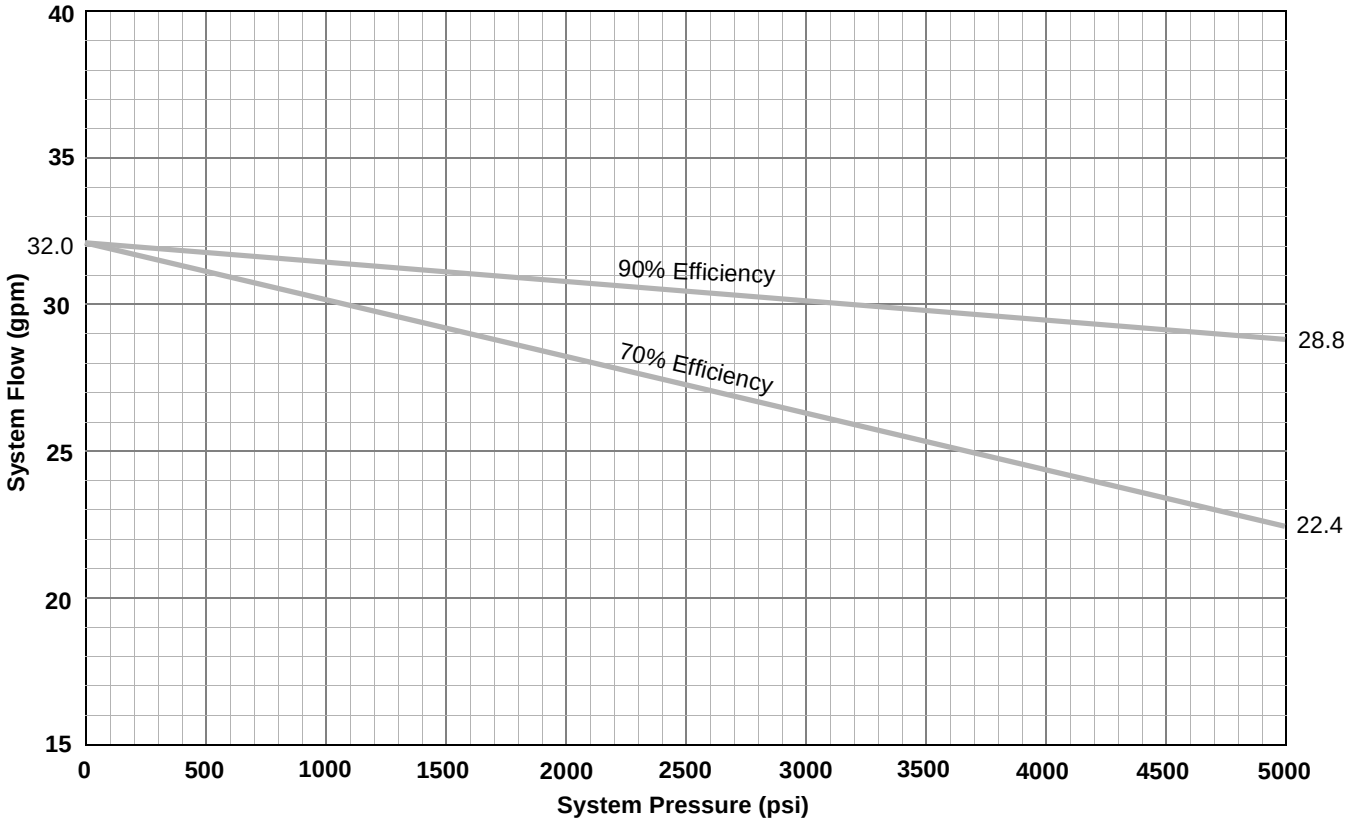
Rotation and Thrust/Pullback Pumps

Repair Order Number:

NOTE: Keep with original repair order.

Instructions

Gradually increase pressure by adjusting the needle valve in the flow meter in 100–200 psi increments. Observe flow meter readings. Plot the pressure and flow rates on the chart below. Refer to page **70-3-14**. (*Rotation System* and *Thrust/Pullback System*) for test instructions.



Test Conditions

Ambient temperature: _____ °F

Hydraulic tank fluid temperature: _____ °F

Suction (inlet) vacuum at full flow: _____ in/Hg

Engine (pump) speed at “no-load” condition: _____ rpm

Engine (pump) speed at “full-load” condition: _____ rpm

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D33X44 PUMP PRESSURE / FLOW CHART

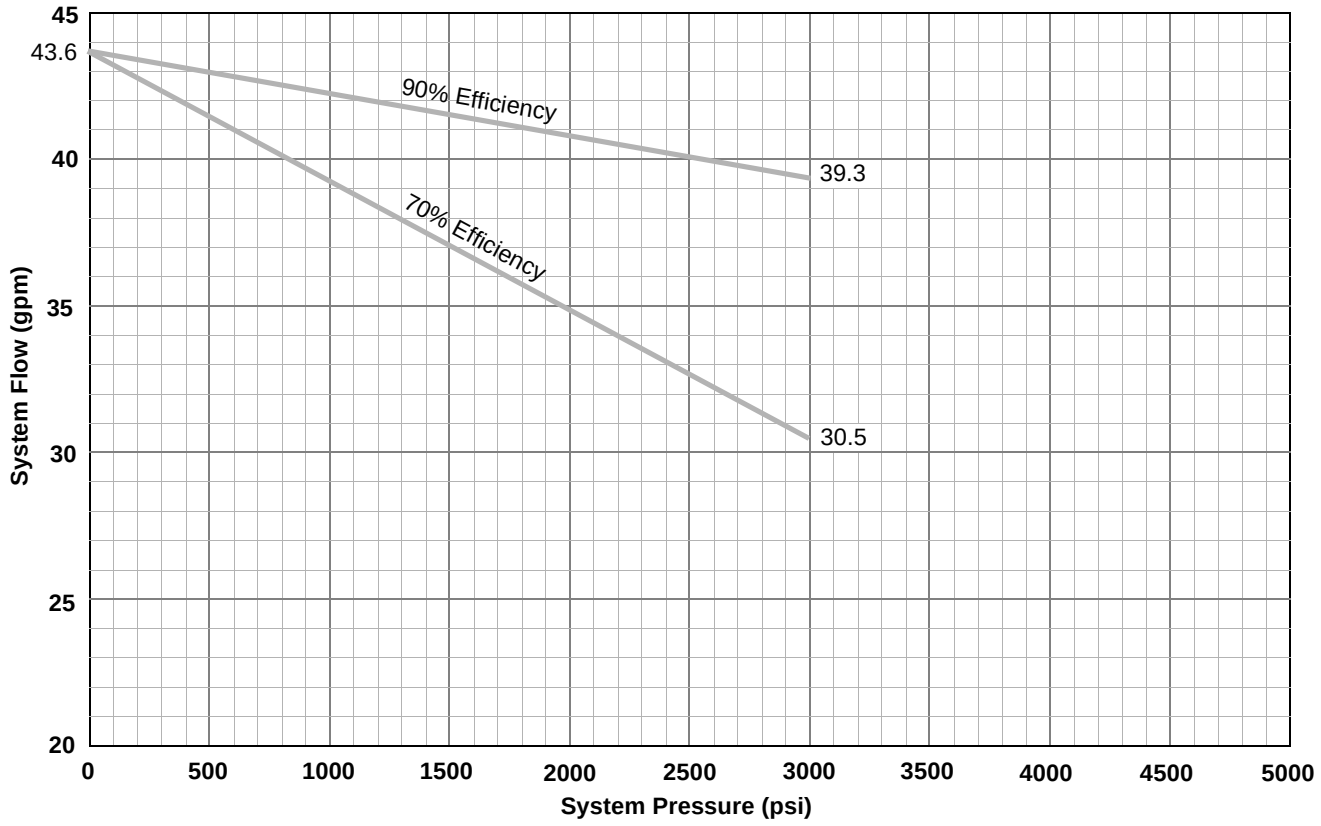
PFC (Implement) Pump

Repair Order Number:

NOTE: Keep with original repair order.

Instructions

Gradually increase pressure by adjusting the needle valve in the flow meter in 100–200 psi increments. Observe flow meter readings. Plot the pressures and flow rates on the chart below.



Test Conditions

Ambient temperature: _____ °F

Hydraulic tank fluid temperature: _____ °F

Suction (inlet) vacuum at full flow: _____ in/Hg

Engine (pump) speed at “no-load” condition: _____ rpm

Engine (pump) speed at “full-load” condition: _____ rpm

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D33X44 PRESSURE / FLOW CHART

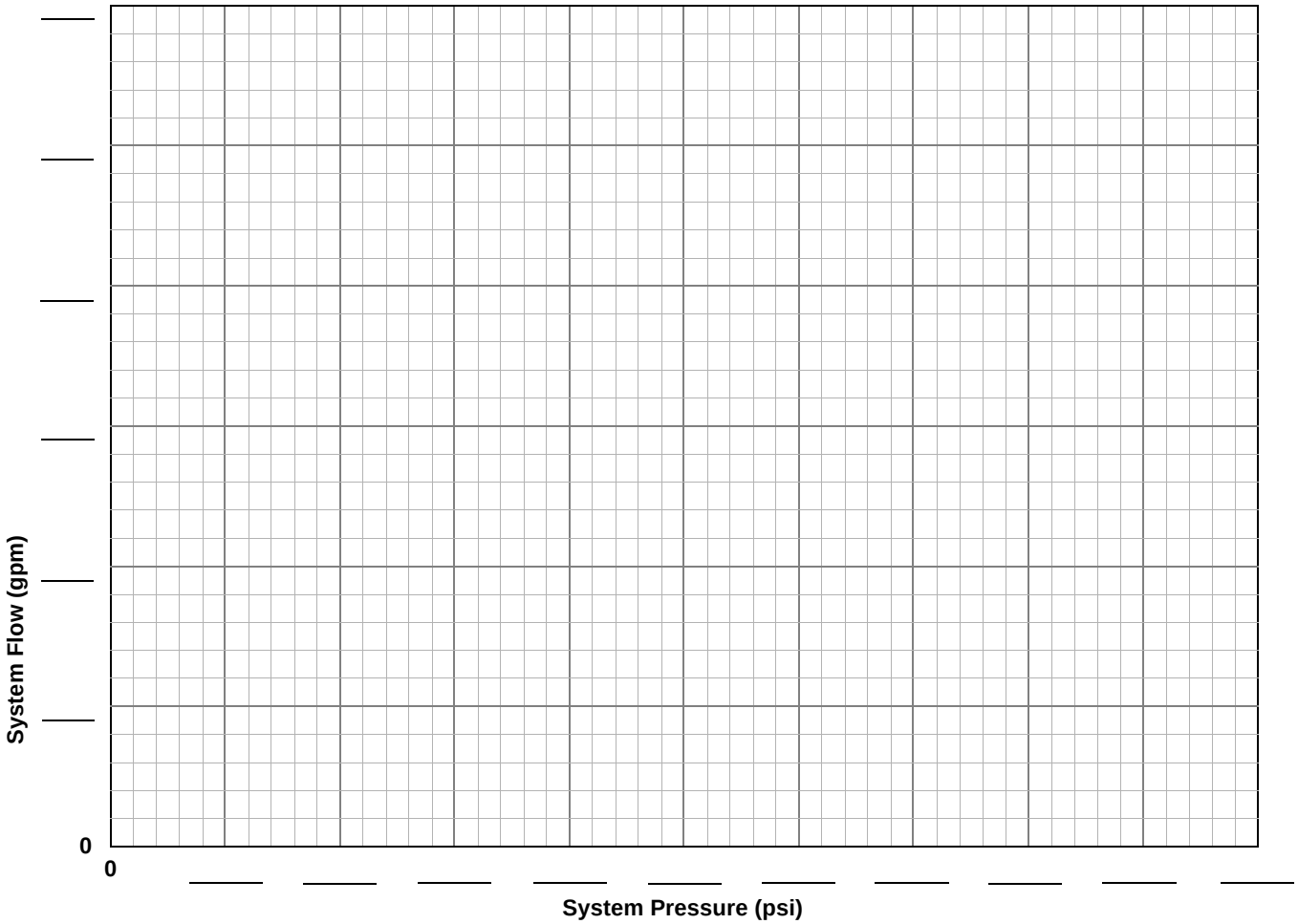
For Miscellaneous Applications

Repair Order Number:

NOTE: Keep with original repair order.

Instructions

This chart is for recording pressures and flows in miscellaneous applications. The pressure and flow values used on the chart are dependent upon the particular test; fill in values as necessary (refer to test instructions). Observe flow meter readings. Plot the pressure and flow rates on the chart below.



Test Conditions

Ambient temperature: _____ °F

Hydraulic tank fluid temperature: _____ °F

Suction (inlet) vacuum at full flow: _____ in/Hg

Engine (pump) speed at “no-load” condition: _____ rpm

Engine (pump) speed at “full-load” condition: _____ rpm

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Section 20-9: Torque Tables

DYNAMIC VS. STATIC TORQUE

The following charts often list values for dynamic and static torque.

The **dynamic** value is used when assembling the fittings. Whenever possible use a torque wrench to achieve the dynamic torque value given in the chart.

The **static** torque value is used to ensure an assembled fitting is correctly torqued. Set the torque wrench for the value and attempt to loosen the fitting. It should not loosen before the static torque value is reached.

Flats After Finger Tight

Some charts also list a “Flats after Finger Tight” value. If no torque wrench is available, you can tighten the fitting as tightly as possible bare-handed, then use a wrench to turn it the additional numbers of flats given. Each flat equals 1/6 of a full revolution of the nut.

NOTE: If at all possible, use a torque wrench to ensure proper torque. The “Flats...” method is intended only as a short-term fix to get the machine running. Later, return with a torque wrench and check the static torque of the fitting to ensure it is secure.

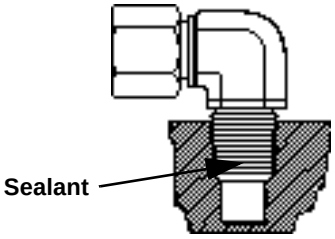
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PIPE THREAD FITTINGS

Pipe thread fittings may be either straight or tapered, and coarse thread or fine thread. The critical factors for a pipe thread fitting are:

- its ability to seal
- its ability to be disassembled again, after the sealant has set



CAUTION: Increasing torque may improve sealing ability up to a point, but too much torque will damage threads and ruin the fittings.

The chart is for use with tapered pipe thread fittings, both fine thread (NPTF) and coarse thread (NPT) where both the male and female fittings are tapered and both are made of ferrous metals.

NOTE: Sometimes, commonly with grease fittings, a straight thread fitting will be joined to a tapered thread fitting. In these cases, use only 50% of the torque value given in this chart.

NOTE: In addition, for non-ferrous fittings, use only 50% of the torque value given in this chart.

Make sure the threads are free from nicks, burrs, dirt or damage.

IMPORTANT: Use a thread sealant such as Loctite Vibraseal, not pipe dope or Teflon tape. Teflon tape can plug filters, drain orifices or ports and cause hydraulic system failures.

Size inch	Thread per in.	Torque with sealant		Torque w/o sealant	
		ft-lb	Nm	ft-lb	Nm
1/16	27	7	10	7	10
1/8	27	12	16	12	16
1/4	18	15	20	18	25
3/8	18	26	35	33	45
1/2	14	33	45	44	60
3/4	14	44	60	55	75
1	11.5	55	75	66	90
1-1/4	11.5	70	95	81	110
1-1/2	11.5	81	110	96	130
2	11.5	96	130	118	160

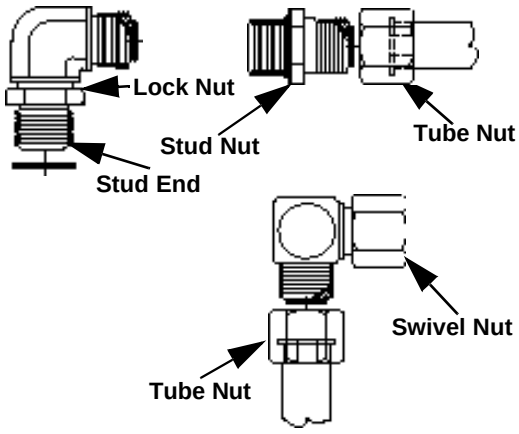
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FACE SEAL FITTINGS WITH O-RINGS

O-ring fittings are not tapered.

Lubricate the O-ring with a light coat of oil and torque to the value given in this chart (unless a different torque value is given in the text for the procedure).

Values are given for both ends of the fitting.



Tube OD or Hose ID			Face Seal Tube or Hose End of Fitting							
mm	Dash size	inch	Thread Dia	Threads per inch	Tube Nut or Swivel Nut Torque					
					Min		Target		Max	
					ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
6	-4	1/4	9/16	18	10	13	12	16	14	19
10	-6	3/8	11/16	16	14	19	18	24	21	29
12	-8	1/2	13/16	16	30	40	37	50	44	60
16	-10	5/8	1	14	41	55	50	69	61	83
22	-14	7/8	1-3/16	12	61	82	75	102	89	122
25	-16	1	1-7/16	12	84	114	105	142	125	170
32	-20	1-1/4	1-11/16	12	112	152	140	190	168	228
38	-24	1-1/2	2	12	129	174	160	217	191	260

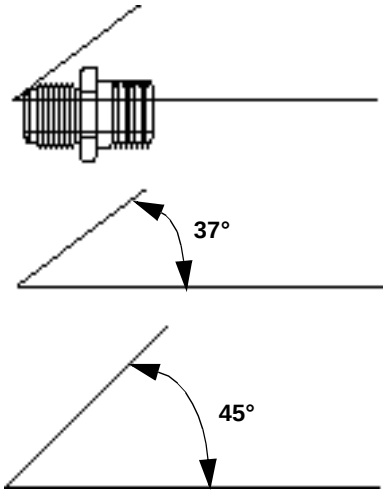
Tube OD or Hose ID			O-Ring End of Fitting							
mm	Dash size	inch	Thread Dia	Threads per inch	Straight Fitting or Lock Nut Torque					
					Min		Target		Max	
					ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
5	-3	3/16	3/8	24	5	6	6	8	7	10
6	-4	1/4	7/16	20	8	10	9	12	10	14
8	-5	5/16	1/2	20	10	13	12	16	14	19
10	-6	3/8	9/16	18	14	19	15	21	18	24
12	-8	1/2	3/4	16	28	37	34	46	40	55
16	-10	5/8	7/8	14	37	50	46	62	54	74
22	-14	7/8	1-3/16	24	73	98	90	122	107	146
25	-16	1	1-5/16	12	84	114	105	142	125	170
32	-20	1-1/4	1-5/8	12	112	152	140	190	168	228
38	-24	1-1/2	1-7/8	12	129	174	160	217	191	260

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FLARE FITTINGS

There are two flare fittings that may be used and the torque values for them are different. The fittings have the angle of the mating face of the male fitting at either 45° or 37° to the internal bore of the fitting.



These are metal to metal fittings that rely on the convex surface on the male fitting nesting tightly to, and slightly expanding the concave surface in the female fitting.

Both the male and female fittings must have the same angle (37° or 45°).

The 37° fittings are used in hydraulic systems and made of steel to withstand those pressures.

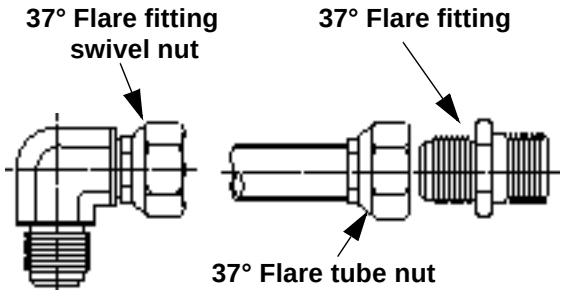
The 45° fittings are usually made of brass and are used in systems with much lower pressures, such as brake lines.

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37° Flare JIC Tube Nuts and Swivel Nuts

Check that the threads and sealing surfaces of both fittings are clean and free of nicks before applying any thread sealant.

The female fitting (nut) expands slightly when tightened to form a seal against the 37° flared surface on the male fitting.



NOTE: Overtightening the fitting may deform or break the female side of the fitting, restricting oil flow or causing a leak.

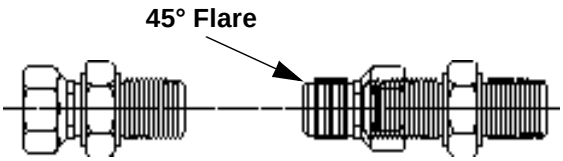
Tube OD			Threads		Dynamic Torque						Static Torque		Flats after finger tight	
					Min		Target		Max					
mm	Dash size	inch	Dia	# per inch	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	New nut	Used Nut
3	-2	1/8	5/16	24	3	4	4	5	4	6	2	3		
5	-3	3/16	3/8	24	7	11	8	11	9	13	6	8		
6	-4	1/4	7/16	20	9	12	12	16	14	20	9	11	2	1
8	-5	5/16	1/2	20	12	15	15	20	18	25	10	14	2	1
10	-6	3/8	9/16	18	15	20	18	25	22	30	14	18	2	1
12	-8	1/2	3/4	16	32	43	37	50	42	57	28	38	1.5	1
16	-10	5/8	7/8	14	43	58	48	65	53	72	39	52	1.5	.75
19	-12	3/4	1-1/16	12	67	90	74	100	81	110	59	80	1.5	.75
22	-14	7/8	1-3/16	12	82	110	88	120	95	130	73	99	2	1.25
25	-16	1	1-5/16	12	89	120	100	135	103	140	82	110	1.5	1
32	-20	1-1/4	1-5/8	12	122	165	133	180	144	195	111	150	1.5	1
38	-24	1-1/2	1-7/8	12	155	210	166	225	177	240	140	190	1.5	1
51	-32	2	2-1/2	12	214	290	234	320	243	330	192	260	1.5	1

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45° Flare Fittings

Check that the threads and sealing surfaces of both fittings are clean and free of nicks before applying any thread sealant.



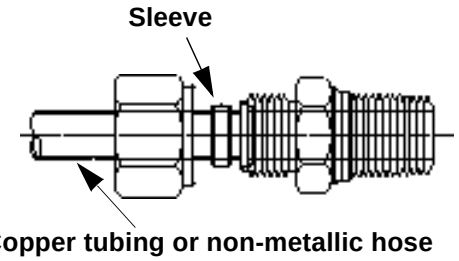
The female fitting (nut) expands slightly when tightened to form a seal against the 45° flared surface on the male fitting.

Tube OD			Threads		Dynamic Torque						Static Torque	
					Min		Target		Max			
mm	Dash size	inch	Dia	# per inch	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
3	-2	1/8	5/16	24	3	4	4	5	5	7	3	3
5	-3	3/16	3/8	24	6	7	6	8	7	10	5	6
6	-4	1/4	7/16	20	7	9	8	11	9	13	6	8
8	-5	5/16	1/2	20	11	14	13	17	14	20	10	13
10	-6	3/8	5/8	18	20	27	22	30	24	33	19	25
11	-7	7/16	11/16	16	20	27	22	30	24	33	19	25
12	-8	1/2	3/4	16	25	34	28	38	30	42	23	30
16	-10	5/8	7/8	14	34	45	37	50	40	55	30	40
19	-12	3/4	1-1/16	12	61	82	66	90	72	98	56	75
22	-14	7/8	1-1/4	12	67	90	74	100	81	110	59	80

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AIR BRAKE FITTINGS

These fittings seal by compressing a small, soft metal sleeve (encircling the air line) between the female (nut) and male parts of the fitting. Inspect the sleeve, as well as the threads for foreign matter and nicks.



Air brake lines may be hoses or copper tubing. The torque values are the same for both types of line.

The different columns for a new or used fitting refer to the female fitting (nut). (Note that the numbers of flats are different between copper and non-metallic tubing.)

Tube OD			Dynamic Torque						Static Torque		Flats after finger tight	
			Min		Target		Max					
mm	Dash size	inch	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	Non-metallic Line	Copper Tubing
6	-4	1/4	6	8	8	11	10	14	4	5	3	2
10	-6	3/8	13	17	15	20	16	23	9	11	4	2
12	-8	1/2	22	29	26	35	30	41	14	19	4	2
16	-10	5/8	25	34	29	40	33	46	17	22	3.5	3
19	-12	3/4	33	44	37	50	41	56	22	29	3.5	3

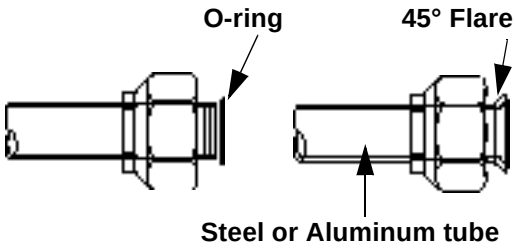
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AIR CONDITIONING FITTINGS

Some fittings employ an O-ring seal, others use a 45° flare for a metal-to-metal seal.

The 45° flare fittings may be used on steel tubing or aluminum tubing. There are different torque settings for O-ring vs. 45° flare and steel vs. aluminum tubing.



O-Ring Fittings

Threads		Dynamic Torque						Static Torque	
inch	per inch	Min		Target		Max			
		ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
5/8	18	8	10	10	14	13	18	8	10
3/4	16	17	23	20	27	22	31	15	26
7/8	14	27	36	29	40	32	44	23	31
1	14	27	36	29	40	32	44	23	31
1-1/16	14	30	40	33	45	36	44	27	31

45° Flare Fittings in Steel Tubes

Threads		Dynamic Torque						Static Torque	
inch	per inch	Min		Target		Max			
		ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
5/8	18	20	27	22	30	24	33	18	24
3/4	16	35	47	38	52	42	57	31	42
7/8	14	39	53	44	60	49	67	37	49
1	14	39	53	44	60	49	67	37	49
1-1/16	14	50	67	55	75	61	83	43	60

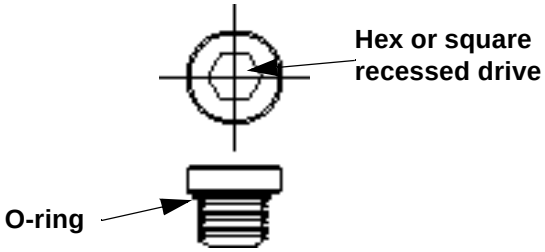
45° Flare Fittings in Aluminum Tubes

Threads		Dynamic Torque						Static Torque	
inch	per inch	Min		Target		Max			
		ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
5/8	18	15	20	17	23	19	26	14	18
3/4	16	22	29	24	33	27	37	20	26
7/8	14	25	34	28	38	30	42	23	30
1	14	25	34	28	38	30	42	23	30
1-1/16	14	34	45	37	50	40	55	30	40

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O-Ring Boss Plug

Use 50% of the given torque value when either the plug or the port is non-ferrous.



Tube OD			Threads		Dynamic Torque						Static Torque	
					Min		Target		Max			
mm	Dash size	inch	Dia	per inch	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
3	-2	1/8	5/16	24	3	4	4	5	4	6	2	3
5	-3	3/16	3/8	24	7	11	8	11	9	13	6	8
6	-4	1/4	7/16	20	9	12	12	16	14	20	9	11
8	-5	5/16	1/2	20	12	15	15	20	18	25	10	14
10	-6	3/8	9/16	18	15	20	18	25	22	30	14	18
12	-8	1/2	3/4	16	32	43	37	50	42	57	28	38
16	-10	5/8	7/8	14	43	58	48	65	53	72	39	52
19	-12	3/4	1-1/16	12	67	90	74	100	81	110	59	80
22	-14	7/8	1-3/16	12	82	110	88	120	95	130	73	99
25	-16	1	1-5/16	12	89	120	100	135	103	140	82	110
32	-20	1-1/4	1-5/8	12	122	165	133	180	144	195	111	150
38	-24	1-1/2	1-7/8	12	155	210	166	225	177	240	140	190
51	-32	2	2-1/2	12	214	290	234	320	243	330	192	260

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DRAIN PLUGS

Use 50% of the given torque value when either the plug or the port is non-ferrous.



Type A | Type B | Type C | Type D conical seal - no gasket

Type	Tube OD			Threads		Dynamic Torque						Static Torque	
	mm	Dash size	Inch	Dia inch	per inch	Min		Target		Max			
						ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
D	8	-5	3/16	1/2	20	6	7	8	11	11	15	6	7
A				1/2	30	11	15	15	20	18	25	11	14
A	10	-6	3/8	5/8	11	23	30	26	35	29	40	20	27
A				3/4	12	34	45	37	50	40	55	28	38
A	12	-8	1/2	3/4	16	34	45	37	50	40	55	28	38
D	16	-10	5/8	7/8	14	36	48	41	55	45	62	31	42
A	16	-10	5/8	7/8	14	41	55	52	70	62	85	37	50
A				1-1/8	12	41	55	52	70	62	85	37	50
C				1-1/8	12	41	55	52	70	62	85	37	50
D				1-3/8	12	56	75	66	90	77	105	52	70
D				1-1/2	12	70	95	81	110	92	125	59	80
B				1-1/2	12	56	75	66	90	77	105	52	70
B	38	-24	1-1/2	2	12	82	110	92	125	103	140	67	90

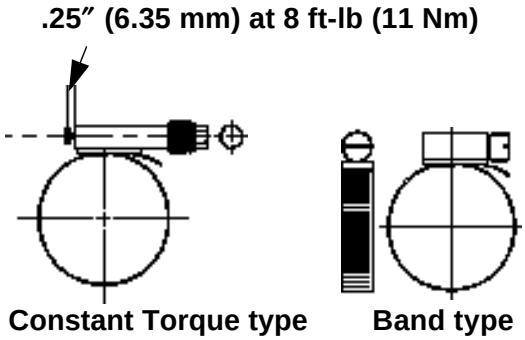
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HOSE CLAMPS

Constant Torque Hose Clamp

There is no chart needed for this clamp. It is correctly torqued when the Belleville washers are compressed nearly flat and the tip of the screw extends 1/4″ (6.35 mm) from the housing.



Band Type Hose Clamp

The hose will compress under the clamp. The compressed portion will not fully expand if the clamp is removed. Thus, different torque values apply for reinstalling a clamp on an existing hose than for installing a clamp on a new hose.

Wait one hour or more after the clamp is installed before checking the static torque to allow the hose to compress and the clamp to stretch.

Band Type Hose Clamps

Band width		Dynamic Torque on New Hose						Static Torque	
		Min		Target		Max			
mm	inch	in-lb	Nm	in-lb	Nm	in-lb	Nm	in-lb	Nm
16	5/8	70	7	66	7.5	70	8	36	4
14	17/32	36	4	40	4.5	44	5	18	2
8	5/16	6	0.7	8	0.9	9	1.1	5	0.5

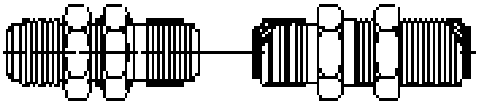
		Dynamic Torque on Used Hose					
		Min		Target		Max	
		in-lb	Nm	in-lb	Nm	in-lb	Nm
16	5/8	36	4	40	4.5	44	5
14	17/32	22	2.5	27	3	30	3.5
8	5/16	5	0.5	6	0.7	7	0.9

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BULKHEAD NUT

Use 50% of the given torque value when either the plug or the port is non-ferrous.



Tube OD			Threads		Dynamic Torque						Static Torque	
					Min		Target		Max			
mm	Dash size	inch	Dia	per inch	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
6	-4	1/4	9/16	18	4	5	5	7	6	9	3	3.5
10	-6	3/8	11/16	16	9	11	10	13	11	15	6	7
12	-8	1/2	13/16	16	16	21	17	23	18	25	10	13
16	-10	5/8	1	14	23	30	24	33	26	36	14	19
22	-14	7/8	1-3/16	12	30	40	33	45	36	50	19	25
25	-16	1	1-7/16	12	43	60	48	65	51	70	29	40
32	-20	1-1/4	1-11/16	12	59	80	64	87	69	94	37	50
38	-24	1-1/2	2	12	70	95	77	105	84	115	45	60

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SAE Grade 2, Grade 5 and Grade 8 Cap Screws and Bolts

Torque values specified in text take precedence over values shown below. These values do not apply when used with lock nuts.

	Grade 2 		Grade 5 		Grade 8 	
Bolt Size	**ft-lb**	**Nm**	**ft-lb**	**Nm**	**ft-lb**	**Nm**
1/4 - 20 NC	4	5	6	8.5	10	13
1/4 - 28 NF	5	6	8	11	11	15
5/16 - 18 NC	9	12	13	18	20	27
5/16 - 24 NF	10	13	15	20.5	22	29.5
3/8 - 16 NC	16	22	25	35	35	47
3/8 - 24 NF	18	24	30	40	40	55
7/16 - 14 NC	25	35	40	55	55	75
7/16 - 20 NF	30	40	45	60	65	88
1/2 - 13 NC	40	55	60	80	90	120
1/2 - 20 NF	45	60	70	95	95	130
9/16 - 12 NC	55	75	90	120	120	165
9/16 - 18 NF	60	80	95	130	135	185
5/8 - 11 NC	75	100	120	165	180	245
5/8 - 18 NF	80	110	145	200	195	265
3/4 - 10 NC	130	175	210	285	300	405
3/4 - 16 NF	145	200	240	325	340	460
7/8 - 9 NC	150	205	320	435	500	680
7/8 - 14 NF	170	230	350	475	560	760
1 - 8 NC	180	245	480	650	800	1085
1 - 12 NF	200	270	560	760	920	1250
1 1/8 - 7 NC	240	325	700	950	1180	1600
1 1/8 - 12 NF	275	375	780	1060	1340	1815
1 1/4 - 7 NC	340	460	1020	1385	1720	2330
1 1/4 - 12 NF	370	500	1140	1545	1900	2575
1 3/8 - 6 NC	460	625	1360	1845	2280	3090
1 3/8 - 12 NF	540	730	1580	2140	2620	3550
1 1/2 - 6 NC	640	870	1840	2495	3060	4150
1 1/2 - 12 NF	740	1000	2100	2850	3460	4690

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METRIC GRADE 5.8, 6.9, 8.8, 10.9 & 12.9 CAP SCREWS AND BOLTS

	Grade 5.8 		Grade 6.9 		Grade 8.8 		Grade 10.9 		Grade 12.9 	
Bolt Size	**ft-lb**	**Nm**	**ft-lb**	**Nm**	**ft-lb**	**Nm**	**ft-lb**	**Nm**	**ft-lb**	**Nm**
M4	1.1	1.5	1.7	2.3	2	2.7	2.9	4	3.6	5
M5	2.3	3.1	3.5	4.7	4	5.4	6	8	7	9.5
M6	3.9	5.3	5.8	7.8	7	9.5	10	13.5	11	15
M7	6.5	8.8	9.4	12.7	11	15	16	22	20	27
M8	10	13.5	14	19	18	24	25	34	29	39
M10	20	27	29	39	32	43	47	64	58	79
M12	34	46	50	68	58	79	83	112.5	100	136
M14	54	73	79	107	94	127	133	180	159	216
M16	80	108.5	122	165	144	195	196	266	235	319
M18	114	155	170	230.5	190	258	269	365	323	438
M20	162	220	220	298	260	353	366	496	440	597
M22	202	274	318	431	368	499	520	705	628	852
M24	245	332	410	556	470	637	664	900	794	1077
M27	360	488	606	822	707	959	996	1351	1205	1634
M30	500	678	815	1105	967	1311	1357	1840	1630	2210

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GRADE B, C, F AND G LOCK NUTS

	Grade B (Grade 5) 		Grade C (Grade 8) 		Grade F (Grade 5 Flange) 		Grade G (Grade 8 Flange) 	
Nut Size	**ft-lb**	**Nm**	**ft-lb**	**Nm**	**ft-lb**	**Nm**	**ft-lb**	**Nm**
1/4 20 NC	7.5 - 10	10 - 13	10 - 14	14 - 19	8 - 10	11 - 14	12 - 16	16 - 21.5
1/4 28 NF	8 - 10	11 - 14	10 - 14	14 - 9	9 - 12	12 - 16	12 - 17	16 - 23
5/16 18 NC	14 - 17.5	19 - 24	17.5-22.5	24 - 30.5	15 - 20	20 - 27	19.5 - 27	27 -36
5/16 24 NF	15 - 18	20 - 25	18 - 23	25 - 32	16 - 22	21.5 - 29	19.5 - 26	27 - 35
3/8 16 NC	21 - 27	28.5 - 37	29 - 37	39 - 50	22.5-32.5	30.5 - 44	30 - 41	41 - 56
3/8 24 NF	27.5 - 38	37 - 51.5	22.5 - 31	30.5 - 42	23.5-31.5	32 - 43	31 - 42	42 - 57
7/16 14 NC	31 - 40	42 - 54	39 - 53	53 - 72	36 - 50	49 - 68	45 - 62	61 - 84
7/16 20 NF	39 - 51	53 - 69	41 - 56	56 - 76	38 - 53	51.5 - 72	51 - 71	69 - 96
1/2 13 NC	49.5-62.5	67 - 85	62 - 79.5	84 - 108	50.5-69.5	68.5 - 94	72 - 102	98 - 132
1/2 20 NF	50 - 65	68 - 88	67 - 87	91 - 118	56.5-78.5	77 - 106	67 - 106	91 - 144
9/16 12 NC	67 - 87	91 - 118	95 - 120	129 - 163	72 - 102	98 - 132	105 - 145	142 - 197
9/16 18 NF	74.5-94.5	101 - 128	95 - 120	129 - 163	79 - 111	107-150.5	113 - 157	153 - 213
5/8 11 NC	95 - 120	129 - 163	125-157.5	169.5-214	100 - 137	136 - 186	130 - 178	176 - 241
5/8 18 NF	97.5-122.5	132 - 166	125 - 160	169.5-217	105 - 145	142 - 197	150 - 120	203 - 285
3/4 10 NC	160 - 200	217 - 271	200 - 255	271 - 346	170 - 230	230.5-312	205 - 285	278-386.5
3/4 16 NF	155 - 200	210 - 271	200 - 255	271 - 346	163 - 227	221 - 308	215 - 315	291.5-427
7/8 9 NC	235 - 300	319 - 407	295-382.5	400 - 519				
7/8 14 NF	250 - 320	339 - 434	295-382.5	400 - 519				
1 8 NC	345 - 445	468 - 603	450-512.5	610 - 695				
1 12 NF	370 - 470	502 - 637	452.5-590	617 - 800				

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Section 30-0: Engine System

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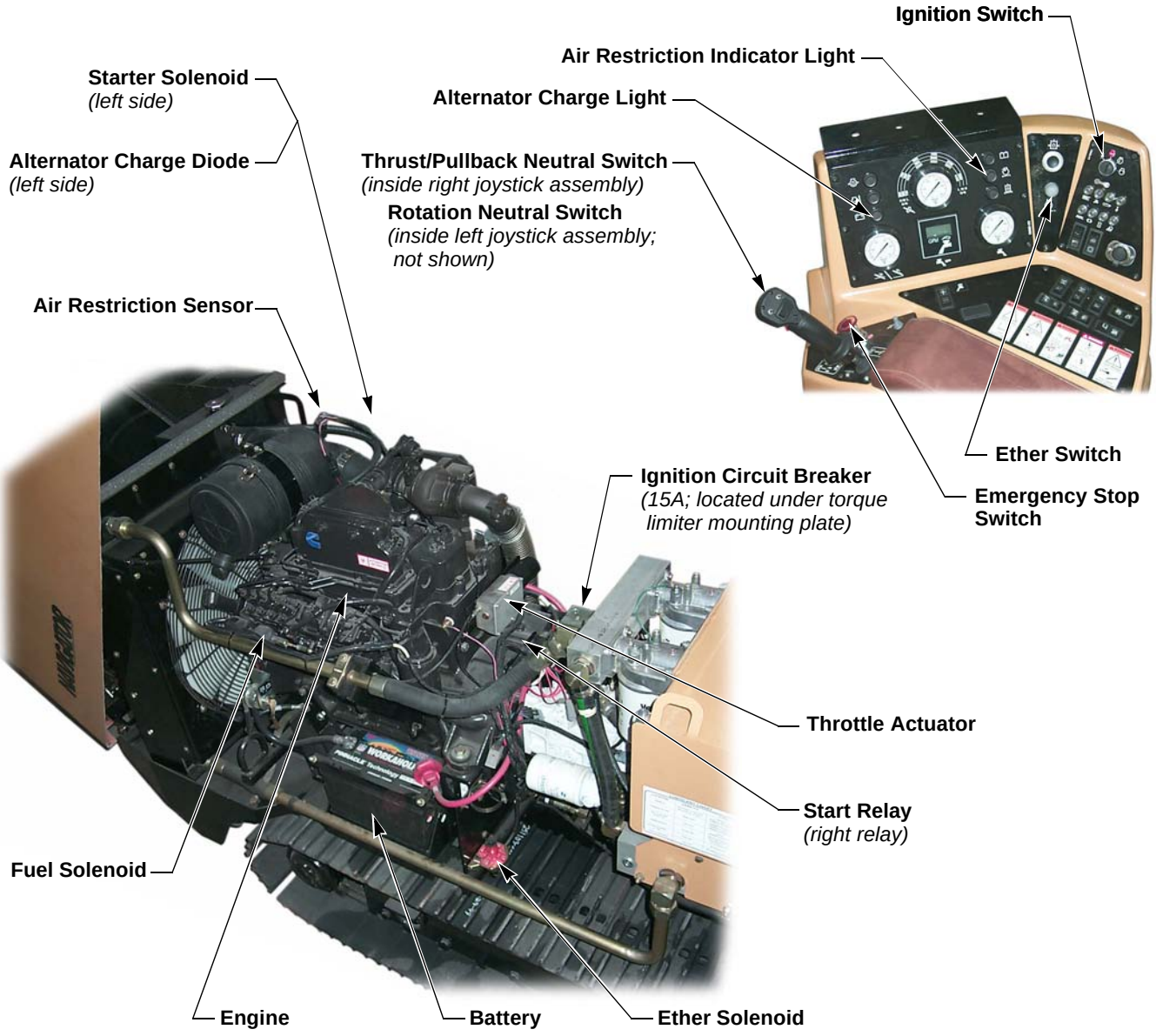
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Section 30-1: Engine System Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Engine System table of contents (will direct you to system and component information)	30-0-1
Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Throttle Solenoid Calibration	30-3-1

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OPERATION OVERVIEW

Air Restriction Indicator

The D33x44 uses an electric air restriction indicator which signals the need to replace the air cleaner through a warning light at the operator console.

Fuel Solenoid

The fuel solenoid uses a “pull-in” winding energized by the starter relay. The “hold-in” winding is energized by the ignition key through the emergency stop switch.

Throttle Actuator

The throttle actuator controls engine speed. Switches located at both control stations provide “bump-up/bump-down” control by varying the position of the control linkage inside the actuator.

Neutral Start

Neutral start functions are controlled by switches in the joystick controllers. Both rotation and thrust/pullback functions must be in NEUTRAL for the machine to start.

SYSTEM SPECIFICATIONS

Specification	Value
Engine	
make / model	Cummins 4BTA3.9-C125
governed engine RPM	2200 rpm
maximum horsepower	125 hp (93.25 kW) at 2200 rpm
minimum operating temperature	160°F (71°C)
normal operating range	180-200°F (82-93°C)
thermostat temperature	180°F (82°C)
maximum operating temperature	212°F (100°C)
maximum engine inclination	30° all directions

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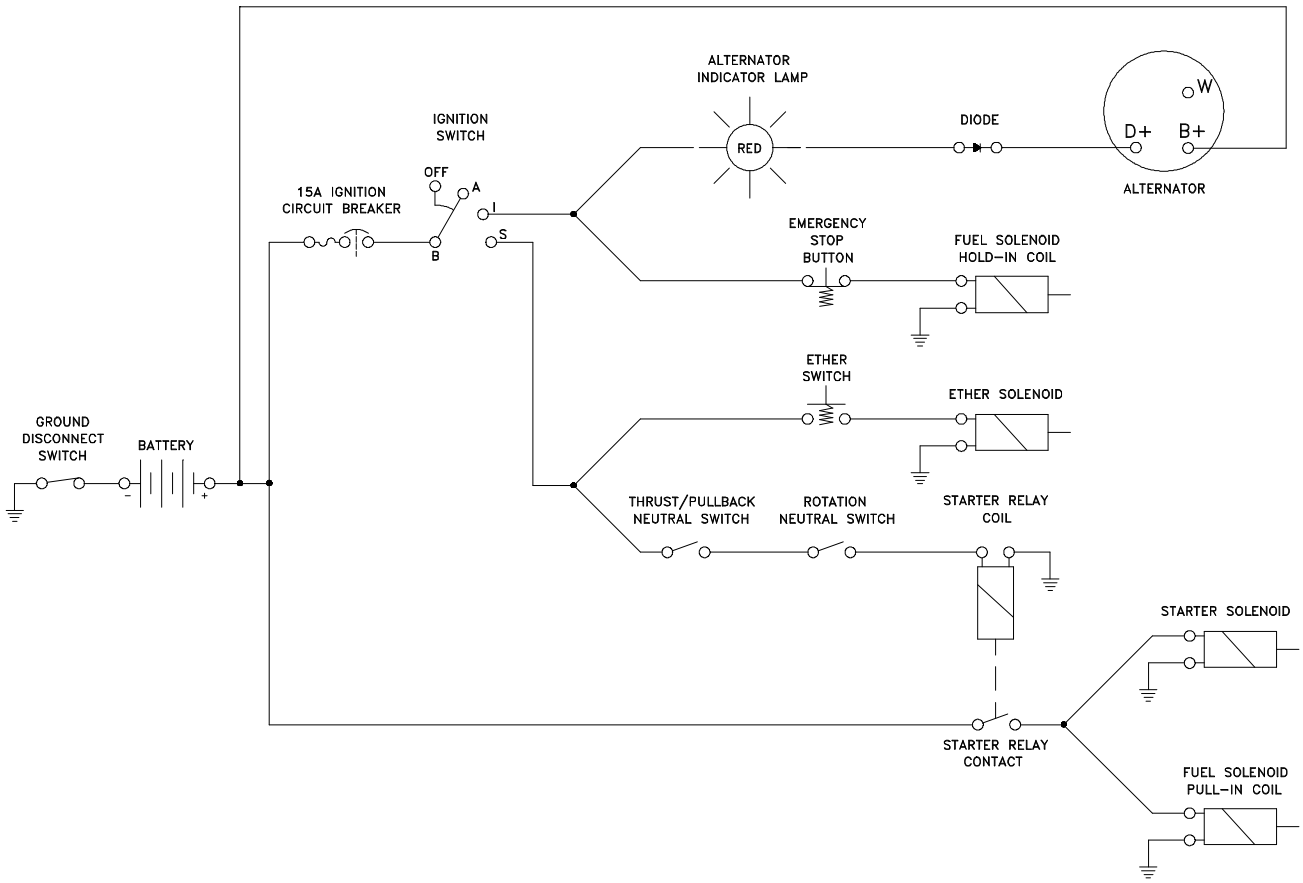
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Specification	Value
Battery	
required	1
BCI group size	31
cold cranking amps (CCA)	950 cold cranking amps, 30 seconds, 0°F (-18°C)
reserve capacity	185 minutes, 25-amp output at 80°F (27°C)
length	13" (33 cm)
width	6-3/4" (17 cm)
height	9-3/8" (24 cm)
Cooling System	
coolant	mixture of 50% water and 50% ethylene glycol base antifreeze to -34°F (-37°C) protection
engine coolant capacity	11.0 gal (42 L)
Fuel System	
make	Bosch
fuel tank capacity	29 gal (110 L)
Lubrication System	
oil capacity	with filter: 11.5 qt (10.9 L) without filter:10.0 qt (9.5 L)
engine oil	Refer to the engine manual supplied with each machine.
Electrical System	
system voltage/alternator	12-volt, 63-amp

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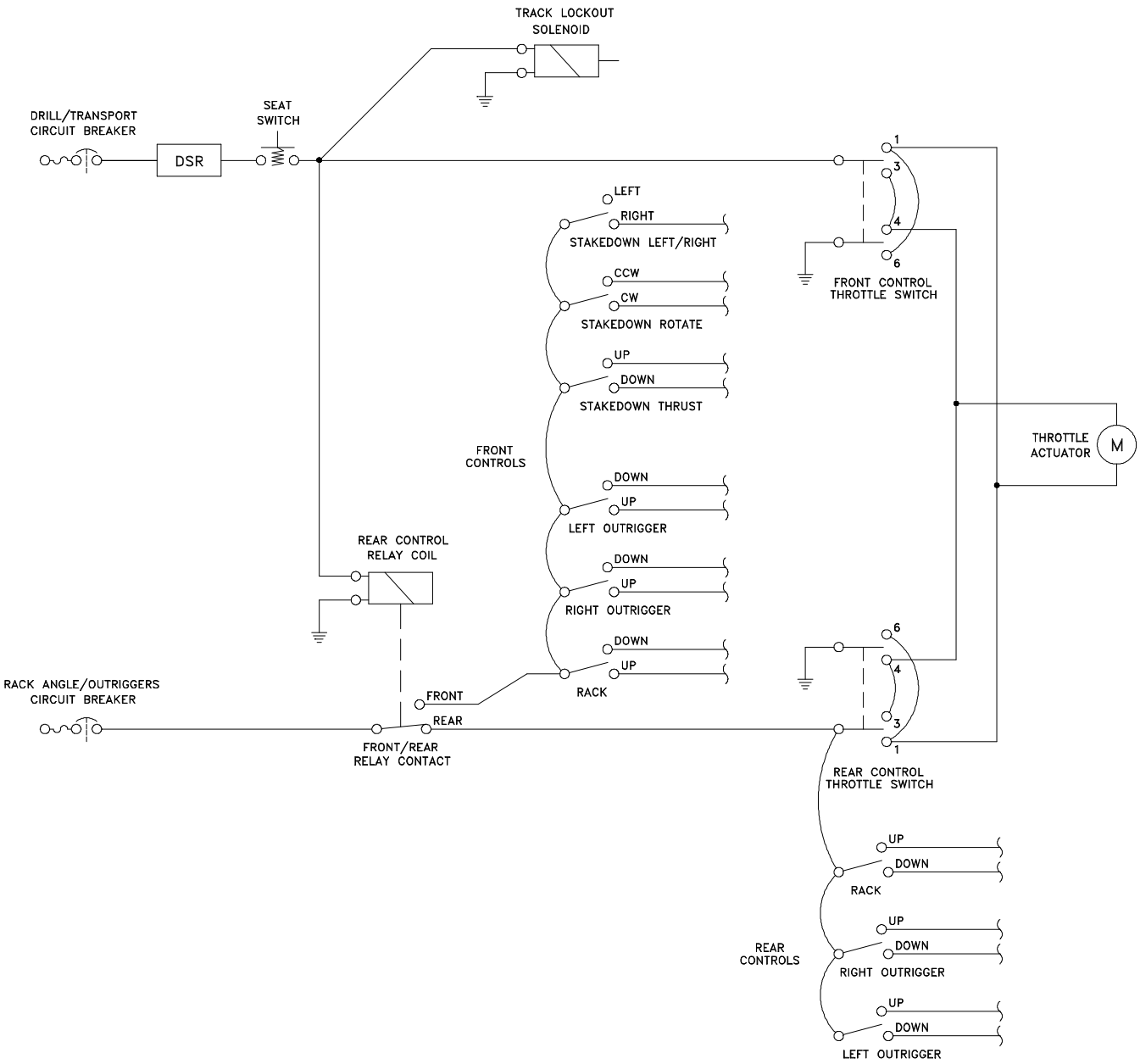
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STARTING/CHARGING ELECTRICAL DIAGRAM



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THROTTLE ACTUATOR ELECTRICAL DIAGRAM



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Section 30-2: Engine System Troubleshooting

How To Do Troubleshooting

Introduction

NOTE: While the engine warranty is in effect, only an authorized Cummins Service Facitity may work on the engine (including the engine wire harness). Unauthorized service on the engine will void the warranty. Before performing any maintenance procedures on the engine, consult the *Cummins Engine Operation and Maintenance Manual* for safety guidelines and instructions.

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***

Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the electrical overall schematic and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking Out Controls and Mechanical Systems

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental questions:

1. ***Is the power source (battery and 15A ignition circuit breaker) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** The ignition switch, the thrust/pullback neutral switch, and the rotation neutral switch must all be closed to operate the starter relay, the starter solenoid, and the fuel solenoid pull-in windingin order for the engine to start . The ignition switch and the emergency stop button switch must be closed to operate the fuel solenoid hold-in winding in order for the engine to continue running.
5. ***Are all electrical actuators OK?*** The fuel solenoid has a pull-in and a hold-in winding. The starter relay must operate and make electrical contact. The starter solenoid and starter must operate correctly.
6. ***Are the mechanical components OK?*** Even if all electrical functions are OK, engine mechanical or fuel system problems may prevent the engine from starting or turning over. Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners

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SYMPTOM: ENGINE DOES NOT TURN OVER

1. Is the starting circuit working correctly? If the starter motor circuit or the neutral start circuit does not deliver current correctly, the engine will not turn over.

Possible Problem	Possible Effect	What to do
Battery disconnected, discharged, or defective	If the battery cannot deliver sufficient current at the correct voltage, the engine will not turn over.	**Check the battery disconnect.** Check battery state of charge and load capacity.
Ground path not OK	If the ground path is missing, is too resistive, or the voltage drop is more than 0.5 V, all electrical operation can be affected.	**Check all grounding locations.** Check ground voltage drop between the ground buss and battery negative terminal under no-load and loaded conditions. Repair any condition causing high ground voltage drop in either condition.
Ignition circuit breaker or switch not delivering voltage	The ignition switch must deliver voltage to the neutral switches to energize the start relay coil.	**Check that voltage is being provided to the start relay coil.**
Thrust and rotation neutral switches defective or out of neutral	Both neutral switches must be closed for the engine to turn over.	**Check neutral switch operation.**
Start relay defective	The start relay must connect battery voltage to the starter solenoid and the fuel solenoid pull-in coil. If the relay does not operate, is wired incorrectly, is not grounded, or if the contacts are not OK, the solenoids may not operate.	**Check that the start relay** is operating and that voltage is being applied to both the starter solenoid and the fuel solenoid.
Current path interrupted or too much resistance	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path.** Inspect visually or use an ohmmeter or voltmeter.
Starter solenoid or starter defective	If the starter solenoid or starter are defective, the engine may not turn over.	**Check solenoid and starter operation.**

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2. Is there a mechanical problem? Mechanical components that are broken, worn, misadjusted, or otherwise out of tolerance will cause faulty operation.

Possible Problem	Possible Effect	What to do
Hydraulic pump or engine mechanical problem	An unlikely, but possible condition is a “locked pump” or engine mechanical condition that prevents the engine from turning.	After verifying all other systems and components are OK, **check for any mechanical condition** that will prevent the engine from turning over such as a locked hydraulic pump, damaged crankshaft, etc.

SYMPTOM: ENGINE TURNS OVER BUT WILL NOT START

1. Are the related systems operating correctly? Fuel supply or battery and charging system problems can prevent the engine from starting.

Possible Problem	Possible Effect	What to do
Fuel problem	If the machine is out of fuel, the fuel filter is plugged, or there is water or other contamination in the fuel, the engine may not start or may run poorly or lack power.	**Check fuel supply.**
Defective battery or not charged	If low battery state-of-charge or other conditions prevent the engine from turning over fast enough, the engine will not start.	**Check cranking speed** with a reliable tachometer; rectify any condition causing cranking speed below 125 rpm (at 10°F (-12° C or above).

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2. Is the control circuit working correctly? If the ignition circuit breaker, ignition switch, or fuel solenoid ground are not OK, the engine may not run.

Possible Problem	Possible Effect	What to do
Ignition circuit breaker not OK	If the ignition circuit breaker does not have power, the engine will not turn over.	**Refer to "Engine Will Not Turn Over"**
Ignition switch malfunction	Current travels to the fuel solenoid hold-in coil from the ignition switch 'I' terminal. If the ignition switch is not OK, the fuel solenoid may not be receiving voltage	**Check that the fuel solenoid hold-in coil** terminal is receiving voltage when the key is ON.
Grounds	If the ground path is missing, is too resistive, or the voltage drop is 0.5V or more, the fuel solenoid may not receive enough current to remain energized.	**Check that the fuel solenoid is grounded.** Check ground voltage between fuel solenoid ground terminal and battery negative terminal at rest and while operating an electrical load. Repair any condition causing high ground voltage either at rest or under load.
Current path	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path.** Inspect visually or use an ohmmeter or voltmeter.
Emergency stop switch malfunction	If the emergency stop switch is pushed in, the fuel solenoid hold-in coil will not be energized. The engine seem to start but stop running when the key is released.	**Check the the emergency stop switch is NOT pushed in.**

3. Is there a mechanical problem? Mechanical components that are broken, worn, misadjusted, or otherwise out of tolerance will cause faulty operation.

Possible Problem	Possible Effect	What to do
Excessive mechanical load	Any condition such as pump malfunction or cold weather, (especially if the battery condition or state-of-charge is poor) that slows down engine cranking speed may prevent the engine from starting. Minimum cranking speed for unaided starting is approximately 125 rpm (at 10°F (-12° C or above).	**Check cranking speed with a reliable tachometer. Rectify any condition causing low cranking speed.**

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SYMPTOM: ENGINE WILL NOT SHUT OFF

1. Is there an abnormal wiring problem?

Possible Problem	Possible Effect	What to do
Alternator diode shorted	Although not likely, a shorted alternator diode could allow sufficient current through the alternator warning light to allow the fuel solenoid hold-in coil to remain energized even while the key is off. This would allow the engine to continue running.	If the engine will not shut off unless the emergency stop switch is pressed, **remove the alternator diode** or disconnect the wire from the D+ terminal at the alternator. If the engine now will shut off normally, the diode is allowing current from the battery to feed through the warning light. Replace the diode.

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SYMPTOM: UNABLE TO CONTROL ENGINE SPEED

1. Is the control circuit working correctly? The engine speed controller can be controlled from the seat if the operator is present (seat switch is closed) or from the rear control station (seat switch is open). Closing the seat switch energizes the rear control relay coil which removes power from the rear control station and applies it to the front throttle and rack controls.

Possible Problem	Possible Effect	What to do
Circuit breaker #3 (rack angle/ outrigger) not powered	If the rack angle/outrigger circuit breaker is tripped or not connected to the battery, engine speed can only be controlled from the operator station, not from the rear control.	**Check circuit breaker status and wiring.**
DSR not providing power to the seat switch.	The DSR requires a minimum of 10.8V to send power to the seat switch. If it does not sense that voltage, engine speed can only be controlled by the rear control.	**Check and correct low voltage condition.**
Grounds faulty	If the ground path is missing, is too resistive, or is not 0.5V or less, all electrical operation can be effected.	**Check that both the front and rear throttle control grounds** (from terminal #5 of each switch) are good. Check ground voltage drop between the ground buss and battery negative terminal under no-load and loaded conditions. Repair any condition causing high ground voltage drop in either condition.
Current path	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path**. Inspect visually or use an ohmmeter or voltmeter.
Throttle control switches defective or wired incorrectly	Both the front and rear throttle controls switch battery voltage and ground between the throttle controller motor wires. If the switches are defective or if the jumpers are not wired correctly, the controls will not work correctly.	**Check throttle control switch operation**.
Rear control relay	The rear control relay receives coil current from the DSR through the seat switch. It receives supply current from the rack angle circuit breaker (#3). If these power sources are not available or if the relay is defective, it may not be possible to control the throttle from the rear station or from either station.	

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2. Is there a mechanical problem? Mechanical components that are broken, worn, misadjusted, or otherwise out of tolerance will cause faulty operation.

Possible Problem	Possible Effect	What to do
Throttle controller defective or misadjusted.	The throttle controller uses a bi-directional motor to move the engine governor control arm. If the external linkage is damaged or the motor or internal mechanism is defective, the throttle controller may not operate correctly.	**Check actuator condition and adjustment** (refer to page **30-3-1**).
Engine throttle linkage damaged or misadjusted		**Check linkage.**

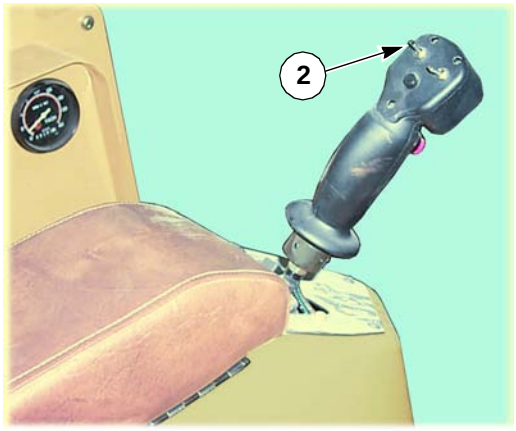
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Section 30-3: Throttle Solenoid Calibration

THROTTLE ACTUATOR





Operation

Throttle solenoid assembly **(1)** controls the range of engine RPM available to the operator. Joystick speed control toggle **(2)** is used to increase or decrease engine speed.

THROTTLE ACTUATOR ADJUSTMENTS

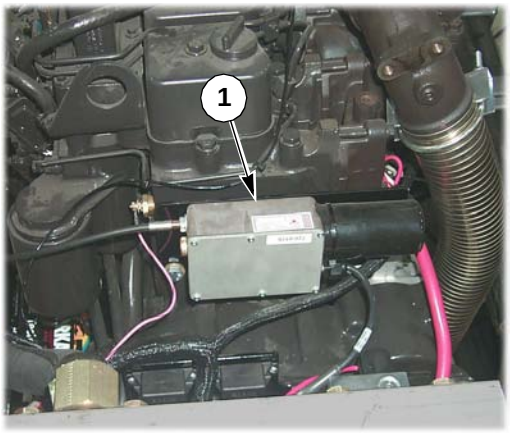
Special Tools and Supplies

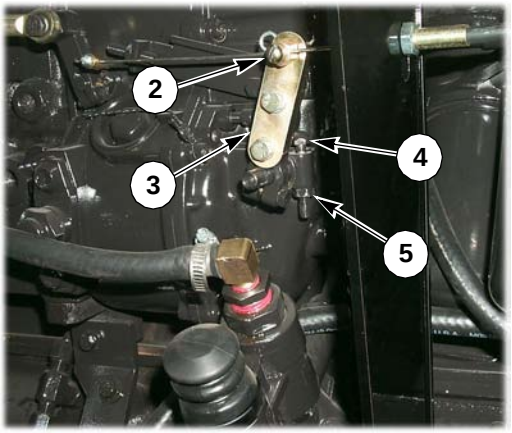
- photo tachometer
- reflective tape

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Engine Low Idle Adjustment





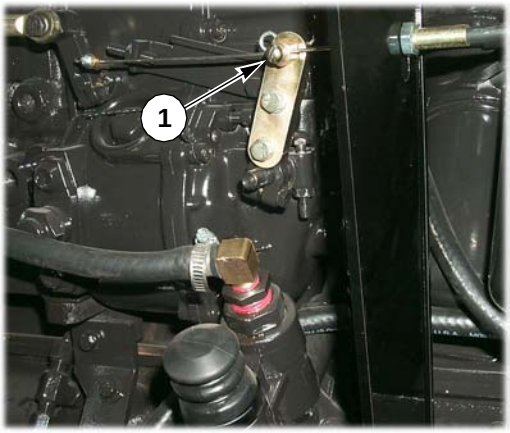
NOTE: The engine low idle speed must be set at 1000-1050 rpm before adjustments to throttle solenoid assembly **(1)**.

1. Loosen screw **(2)** and position lever **(3)** fully against stop screw **(4)**.
2. Place reflective tape on the crankshaft pulley and start the engine. Record the engine RPM using a photo tachometer.
3. Adjust the idle speed as follows:
   - Loosen lock nut **(5)**.
   - Turn screw **(4)** clockwise to decrease idle speed and tighten lock nut **(5)**.
   - Position lever **(3)** fully against stop screw **(4)**.
   - Record engine RPM.
   - Repeat procedure until correct idle speed (1000-1050 rpm) is achieved. Shut off engine.
4. Do not tighten screw **(2)**. Proceed to adjust the throttle actuator.

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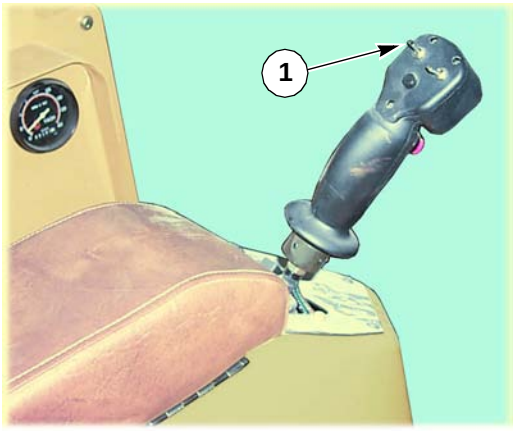
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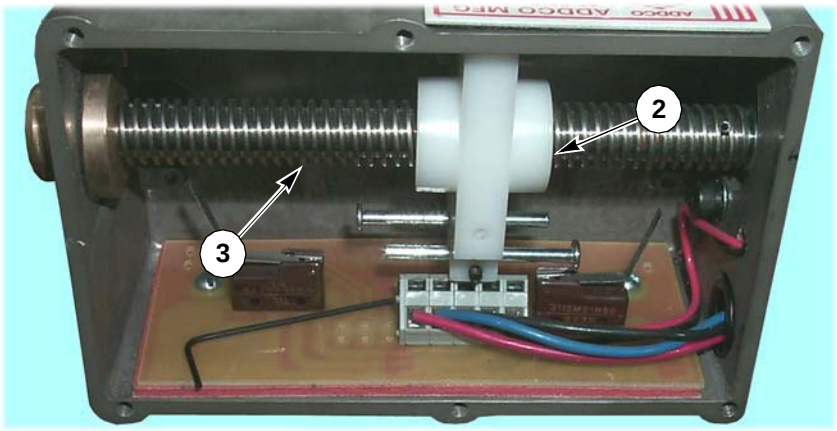
Throttle Actuator Adjustments





1. Verify that screw **(1)** is loosened. Remove cover **(2)** on the throttle solenoid assembly.



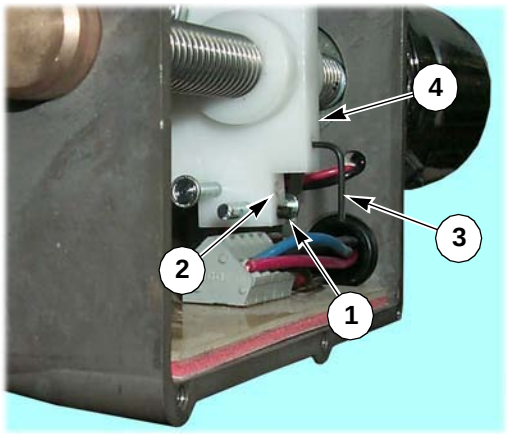


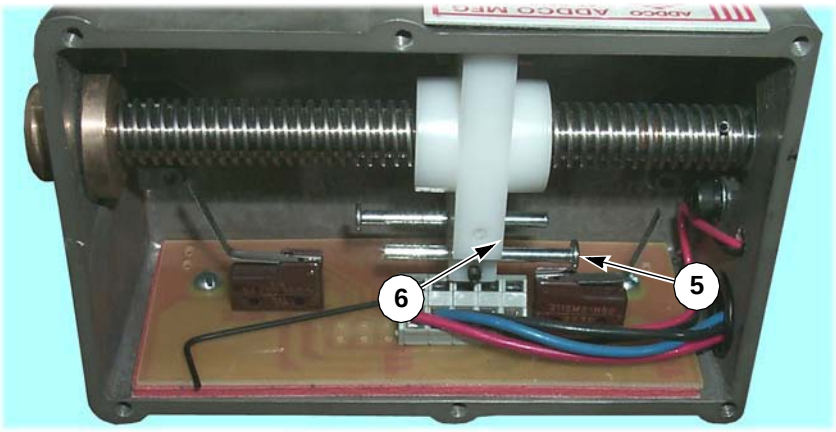
2. Turn the ignition key to the RUN position. Sit in the seat to activate the seat switch. Use joystick speed control toggle **(1)** to center actuator **(2)** on screw **(3)** as shown.

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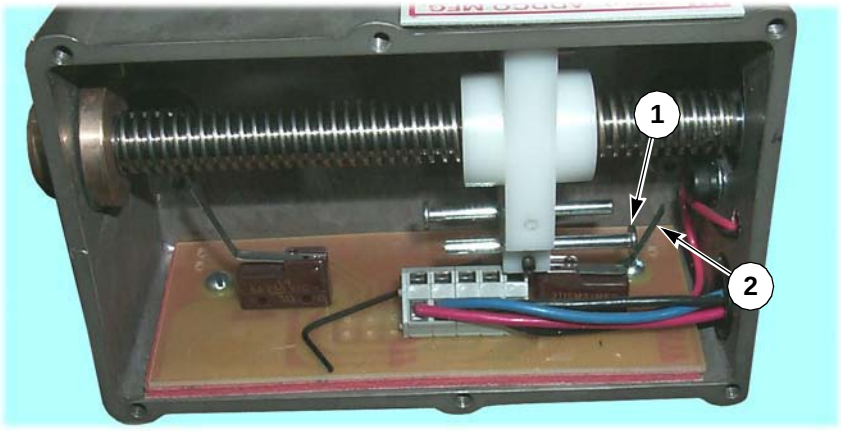
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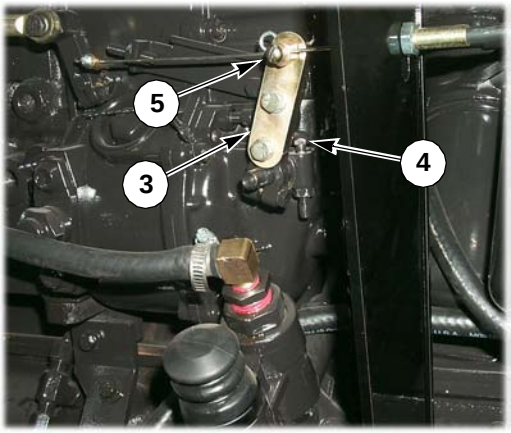
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3. Loosen lock screws **(1)** and **(2)** (recessed in hole), using Allen wrench **(3)** retained in actuator **(4)**. Adjust a preliminary dimension of 3/4" (19 mm) measured from low idle stop head **(5)** to actuator surface **(6)**. Tighten lock screw **(1)**.





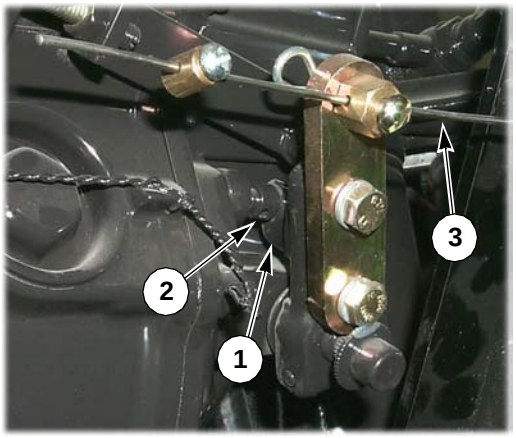
4. Use the joystick speed control toggle and move low idle stop **(1)** against limit switch **(2)** until the switch activates.

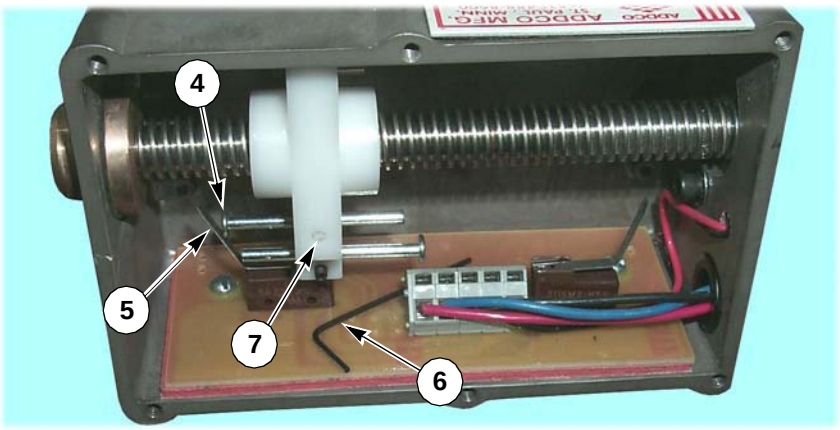
5. Position lever **(3)** fully against stop screw **(4)**, and tighten screw **(5)**.

The operator can now select low engine idle speed, using the joystick speed control toggle.

Continued on next page...

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The fuel pump high idle stop is factory set to 2400-2600 rpm.

6. Use the joystick speed control toggle to move lever stop **(1)** into slight contact with fuel pump high idle stop **(2)**.

NOTE: Control wire **(3)** must not deflect as the lever stop contacts the fuel pump high idle stop.

7. Adjust the length of high idle stop **(4)** against limit switch **(5)** until the switch activates, and tighten the lock screw.

The operator can now select high engine idle speed, using the joystick speed control toggle.

8. Place Allen wrench **(6)** in storage hole **(7)**. Install the cover.

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Section 40-0: Common Hydraulic System

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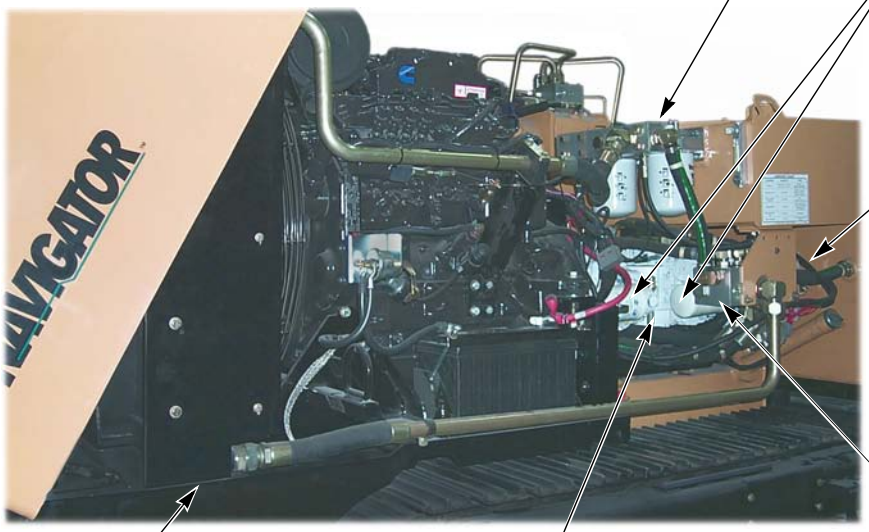
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Section 40-1: Common Hydraulic System Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Hydraulic System table of contents (will direct you to system and component information)	40-0-1
Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Engine	30-0-1
Common Electrical System	50-0-1
Thrust/Pullback Charge Pump	40-5-3

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OPERATION OVERVIEW

Tank and Suction Screen

Oil flows through a single 200 micron mesh suction strainer to the three pump suction lines from the hydraulic oil tank.

Hydraulic Pumps

Three pumps are stacked in-line. The rotation and thrust/pullback pumps are both 90 series Sundstrand hydrostatic pumps. The pressure-flow-compensated (PFC) pump is a Sundstrand 45 series variable displacement open circuit pump. Each pump has a separate suction inlet line. The PFC pump receives its load sense signal either from the transport valve, the water pump proportional valve, or from the load sense solenoid valve which is energized electrically by hydraulic function switches through one of two diode modules.

Return Manifold

Return oil from the two hydrostatic pumps, the rotation gearbox case drain circuit, the transport valve, and the water pump drive motor flows to the return manifold. Three ball-checks direct oil flow either to the cooler, the return filter manifold, or directly to the tank.

Charge Filters

Each hydrostatic pump is protected by a charge filter.

Cooler

The hydraulic cooler is protected by a 60 psi (4.1 bar) bypass valve.

Return Filters and Manifold

Oil from the return manifold, the proportional/dump valve, the PFC pump, rod loader manifold, and the oil cooler flows to the two return filters which are protected by 22 psi (1.5 bar) pressure reliefs.

Load Sensing

The load sensing function can be triggered two ways:
--either by metered oil flow to the pressure/flow compensator from the transport valve or the water proportional valve, or,
--from a full pressure signal from the load sense solenoid. The solenoid is energized through a diode module whenever a electric switch for a hydraulic function is activated.

Diode Modules and 5 second delay

Two diode modules are used to direct current from hydraulic function switches to the load sense solenoid valve in the proportional/dump valve manifold on the PFC pump. This allows an electrical signal to replace the load sense line for each hydraulic function that requires full pump pressure. A 5-second delay module prevents rapid cycling of the load sense solenoid.

Proportional/Dump Valve

All oil from the PFC pump travels through the proportional/dump valve manifold. The **track disable solenoid** allows oil flow to the transport valve when the operator is not in the seat. The **hydraulic enable solenoid** prevents operation of any other function until the hydraulic enable button is pressed. The water pump drive motor receives a controlled oil flow based on operator input acting on a charge pressure pilot signal from the thrust/pullback pump. Internal check valves isolate the load sense functions of the proportional valve and the load sense valve from each other.

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SYSTEM SPECIFICATIONS

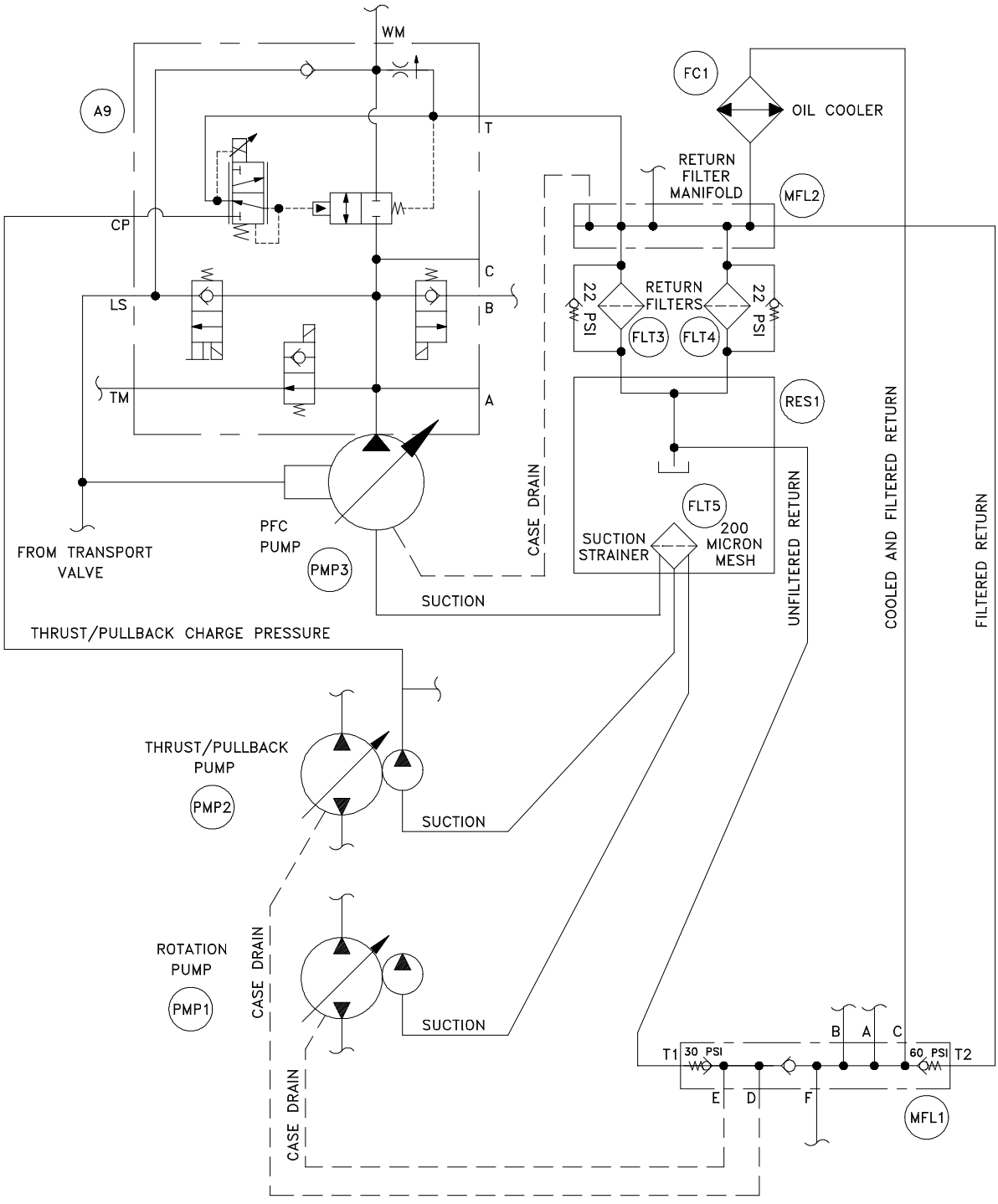
The following specifications are for the hydraulic system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
rated engine RPM	2200 rpm
Hydraulic Oil Tank	
capacity	60 gal (227 L)
typical case pressure (depending on ambient temperature and duty cycle)	25–60 psi (1.7–4.1 bar)
Hydrostatic Pumps (refer to Rotation and Thrust/Pullback sections for detailed specifications)	
make / model	Sundstrand 90 series
displacement per revolution	3.35 cid (55 cc)
nominal flow @ 2200 rpm	32 gpm (121 L/min)
Hydraulic (PFC) Pump	
make / model	Sundstrand 45 series
displacement per revolution	4.52 cid (74 cc)
pressure compensator setting	3000 psi (210 bar)
nominal flow @ 2200 rpm	42 gpm (159 L/min)

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HYDRAULIC DIAGRAM



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Hoses

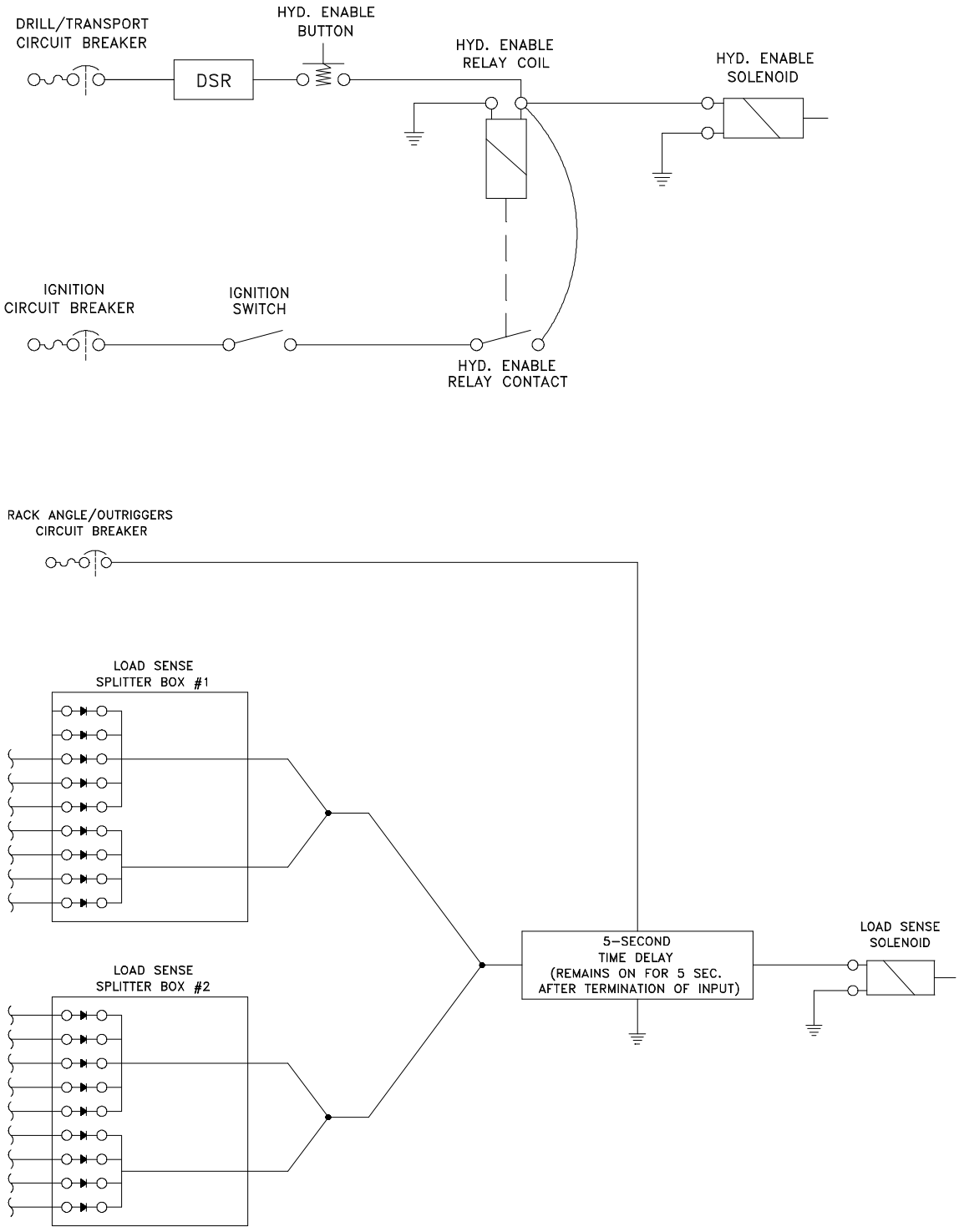
Hose ID/ Pressure	Circuit Type	Function
Load Sense **No Functions Activated:** nominal pressure **Functions Activated:** load demand pressure	pilot	Receives load sense signal from transport valve (A5) port ‘LS’ or load sense solenoid in proportional/dump valve (A9) port ‘LS’.
Thrust/Pullback Charge charge pressure	pilot	Provides charge pressure to control the water pump rotation speed.
Case Drain (PFC Pump) nominal pressure	drain	Drains PFC pump (PMP3) to the return filter manifold (MFL2).
Case Drain (Thrust/Pullback and Rotation Pumps) nominal pressure	drain	Drains hydrostatic pumps to the return manifold (MFL1).
Filtered Return nominal pressure	return	Drains return manifold (MFL1) to the return **filter** manifold (MFL2).
Unfiltered Return nominal pressure	return	Drains return manifold (MFL1) directly to the tank if backpressure exceeds 60 psi (4.1 bar).
Suction (PFC Pump, Rotation Pump, Thrust/Pullback Pump)	suction	Supplies oil to PFC, rotation, and thrust/pullback pump (PMP1–3) inlets from tank (RES1) whenever engine is turning.
Oil Cooler nominal pressure	return	Directs return manifold (MFL1) oil to the oil cooler (FC1) when back pressure is less than 60 psi (4.1 bar).

*__NOTE__: under “standard operating conditions,” the following pressures will normally be found in the circuits indicated:
“nominal pressure” = 25–100 psi (1.7–6.9 bar)
“charge pressure” = 300–500 psi (20–35 bar) (same as “low side” pressure)

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ELECTRICAL DIAGRAM



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Section 40-2: Common Hydraulic System Troubleshooting

HOW TO DO TROUBLESHOOTING

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***
5. ***Are the hydraulic components functioning correctly?***

Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking Out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, drill/transport, rack angle/ stakedown or, ignition circuit breakers, or DSR) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** The ignition switch and hydraulic enable switch control the hydraulic enable solenoid.
5. ***Are both splitter modules OK?*** Any implement function requires a current path through a diode to the 5-second delay and to the load sense solenoid.
6. ***Are all relays and solenoid coils OK?*** make sure relays and solenoid coils are within tolerance, both cold and hot.
7. ***Are the valves and relay contacts OK?*** Even if all electrical functions are OK, a valve may leak or fail to move, or relay contacts may stick or not conduct current.

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Checking Out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is a variable signal based on function demand being delivered to the compensator, either from a variable control such as the transport or water control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motors work ok unless the motors are worn, defective, incorrect replacements, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Some electrically controlled systems using variable current control of proportional solenoids might also change with temperature since current and temperature can be closely related.

Checking Out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

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SYMPTOM: HYDRAULIC FORCE, PRESSURE, OR SPEED LOW

1. Are the machine common systems operating correctly? Operating the machine outside of intended parameters (i.e. in HIGH when it should be in MEDIUM or LOW) can lead to customer complaints. Also, oil level, temperature, and condition, oil cooler problems, or engine speed and power outside of specifications can cause or contribute to faulty operation.

Possible Problem	Possible Effect	What to do
hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
plugged suction screen	A plugged suction screen will cause machine operation problems and eventually will cause extensive equipment damage.	**Clean suction screen** (refer to **40-6-1**).
charge filters are plugged	Plugged charge filters can affect many aspects of machine operation since charge pressure is used to control other machine functions.	**Replace charge filters.**
engine RPM too low	Hydraulic functions that rely on maximum pump flow will have slow operation since maximum flow is reduced when RPM is reduced.	**Check engine RPM** while operating under load.
overheating	A blocked oil cooler or other conditions causing overheating of the hydraulic oil can cause various problems.	**Check hydraulic oil cooler.**

2. Is the load sense electrical circuit working correctly?

Possible Problem	Possible Effect	What to do (refer to:)
load sense solenoid control defective	The load sense solenoid is energized any time a hydraulic function is electrically activated, and remains on for five seconds after the power is removed. If the delay module is defective (not receiving power or not receiving load sense inputs from the load sense splitters) pump output pressure will be limited to standby pressure.	**Check** that the **load sense solenoid** receives current from the 5-second delay module whenever a hydraulic function is electrically activated.

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3. Are the hydraulic components functioning correctly? Operation of a hydraulic system requires the correct function of pump, flow and direction controls, and actuators.

Possible Problem	Possible Effect	What to do
pump flow at pressure inadequate	If the pump is damaged or badly worn, it will not be able to develop sufficient flow and pressure to operate functions as designed.	**Check pump flow and pressure.**
system pressure relief misadjusted	If the system pressure relief has been adjusted, it may be set lower than the pump compensator setting, causing heating of the oil and possibly significant loss of working pressure.	**Check pressure relief setting.**
load sense system malfunction	The PFC pump must receive a load sense signal either from the water pump control circuit, the transport valve, or the load sense solenoid in order to increase pump displacement to match demand. If the load sense signal is not present, pump pressure will remain at standby pressure of 300 psi (20 bar).	**Check that pressure on the load sense line rises when a function is activated.** Check that the load sense control circuit is operating correctly (see previous chart). Check that the check ball in the transport or water pump motor circuit are not leaking.

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SYMPTOM: NO HYDRAULIC POWER TO HYDRAULIC FUNCTIONS

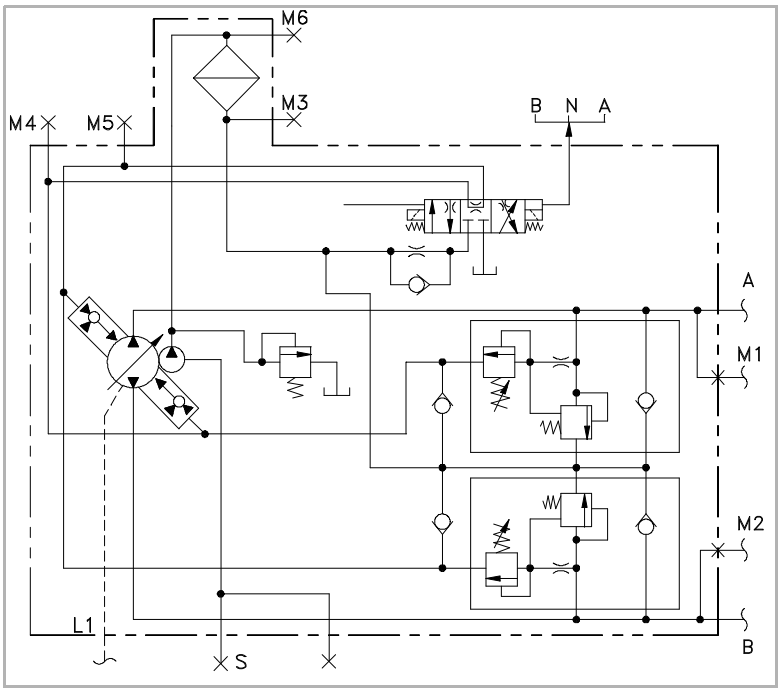
1. Is the hydraulic enable circuit working correctly? Each time the engine is started, the hydraulic enable circuit must be activated by pressing the hydraulic enable button. This allows hydraulic flow to the rack, rod loader, stakedown, and vise manifolds.

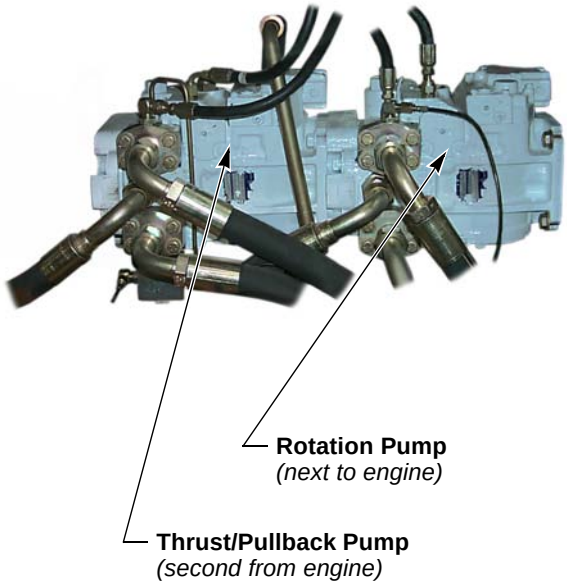
Possible Problem	Possible Effect	What to do
DSR not supplying power	The hydraulic enable button receives current from the DSR module. If the DSR does not supply current, the hydraulic enable solenoid cannot be energized.	**Check power from DSR to hydraulic enable button.**
ignition switch not supplying power to hydraulic enable relay	The hydraulic enable relay supplies current to the hydraulic enable solenoid from the ignition switch 'I' terminal. The circuit "latches" to supply its own relay coil current also. If the relay is defective it may be possible to operate hydraulic functions only as long as the hydraulic enable button is pushed in.	**Check ignition supply to the hydraulic enable relay.** Check operation of the relay and the hydraulic enable solenoid.
grounds	If the ground path is missing, is too resistive, or the voltage drop in the ground circuit is more than 0.5V, all electrical operation can be affected.	**Check grounds for the hydraulic enable relay and the hydraulic enable solenoid at rest and while operating an electrical load.** Repair any condition causing high ground voltage either at rest or under load.
current path	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path.** Inspect visually or use an ohmmeter or voltmeter.

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Section 40-5: Hydrostatic Components

HYDROSTATIC PUMPS (PMP1, PMP2)





Operation

The closed loop hydrostatic pumps provide oil flow from either the 'A' or the 'B' port to the rotation or thrust/pullback motors to allow variable speed, bi-directional operation of the motors.

IMPORTANT: When working on closed loop components, special procedures and extreme cleanliness standards are required (refer to *Hydrostatic Service Procedures*, page **40-6-1**).

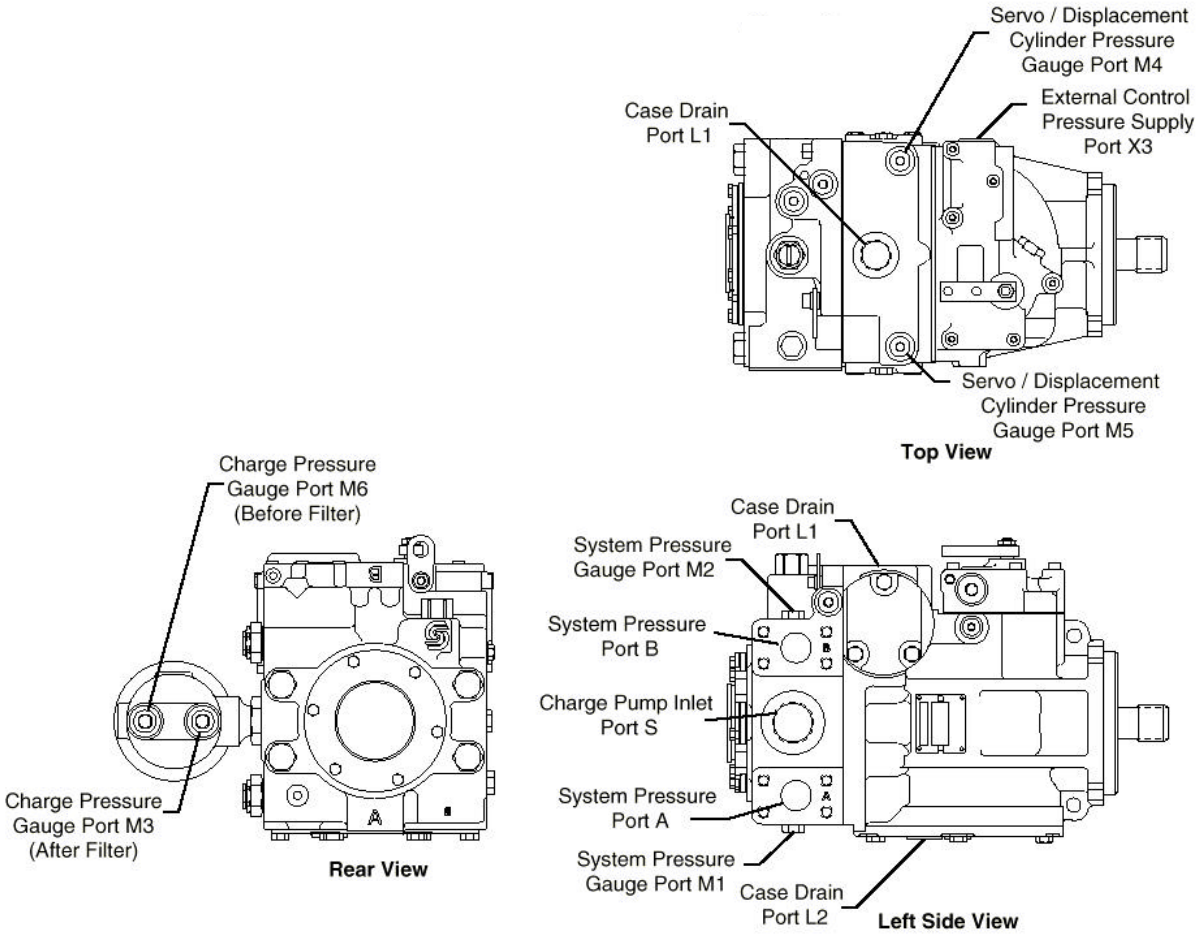
Action

The charge pump fills the loop hoses and provides control pressure (refer to *Charge Pump*, page **40-5-3**). The direction lever and splitter box provides an electrical signal to the EDC, which provides a hydraulic pressure signal that operates a servo piston to "stroke" the pump (change the swashplate angle). The angle of the swashplate in either direction from zero (neutral) determines pump output and flow direction. A combined pressure limiter and pressure relief limits pump output by destroking the pump or relieving excess flow.

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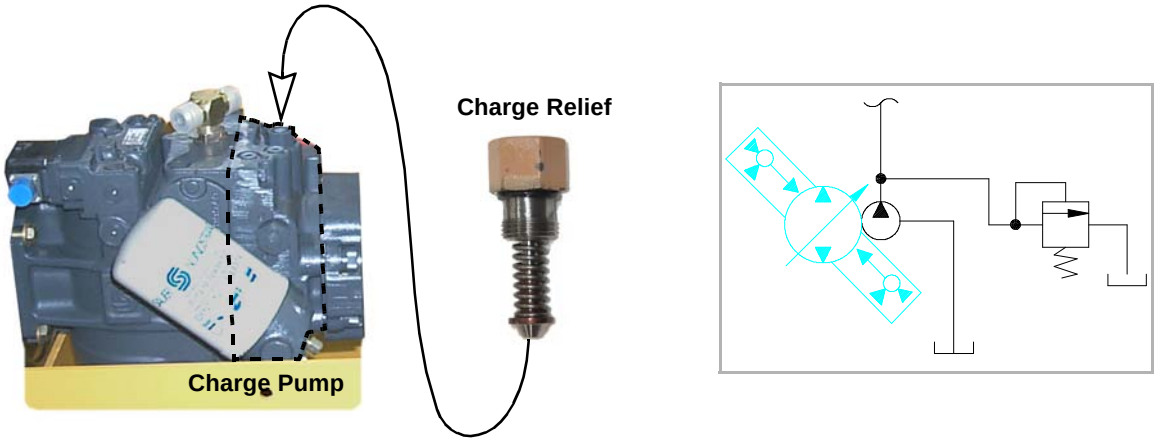
Port Locations



Port	Function	Recommended Gauge Size	Fitting
M1	system pressure port ‘A’	10,000 psi or 1000 bar gauge	9/16”–18 O-ring fitting
M2	system pressure port ‘B’	10,000 psi or 1000 bar gauge	9/16”–18 O-ring fitting
M3	charge pressure (after filter)	1000 psi or 50 bar gauge	9/16”–18 O-ring fitting
M6	charge pressure (before filter)	1000 psi or 50 bar gauge	9/16”–18 O-ring fitting
M4 M5	servo pressure	500 psi or 50 bar gauge	9/16”–18 O-ring fitting
L1 L2	case pressure	100 psi or 10 bar gauge	1-1/16”–12 O-ring fitting
X1 X2	EDC pressure	1000 psi or 50 bar gauge	7/16”–20 O-ring fitting or 9/16”–18 O-ring fitting
X3	external control pressure	1000 psi or 50 bar gauge	9/16”–18 O-ring fitting
S	charge pump inlet	vacuum gauge—tee into inlet line	1-5/8”–12 O-ring fitting

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CHARGE PUMP



Operation

Charging the Closed Loop: The charge pump fills the loop hoses and other components with oil during initial start-up.

Replenishing oil lost to leakage: The charge pump replaces oil lost to leakage past component clearances.

Provides cooling and filtering: The charge pump replaces hot oil shuttle flow with cooled and filtered oil from the tank.

Pilot pressure for pump control systems: The charge pump provides pressurized oil to position the swashplate.

Pilot Pressure for external systems: Rotation charge pump oil is used as pilot pressure to release ground drive brakes and to control the water pump hydraulic proportional valve.

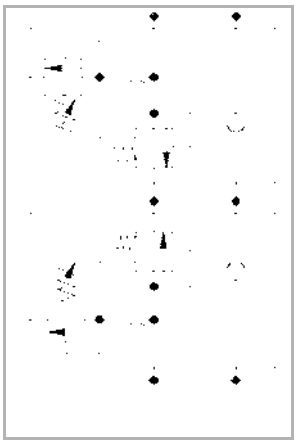
Action

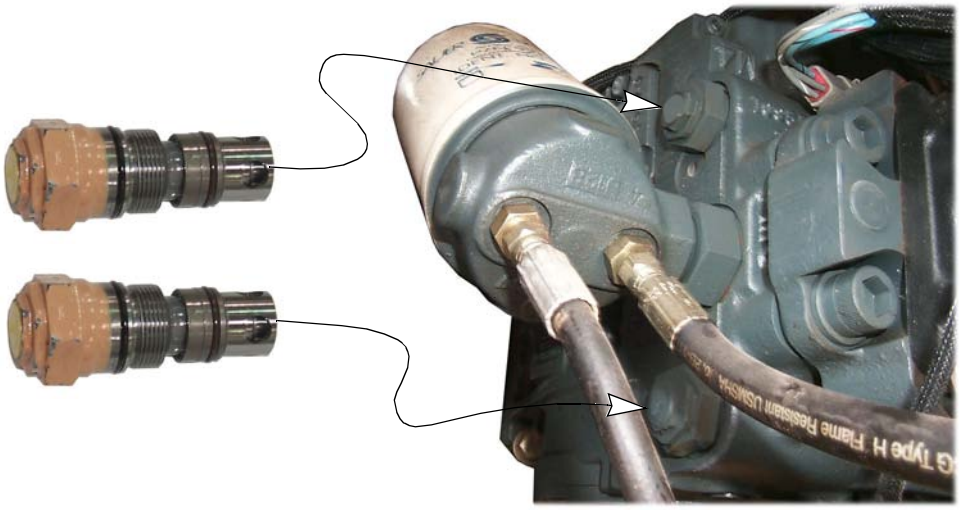
The charge pump is a positive displacement gerotor pump that is attached to the rotation pump. Oil is forced by atmospheric pressure through the suction strainer in the tank, into the charge pump, through the charge filter, and through the charge check valves to both sides of the loop (in neutral) or the low side of the loop (when the pump is stroked). The remainder of the oil goes across the charge pressure relief, into the pump case, and into the drain circuit to tank.

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MULTI-FUNCTION VALVES





Operation

A multi-function valve is used in each closed loop port to limit the system pressure and to allow charge oil to keep the closed loop filled.

Action

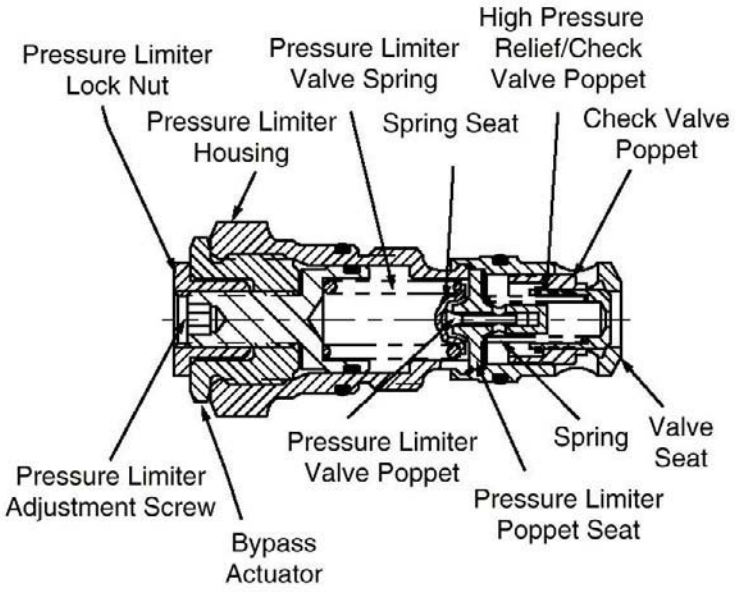
Pressure relief: If the closed loop oil pressure exceeds a preset limit, it goes over relief until the multi-function valve destrokes the rotation pump.

Pressure limiter: The multi-function valve pressure limiter sends a pilot signal to destroke the pump (i.e. to reduce swashplate angle). The pump maintains pressure but there is almost no flow.

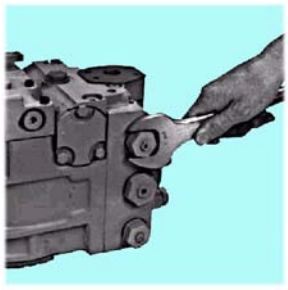
Charge inlet: Each multi-function valve has a check valve inside which allows charge pump oil to keep the low side of the loop filled and pressurized.

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MULTIFUNCTION VALVES - REMOVE



1. Remove the multi-function valve cartridge with a 1-1/4” wrench on the largest hex of the cartridge.



2. Inspect cartridge for damage to parts and O-rings. The multi-function valve cartridge may be disassembled for cleaning. However, if the pressure limiter housing assembly is disassembled, the pressure settings must be readjusted. Usually, if there is contamination problem, it will be in the valve seat assembly. If it is not necessary to clean the interior of the cartridge, proceed to step 7.

Multi-function valve components (except O-rings) are not sold separately as service parts.



3. The valve seat section is pressed over a lip. Place the cartridge in a vise and pry the lower section off with an appropriate tool. Maintain sufficient control to prevent the contents from flying loose.

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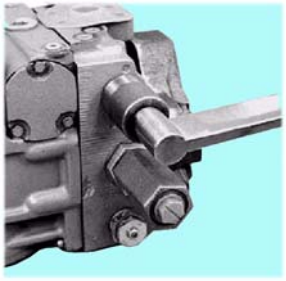
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4. Remove pressure limiter lock nut and bypass actuator.
5. Unscrew the pressure limiter adjustment screw from the bypass actuator.
6. Clean and inspect all disassembled parts.

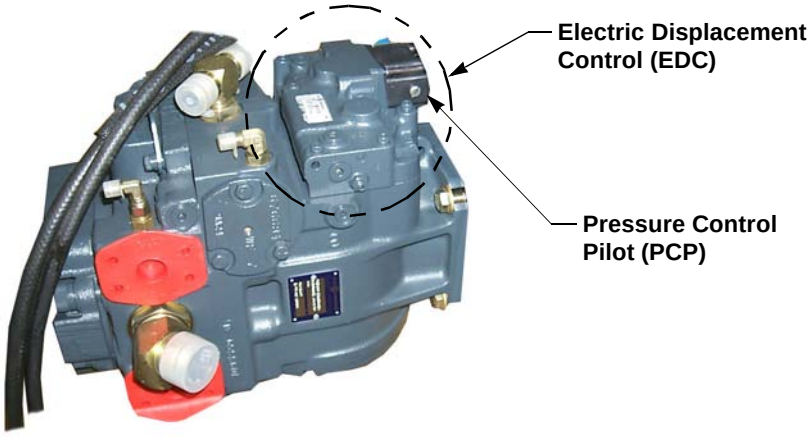
IMPORTANT: Assemble with new, lightly lubricated O-rings by reversing the above procedure. Place the cartridge in a vise and press on lower assembly. **The pressure settings must be readjusted after disassembling the pressure limiter housing of the multi-function valve cartridge.**

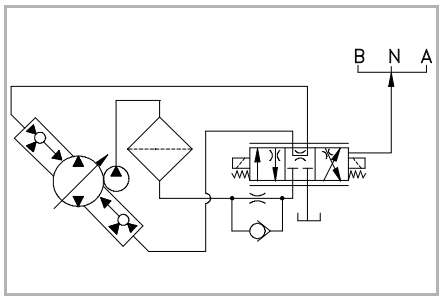
7. Install cartridge in multi-function valve cavity and torque to 66 ft-lb (89 Nm). Do not overtorque the multi-function valve cartridge.

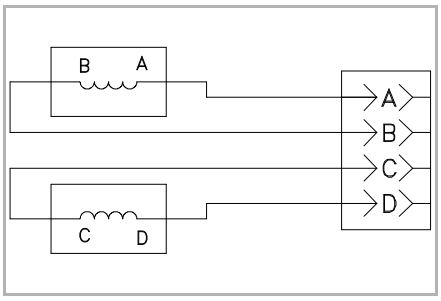


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EDC (ELECTRIC DISPLACEMENT CONTROL)







Function

The EDC converts the electrical signal from the joystick or control module into a hydraulic signal to vary the displacement and flow of the pump.

Action

Within the EDC, the pressure control pilot (PCP) valve converts a DC electrical input signal to a hydraulic signal which operates a spring-centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swash-plate through an angular rotation of ±17°, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction. The control is designed so the angular position of the swashplate is proportional to the EDC input. A feedback link monitors swashplate position to shut off oil flow to the servo piston when the desired position is reached.

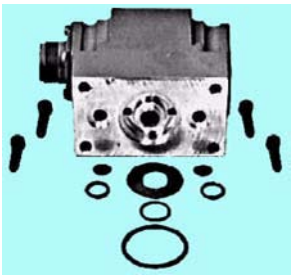
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EDC - SERVICE

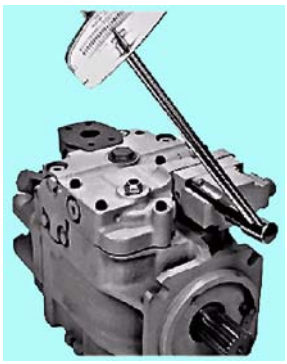
Replace PCP

1. Thoroughly clean external surfaces of control.
2. Using a 4 mm Allen wrench, remove the four screws and remove the PCP.
3. Check surfaces for nicks or damage. Clean internal screens.



Do not remove black plastic cover from the aluminum plate. This is not a serviceable item and will void the product warranty.

4. Install new O-rings in PCP Housing. Place PCP against EDC housing and install the screws. Torque to 5.4 Nm (48 in-lb).



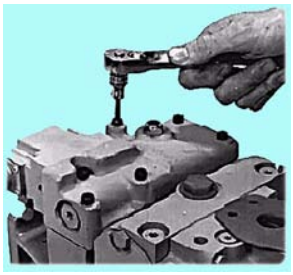
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Replace EDC

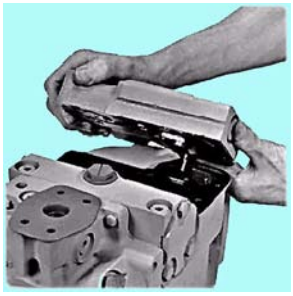
Remove

1. Thoroughly clean external surfaces prior to removal of control. Using a 5 mm Allen wrench, remove the eight control mounting screws.



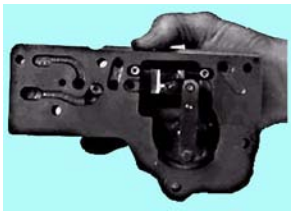
Protect exposed surfaces and cavities from damage and foreign material.

2. Remove the control (with orifice check valve and spring) and control gasket from housing.



Install

3. In preparation for installing the control, place a new gasket on the housing. Inspect to ensure that the control orifice check valve and spring are in their proper position in the control.



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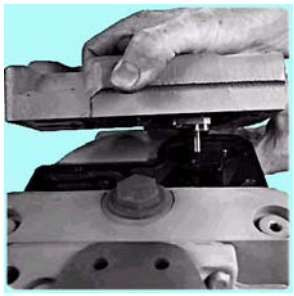
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WARNING: Failure to properly engage the feedback link can cause loss of control of the rotation function when the controls are operated.

4. While setting the control into position, engage the pin on the control linkage into the mating hole in the link attached to the swashplate.

   With the control in position, move control assembly left and right to check engagement of pin in the link. Proper engagement will be indicated by an increasing resistance as the control is moved away from center position. Non-engagement of pin will be indicated by lack of spring force. In case of non-engagement, remove control and repeat the above procedure.

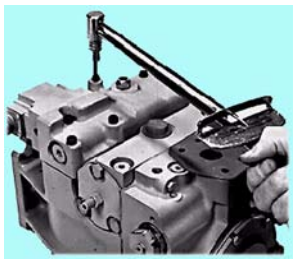


5. Align the control gasket and install the screws.



A sealing washer must be installed under the head of any mounting screws that are installed into "through" holes in the housing.

6. Torque the screws to 12 ft-lb (16 Nm).



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Adjust EDC Neutral Setting (“Null the Pump”)

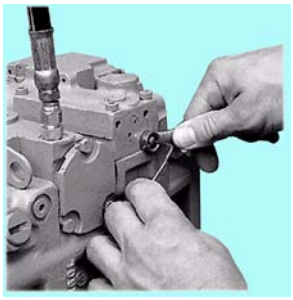
WARNING: Entanglement in rotating drill chuck and drill rod can cause death or serious injury. Stay away from rotating equipment. Do not wear loose clothing that could catch on rotating equipment.

Use matched calibrated gauges when adjusting EDC neutral.

1. Install a 1000 psi (70 bar) gauge in each of the two displacement control cylinder gauge ports (M4 and M5). Disconnect the EDC. Start the engine and operate at high idle speed.



2. Loosen the lock nut with a 13 mm wrench. Using a 4 mm Allen wrench, rotate clockwise until the pressure increases in one of the pressure gauges. Note the angular position of the wrench. Then rotate the neutral adjusting screw counterclockwise until the pressure increases by an equal amount on the other gauge. Again note the angular position of the wrench.



3. Rotate the adjusting screw clockwise half the distance between the locations noted above. The gauges should read the same pressure (case pressure), indicating that the control is in its “neutral” position.
4. Hold the neutral adjusting screw stationary. Tighten the neutral adjusting screw lock nut to 120 in-lb (13.6 Nm). Do not overtorque the nut.
5. Once the neutral position is set, stop the engine, remove the gauges, and install the gauge port plugs. Connect the external control input.

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Section 40-6: Hydrostatic Repair

HYDROSTATIC SERVICE PROCEDURES

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

WARNING: Relieve all pressure in the hydraulic system before disconnecting the lines or performing other work on the system. Make sure all connections are tight and lines are in good condition before applying pressure to the system.

WARNING: Before performing any maintenance on the machine, follow the Shutdown Procedure unless instructed differently by the manual.

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The hydrostatic drive components are precision-built to very close tolerances and operate at very high pressures. Cleanliness is extremely important when servicing a hydrostatic system.

When servicing the machine:

- When setting or checking pressure, oil temperature should be at least 100°F (38°C).
- Clean the machine before servicing it. Use only filtered hydraulic oil and a clean funnel.
- Label hoses for location before disconnecting them. Plug all hoses and cap all fittings when disconnecting them to prevent contamination of the hydraulic system.
- Unless specified in the instructions, tighten all bolts and fittings according to the Torque Values Section (refer to page **20-9-1**).
- When installing pumps and motors, coat drive splines with Molykote G-N paste (Vermeer P/N 94469-003).
- Whenever replacing charge filters, crank engine without starting to ensure there is adequate charge pressure.
- Never attempt to bypass neutral start lockouts to allow the machine to start when pumps are not in neutral.
- All components (tank, hoses, tubes, fittings, etc.) must be clean before installation. If possible, use a foam projectile cleaning system. Otherwise, rinse all components with clean solvent (solvent must be filtered through a 10 micron filter), and dry with filtered air before installation.
- Filter the closed loop systems whenever they have been opened or exposed to contamination such as when replacing a hose or component.
- Do not run a new motor over half speed until the motor has been worked under a full load.

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RETURNING SYSTEM TO SERVICE

The hydrostatic systems can be easily damaged by contaminants or by lack of oil. After repairing a hydrostatic system, use the following procedure to assure an adequate supply of oil to each part of the system.

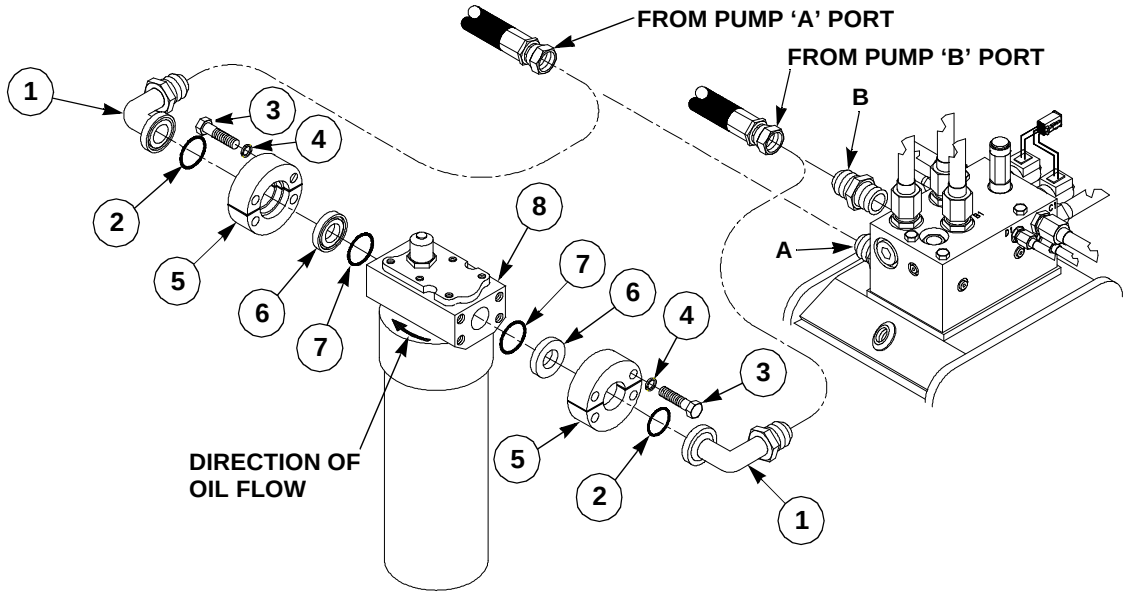
- Fill the tank with the recommended hydraulic fluid. Filter the oil with a 10 micron oil filter as it is added to the tank. Do not reuse hydraulic fluid.
- If replacing a hose, fill it with oil before starting the machine.
- If replacing a pump or motor, fill the case with oil before starting the machine.

IMPORTANT: Hydrostatic components can be destroyed if not filled with oil before the engine is started.

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FILTER KIT PARTS

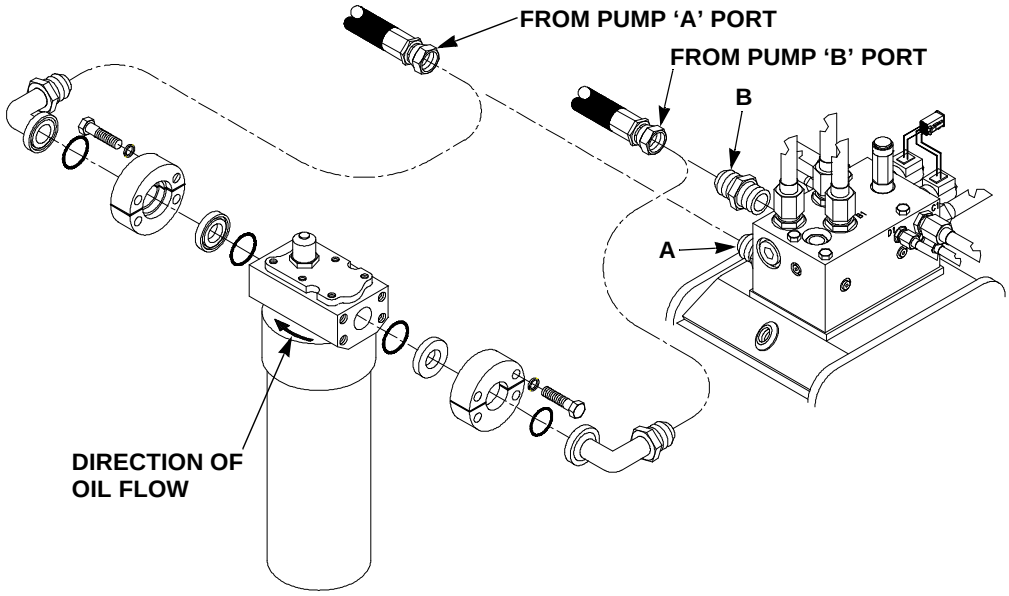


Filter Kit for Rotation and Thrust/Pullback Systems			
Number	**Part Number**	**Description**	**Quantity**
(1)	82923-001	Fitting-16M JIC x 16/62 90° SH Ref	2
(2)	72895-001	O-ring-Sq. #16 Flange	2
(3)	235718-001	Bolt-1/2"-13" x 2" GR8 Hex Zinc PLT	8
(4)	485-025	Washer-1/2" Flat Hardened Zinc	8
(5)	75351-001	Split Flange	2
(6)	75350-001	Spacer	2
(7)	72896-001	O-ring-Sq. #20 Flange	2
(8)	71927-001	Filter Assembly	1
	71928-001	Element-Filter	1
	75353-001	Seal Kit	1
	71927-005	Indicator-Visual	1
	71927-007	Glass-Visual Indicator	1

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FLUSHING THE ROTATION SYSTEM



Special Tools

- torque wrench capable of producing 90 ft-lb (122 Nm)

Procedure

IMPORTANT: Do not start the machine after installing a new pump, motor, hose or tube until the filter kit is installed. If installing a new hydrostatic pump or motor, fill the case with oil prior to starting the engine.

1. The drill rack should be level and the gearbox should be at the rear of the rack.
2. Follow the *Shutdown Procedure* (refer to page **10-2-1**).
3. Thoroughly clean the 3-speed loop flush valve and top of the gearbox.
4. Label and remove the 'A' port hose and 'B' port hose, capping the fittings on the 3-speed loop flush valve.

Oil the threads and seats of the hoses or fittings to achieve correct torque values.

IMPORTANT: Note the orientation of the arrow showing oil flow direction, and connect the hoses to the filter kit. Torque the hoses to 88 ft-lb (119 Nm).

5. Install a 600 psi (40 bar) pressure gauge on the charge pressure diagnostic port connected to the oil filter.

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IMPORTANT: Push the emergency stop button down to prevent the engine from starting before charge pressure is established. Pump damage will result if the engine starts before the hydrostatic system is properly filled with oil.

NOTE: Do not crank the engine for more than 30 seconds at a time to prevent the starter from overheating. Allow the starter to cool two minutes between cranking attempts.

6. Crank the engine until the charge pressure is 25-50 psi (1.7-3.4 bar).
7. Pull the emergency stop button up. Start the engine and run it at the lowest possible RPM until charge pressure is at least 290 psi (20 bar).

IMPORTANT: To avoid internal damage to the pump, never attempt to start the machine unless the pump is in neutral.

8. Pull the left joystick back and flush the circuit for 10 minutes at half throttle.

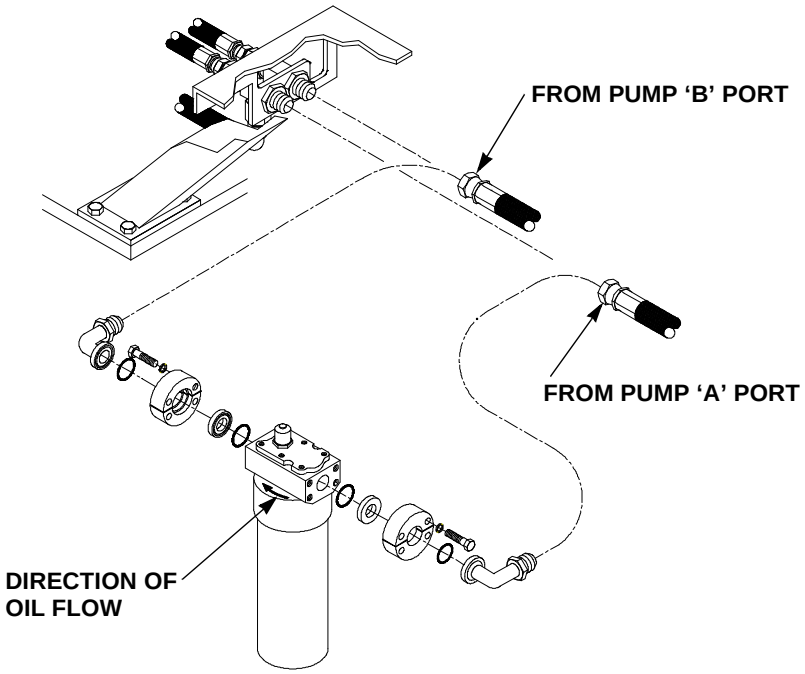
IMPORTANT: To prevent reintroducing contaminants, do not push the joystick forward while the filter is installed.

Oil the threads and seats of the hoses or fittings to achieve correct torque values.

9. Follow the *Shutdown Procedure* (refer to page 10-2-1). Remove the filter kit, and connect the 'A' port hose and 'B' port hose to the three-speed loop flush valve, being careful not to get contaminants into the circuit. Torque the hoses to 88 ft-lb (119 Nm).
10. Take an oil sample (refer to page 40-6-9).

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FLUSHING THE THRUST/PULLBACK SYSTEM



Special Tools

- torque wrench capable of producing 90 ft-lb (122 Nm)

Procedure

IMPORTANT: Do not start the machine after installing a new pump, motor, hose or tube until the filter kit is installed. If installing a new hydrostatic pump or motor, fill the case with oil prior to starting the engine.

1. Follow the *Shutdown Procedure* (refer to page **10-2-1**).
2. Thoroughly clean the hose ends and hose carrier mount.
3. Label and remove the 'A' port hose and 'B' port hose, capping the fittings on the hose carrier mount.

Oil the threads and seats of the hoses or fittings to achieve correct torque values.

IMPORTANT: Note the orientation of the arrow showing oil flow direction, and connect the hoses to the filter kit. Torque the hoses to 88 ft-lb (119 Nm).

4. Install a 600 psi (40 bar) pressure gauge on the charge pressure diagnostic port connected to the oil filter.

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IMPORTANT: Push the emergency stop button down to prevent the engine from starting before charge pressure is established. Pump damage will result if the engine starts before the hydrostatic system is properly filled with oil.

NOTE: Do not crank the engine for more than 30 seconds at a time to prevent the starter from overheating. Allow the starter to cool two minutes between cranking attempts.

5. Crank the engine until the charge pressure is 25-50 psi (1.7-3.4 bar).
6. Pull the emergency stop button up. Start the engine, running it at the lowest possible RPM until charge pressure is at least 290 psi (20 bar).

IMPORTANT: To avoid internal damage to the pump, never attempt to start the machine unless the pump is in NEUTRAL.

7. Pull the right joystick back and flush the circuit for 10 minutes at half throttle.

IMPORTANT: To prevent reintroducing contaminants, do not push the joystick forward while the filter is installed.

Oil the threads and seats of the hoses or fittings to achieve correct torque values.

8. Follow the *Shutdown Procedure* (refer to page **10-2-1**). Remove the filter kit, and connect the 'A' port hose and 'B' port hose to the hose carrier mount, being careful not to get contaminants into the circuit. Torque the hoses to 88 ft-lb (119 Nm).
9. Take an oil sample (refer to page **40-6-9**).

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OIL SAMPLING

IMPORTANT: It is very important that the inside of the bottle does not become dirty when taking an oil sample. Do not put your fingers inside the bottle or leave the cap off of the bottle except when filling it. Even a very small amount of dirt or foreign matter will contaminate the oil sample. Install and remove the bottle only in a clean environment.

To take an oil sample from a diagnostic port:

IMPORTANT: Do not allow system pressure to be applied to the sample hose; hook up to charge pressure only.

- Connect the fluid sample hose (Vermeer P/N 104159-001) to the diagnostic port of the desired system.

NOTE: When taking a fluid sample, hydraulic oil temperature should be at least 100°F (38°C).

- With warm fluid and the engine at idle, slowly open the valve on the hose and fill the sample bottle. Close the valve.
- Follow the *Shutdown Procedure* (refer to page **10-2-1**) and disconnect the fluid sample hose.

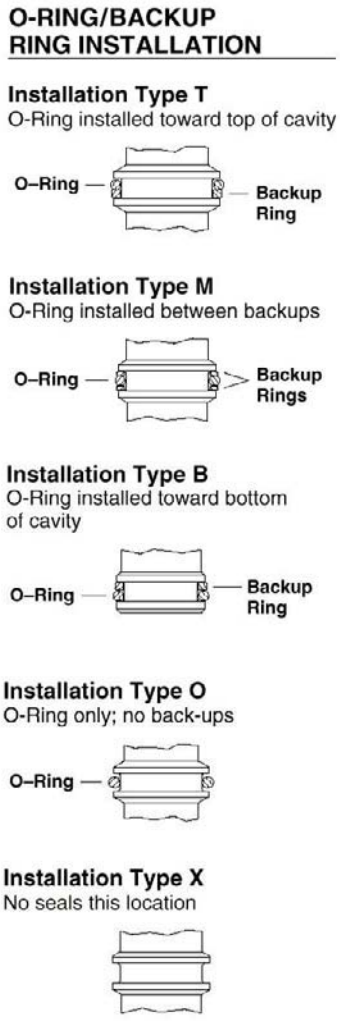
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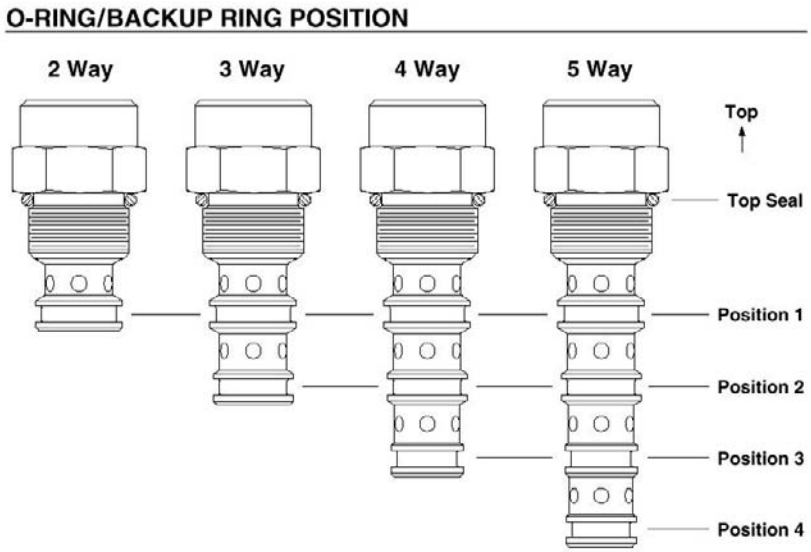
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Section 40-7: Solenoids and Valves

O-RING INSTALLATION





The diagram shows O-ring position information for most of the types of cartridges used on the D33x44. Refer to the component sections in the component chapters for O-ring positions for individual valve cartridges. The diagram above shows the classification of positions for 2-way through 5-way valves.

NOTE: Black elastomer back-up rings are serviced in the field with single-turn (white) Teflon (TFE) back-up rings, since special tools are required to install the black back-up rings.

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VALVE SERVICE

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

WARNING: Use extreme caution when removing a cartridge valve. The cartridge may be released with great force if trapped pressure remains in the circuit. Do not stand in front of the cartridge when removing it.

WARNING: Before performing any maintenance on the machine, follow the Shutdown Procedure unless instructed differently by the manual.

Always depressurize and verify before removing any solenoid valve. Certain cartridge valves may function as check valves and could trap and retain pressure in a system indefinitely. It may be possible in some cases to relieve pressure by shutting off the machine, turning the key back on (leave the engine off) and cycling the function switch for the circuit you are servicing. However, some valves may require pilot pressure from the PFC pump or one of the charge pumps to open the valve and relieve trapped pressure. **Never assume that because the machine is off or a function control has been cycled that there is no pressure present in the system!**

Continued on next page...

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Cartridges

Inspect the cartridge to ensure that no external contaminant is present. Be sure O-rings and back-ups are intact and correctly positioned. The O-ring should always be toward the higher pressure port or between double back-ups on bidirectional valves.

Coils

Tighten the coil retaining nut to the following specifications:

- '08' size: 5–7 ft-lb (6.75–9.5 Nm) maximum
- all other sizes: 7–10 ft-lb (9.5–13.5 Nm) maximum

Housings

Inspect cavity for burrs or other machining irregularities which could damage O-rings during installation.

Assembly

Dip the cartridge in clean oil. Screw the cartridge in **by hand** until the top O-ring makes contact, then wrench tighten to the following torque specifications:

- '08' size: 20 ft-lb (27 Nm)
- '58' size: 20 ft-lb (27 Nm)
- '10' size: 25 ft-lb (33.4 Nm)
- '12' size *spool* type: 35 ft-lb (46.5 Nm)
- '12' size *poppet* type: 60 ft-lb (80 Nm)
- '16' size 50 ft-lb (67 Nm)

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SOLENOID COILS

Three types of solenoid coils are used on the D33x44. The following chart lists features and torques for most of the types used on the D33x44. For correct operation of solenoid valves it is very important to torque the coils correctly.

Coil Specifications

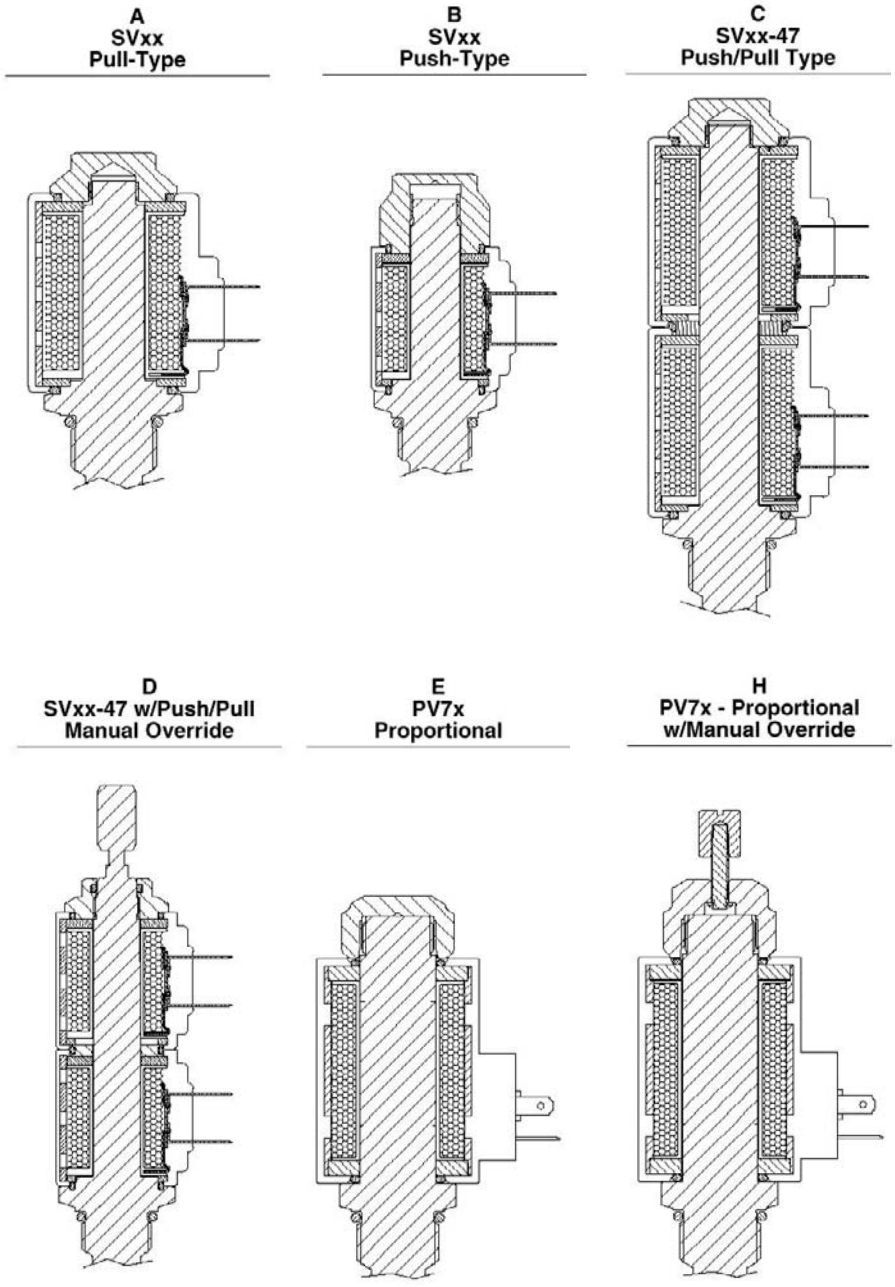
NOTE: Ohms and Watts are at 70°F (20°C). The drop-out voltage for '08' and '10' size coils is 10.2V. Coils are rated to operate continuously at up to 212°F (100°C). For accurate testing, be sure to check voltage, resistance, and current at normal coil operating temperatures. **Regardless of voltage and temperature conditions, pull-in current must be at least 0.840 A for size '08' coils and 1.18 A for size '10' coils.**

Coil Type	Vermeer P/N	Amps	Ohms	Watts	Installation Torque
'08'	251117-009	1.2	9.8	14.7	5–7 ft-lb (6.75–9.5 Nm)
'10'	251112-005	1.67	7.2	20	7–10 ft-lb (9.5–13.5 Nm)
EHPR proportional	251108-003	1.2 (max)	5.4	NA	7–10 ft-lb (9.5–13.5 Nm)

The solenoid coils installed on the D33x44 use external O-rings to seal the coils against moisture. Ensure that, whenever a coil is replaced, the appropriate O-ring seals are correctly positioned to prevent the coils from being damaged by water. Consult the following chart and compare with the specification number in the component section to determine the correct positioning of waterproofing O-rings and seals.

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Coil Waterproofing



The solenoid coils installed on the D33x44 use external O-rings to seal the coils against moisture. Ensure that, whenever a coil is replaced, the appropriate O-ring seals are correctly positioned to prevent the coils from being damaged by water. Compare the configurations shown above with the specification number in the component section to determine the correct positioning of waterproofing O-rings and seals.

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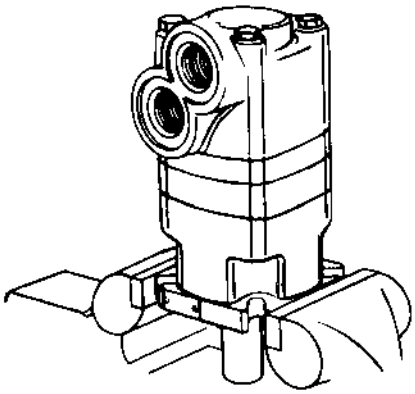
Section 40-8: Hydraulic Motors

EATON 4000 SERIES MOTOR SERVICE

Special Tools

- torque wrenches capable of producing 50 in-lb (5.5 Nm), 30 ft-lb (40 Nm), and 50 ft-lb (68 Nm)
- press
- plastic or rubber hammer
- Eaton seal installation tube
- Eaton seal driver
- Eaton tool for protective sleeve on motor shaft

Eaton 4000 Series Motor Disassembly



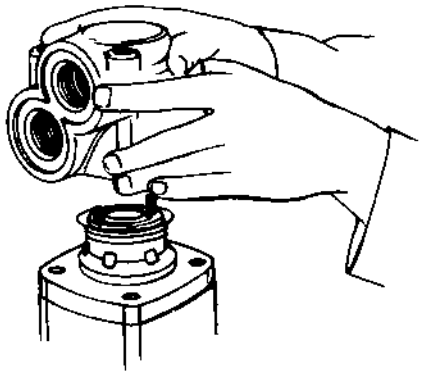
IMPORTANT: Inspect all parts for damage (scratches or burrs) or unusual wear during each step of disassembly. Check the condition of all mating surfaces. Do not re-use O-rings or seals.

1. Drain oil from the motor and thoroughly clean the exterior.
2. Place the motor in a soft-jawed vise with the output shaft down. If possible, keep the motor in a vise during disassembly and assembly.

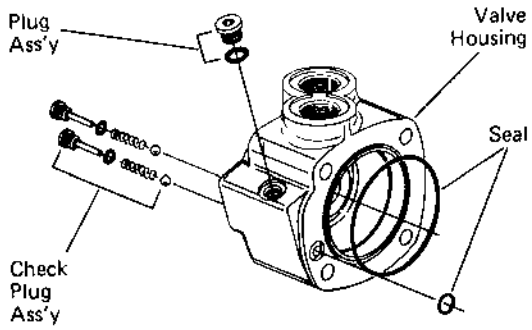
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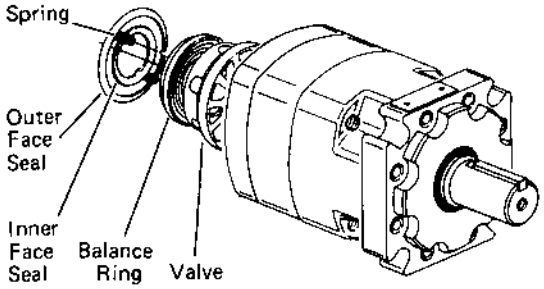
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3. Remove four tie bolts from the motor. Lift the valve housing straight up. If done carefully, the springs and balance ring will remain on the valve.



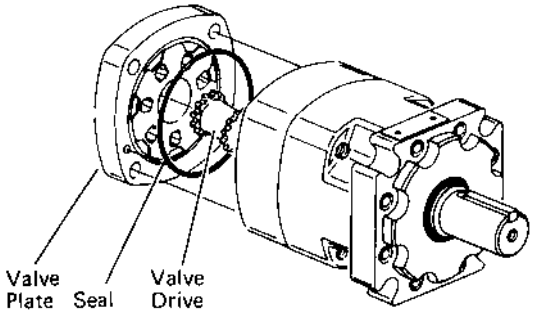
4. Carefully remove the seals, plug assembly and check plug assembly from the valve housing.



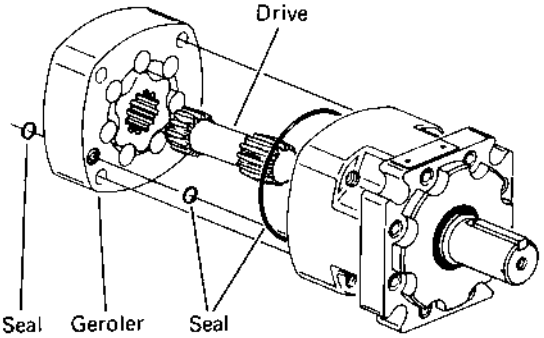
5. Remove the balance ring subassembly, and the balance ring's inner and outer face seals. Remove the valve.

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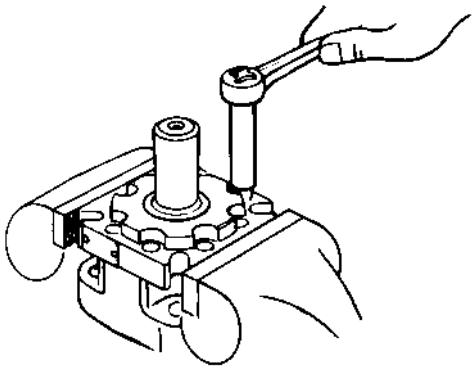


6. Remove the valve plate and its seal. Remove the valve drive.



7. Remove the Geroler, being sure to retain the rollers in the outer ring if they are loose. Remove two seals from each side of the Geroler.

8. Remove the drive and 3-1/2" seal from the bearing housing.

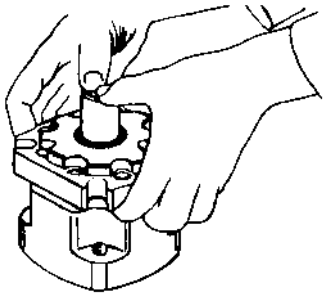


9. Clamp the bearing housing in a vise, loosen the eight cap screws, and place the housing on a clean, flat surface.

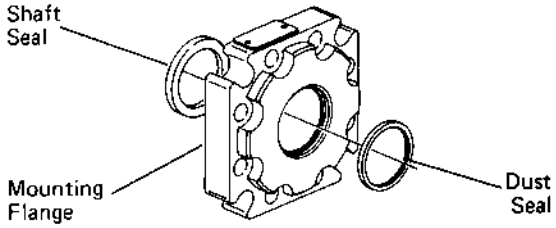
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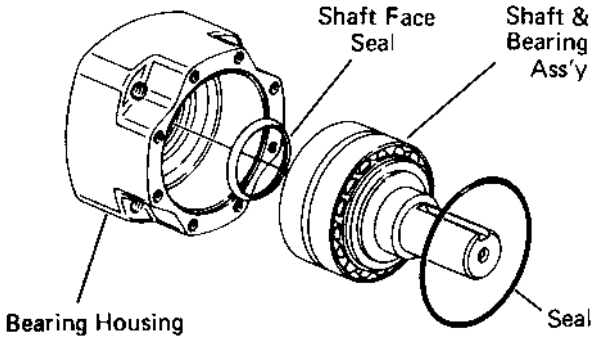
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10. Remove the cap screws and mounting flange.



11. Remove the shaft seal and pry the dust seal loose, using a small screwdriver. Do not damage the mounting flange bore.



12. Remove the 3-1/2" seal from the bearing housing, followed by the shaft and bearing assembly. A press may be necessary.

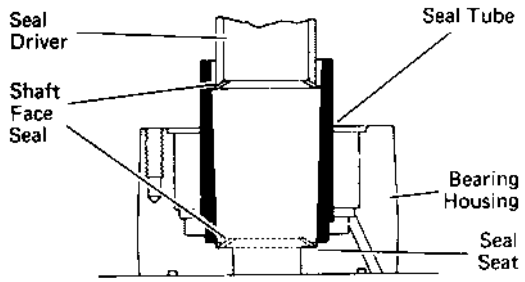
13. Remove the shaft face seal from the bearing housing bore. Be careful not to damage the bore.

14. Clean all metal parts in clean solvent and blow dry with air. Do not wipe with cloth or paper towels because lint or other matter could get into the hydraulic system and cause damage. Do not use abrasives or try to file or grind motor parts.

15. Check around the keyway and chamfered area of the shaft for burrs, nicks or sharp edges that can damage seals during assembly.

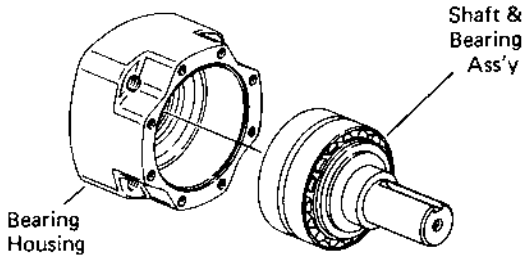
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Eaton 4000 Series Motor Assembly



NOTE: Use all new O-rings and seals. Coat with petroleum jelly to help position them during installation.

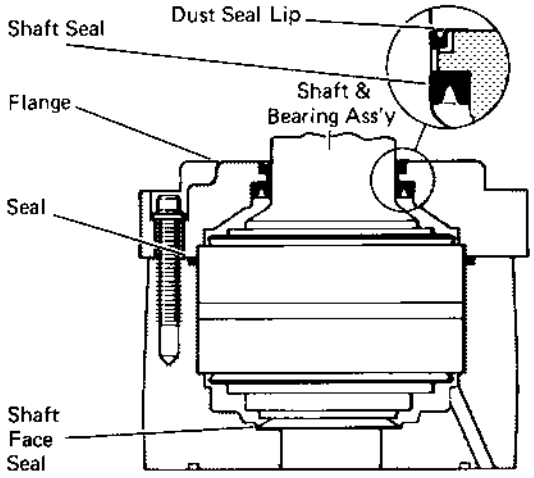
1. Place the bearing housing on a smooth, flat surface with the largest open end of the housing up. Align the Eaton seal installation tube with the seal seat. Apply petroleum jelly to the shaft face seal. Install the seal in the bore of the tube exactly as shown. Then, insert the Eaton seal driver in the tube. Push the face seal into the seal seat with rotating action. Seat the seal properly in the groove.



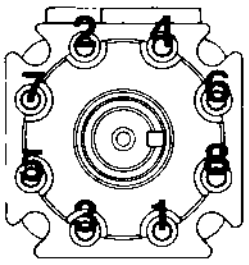
2. Install the shaft and bearing assembly in the bearing housing. A press may be necessary. Do not distort the shaft seal.

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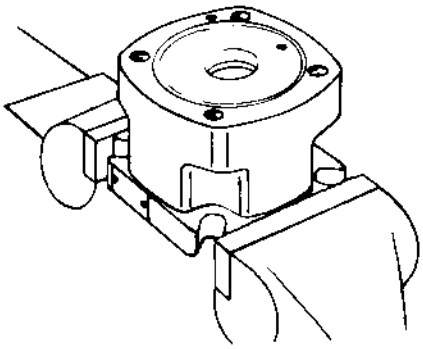
3. Apply petroleum jelly to the 3-1/2" seal. Install the seal in the outer seal groove of the bearing housing.
4. Install the dust seal in the flange (metal side of seal facing flange as shown), using a press. If a press is not available, use a plastic or rubber hammer. Be careful not to damage or cock the seal in the bore.
5. Install the shaft seal in the flange (flat, smooth side facing flange as shown). Then, apply petroleum jelly to the inner diameter of the shaft seal and dust seal.
6. Tape or apply a protective sleeve (Eaton tool) to the shaft to prevent cutting or distorting the seals. Install the flange, lubricate the threads of eight flange cap screws with oil, and finger tighten the screws.



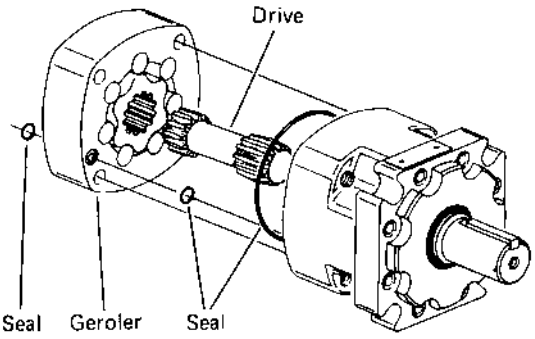
7. Clamp the bearing housing in a vise. Gradually torque the cap screws to 20 ft-lb (20 Nm), using the sequence shown.

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8. Reposition the motor in a vise with the output shaft down, clamping the motor across the flange edge. Pour a small amount of light oil inside the shaft.



9. Apply petroleum jelly to the 3-1/2" seal, and install the seal in the groove of the bearing housing. Install the drive in the output shaft, inserting the longer splined end first. Install two alignment studs in bolt holes (diagonal corners) of the bearing housing.

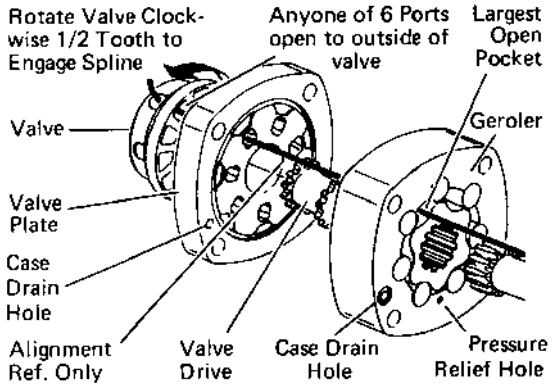
10. Install two small seals in the case drain grooves of the Geroler, lubricating them with petroleum jelly.

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Timing



NOTE: There are three steps involved in timing the motor. Timing determines the shaft rotation direction. Timing parts include Geroler, valve drive, valve plate and valve.

11. *Timing step #1:*

- Locate largest open pocket in Geroler, and mark it on outside edge.
- Align case drain hole and pressure relief hole in Geroler with case drain and pressure relief hole in bearing housing; install Geroler on bearing housing; and retain rollers in outer Geroler ring if loose.
- Install valve drive in Geroler.
- Apply petroleum jelly to 3-1/2" seal and install in valve plate.
- Align case drain hole in valve plate with case drain hole in Geroler; and install valve plate (seal side toward Geroler).

12. *Timing step #2:*

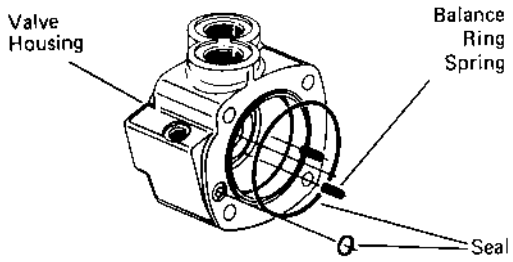
- Locate slot opening in valve plate which is in line with largest open pocket of Geroler.

13. *Timing step #3:*

- Locate any one of the side openings of the valve that goes through to the face of the valve.
- Align selected side opening with open slot of valve plate that is in line with largest open pocket of the Geroler.
- Install valve by rotating clockwise 1/2 spline tooth until spline teeth engage, providing correct rotation.

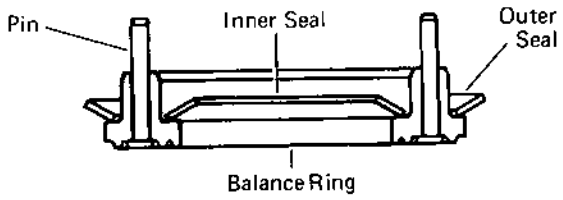
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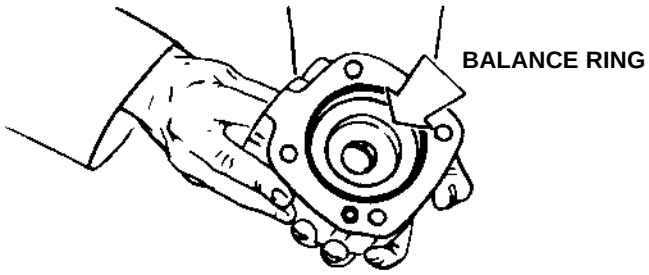
14. Apply clean grease to the balance ring assembly springs. Install two springs and two pins in the holes of the valve housing bore.

15. Apply petroleum jelly to both seals and install them in the valve housing.



IMPORTANT: The inner and outer face seals must be installed correctly for the motor to operate properly. Damaged seals, resulting from forcing or bending, will adversely affect motor operation.

16. Apply petroleum jelly to the inner and outer face seals. Install the seals on the balance ring exactly as shown.

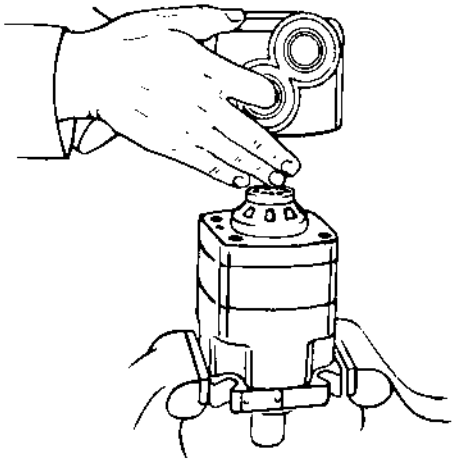


17. Align two pins of the balance ring with two spring holes in the valve housing. Install the balance ring in the housing.

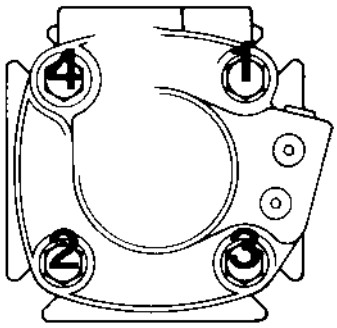
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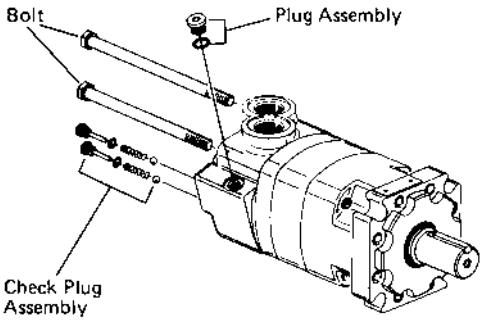
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18. Insert a finger through the port. Apply pressure to the side of the balance ring, holding it in position until the valve housing is in place. Align the case drain hole (refer to steps 11-13 for case drain hole location) in the valve housing with the case drain hole in the valve plate. Install the valve housing against the valve plate. Check between the body parts of the motor for unseated seals.





19. Gradually torque the bolts to 50 ft-lb (68 Nm), using the sequence shown.
20. Install the plug assembly and check plug assembly.

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Section 50-0: Common Electrical System

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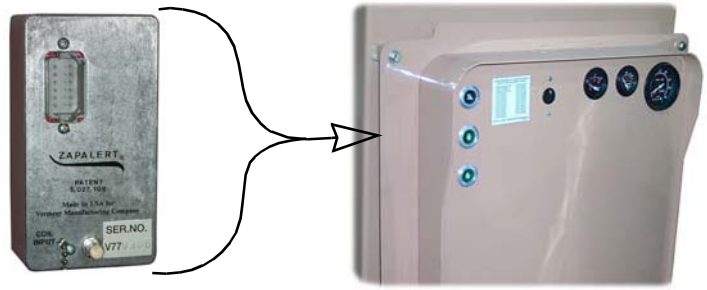
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“Voltage Test” Failed	50-3-13
“Current Test” Failed	50-3-16

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Section 50-1: Common Electrical System Overview

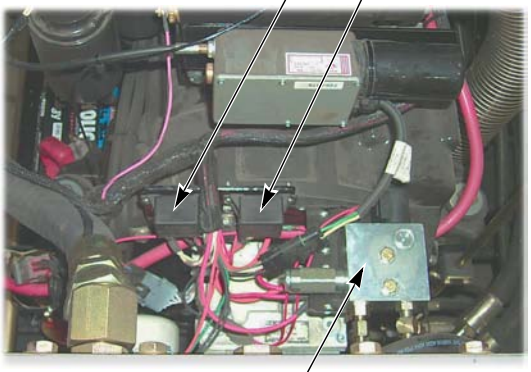
SYSTEM AND COMPONENT LOCATIONS



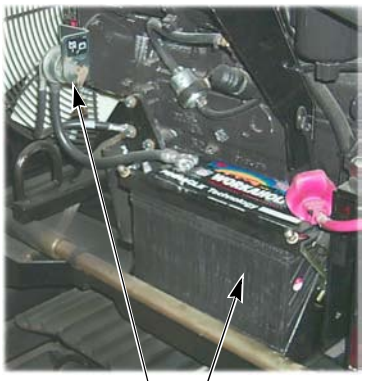
Strike Alert Box
(located behind panel)



DSR Module
(inside console)



Ignition Circuit Breaker
(15A)
Power Circuit Breaker
(40A)
(both circuit breakers are located under torque limiter mounting plate)



Battery

Ground Disconnect

Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Electrical System table of contents (will direct you to system and component information)	50-0-1
Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Engine	30-0-1
Strike Alert System	50-3-1

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OPERATION OVERVIEW

Connectors

Most of the circuits on the D33x44 use Deutsch connectors to provide maximum protection and service. The hydrostatic pumps and some other components use Packard (Weatherpack) or other types of connectors. Because of the harsh use and transport conditions, it is important to maintain the integrity of the connectors and to perform wire and harness repairs in a professional manner.

Grounding Terminals

Instead of using grounding terminal strips that are open to the elements, the D33x44 uses sealed Deutsch connectors that incorporate a grounding bus. Each of the three grounding connectors is grounded to the machine and to the other grounding connectors.

Power Relay and Circuit Breakers

Power from the battery/alternator to all eight circuit breakers comes from the power relay by way of the 8-ga. circuit '401' wire. The power relay is energized by circuit '001' from the 'A' terminal on the ignition switch whenever the ignition key is in ACC, RUN, or START.

Ignition Switch

The ignition switch does not carry machine power. Power from the ignition switch circuit breaker is available at the ignition switch 'B' terminal at all times. The ignition switch is used to energize the power relay for normal machine operation and the start relay to operate the starter solenoid.

Ground Disconnect

A ground disconnect between the battery negative terminal and the machine frame disconnects all electrical power.

DSR

The DSR control box prevents any operation of the drilling or rack functions unless sufficient voltage to operate the Strike Alert system is present.

Strike Alert

The Strike Alert system is functionally identical to previous Vermeer systems but uses a sealed Deutsch connector for greater reliability.

Seat Switch

The seat switch controls several hydraulic functions. When the seat is occupied, the transport valve is disabled and all other controls are enabled.

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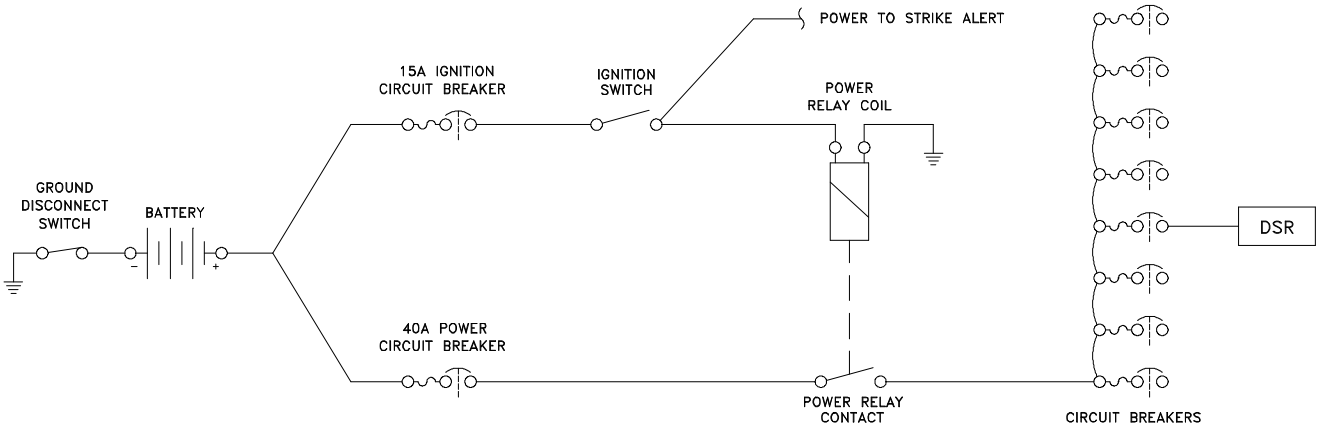
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SYSTEM SPECIFICATIONS

The following specifications are for the electrical system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
governed engine RPM	2200 rpm
Alternator	
rated amperage	63A @ 12V
Battery	
cold cranking amps (CCA)	950 cold cranking amps, 30 seconds, 0°F (-18°C)
reserve capacity	185 min, 25 amp output at 80°F (27°C)
BCI group size	31

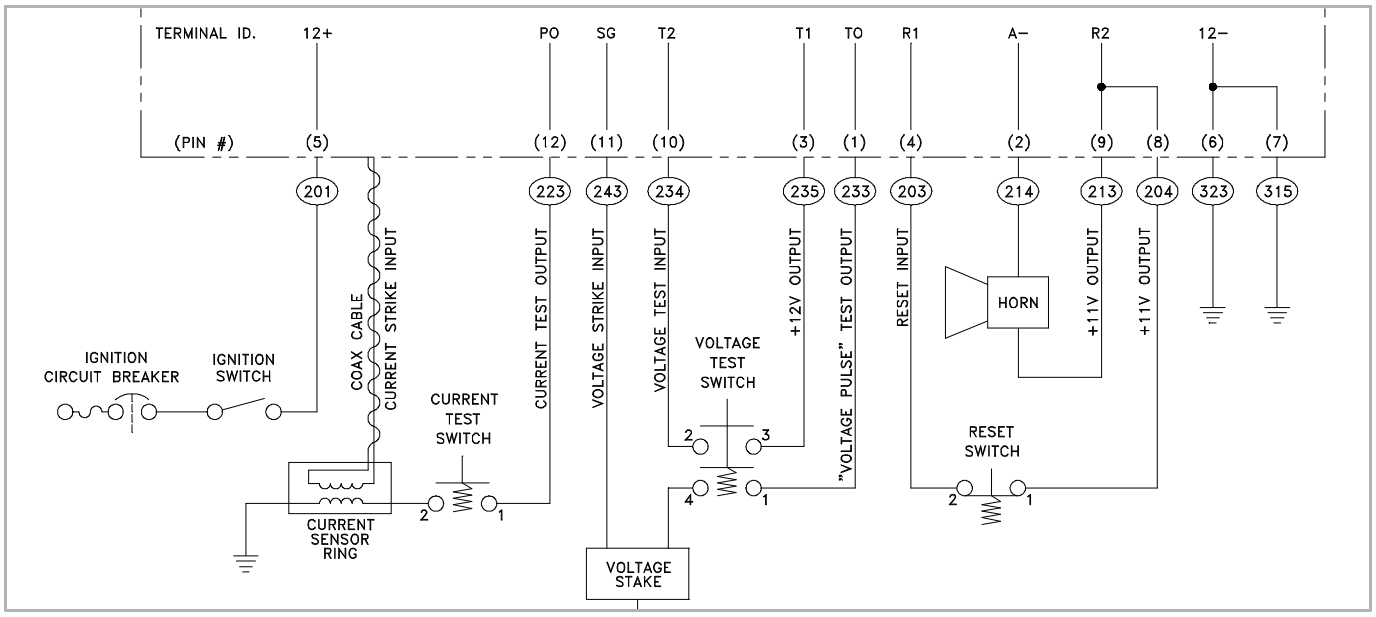
ELECTRICAL DIAGRAM - POWER CIRCUITS



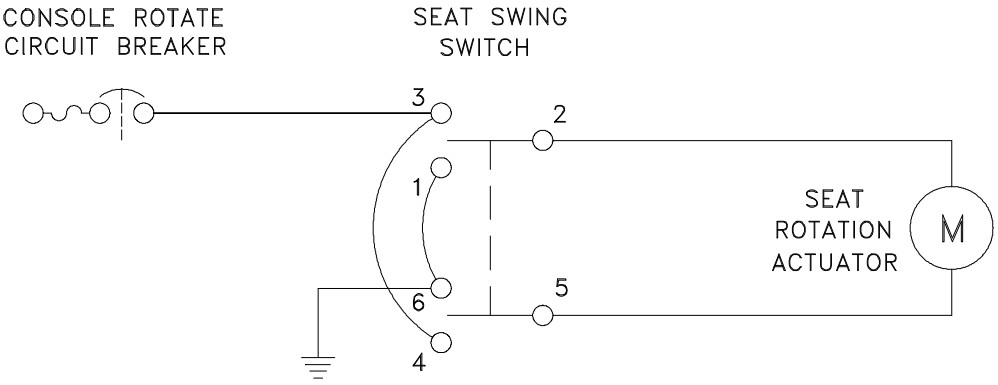
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ELECTRICAL DIAGRAM - STRIKE ALERT



ELECTRICAL DIAGRAM - SEAT ROTATE CIRCUIT



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Section 50-2: Common Electrical System Troubleshooting

HOW TO DO TROUBLESHOOTING

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

21. ***Is there a mechanical problem?***
22. ***Are the machine common systems operating correctly?***
23. ***Are the related systems working correctly?***
24. ***Are the controls working correctly?***

Check out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the electrical overall schematic and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, 15A ignition circuit breaker and 40A power circuit breaker) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Is the ignition switch OK?*** The ignition switch provides power directly to the strike alert and to the power relay coil.
5. ***Is the power relay OK?*** Power to the circuit breakers and the DSR travels through the power relay contacts when the ignition switch energizes the relay coil. Make sure the coil is not open and that the contacts operate and make good electrical contact.

Checking out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

SYMPTOM: NO POWER TO STRIKE ALERT

1. Is the ignition circuit live? Strike alert power is provided from the 15A ignition circuit breaker through the ignition switch.

Possible Problem	Possible Effect	What to do
Ignition circuit breaker tripped or defective, or ignition switch defective	Strike alert power is provided from the 15A ignition circuit breaker through the ignition switch.	**Check the ignition circuit breaker. Check that power is available from the ignition switch 'A' terminal to the strike alert module.**

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SYMPTOM: NO POWER TO CIRCUIT BREAKERS OR DSR

1. Is the power circuit live? Circuit breaker and DSR power is provided from the 30A power circuit breaker through the power relay.

Possible Problem	Possible Effect	What to do
Ignition circuit breaker or ignition switch defective	Power relay coil power is provided from the 15A ignition circuit breaker through the ignition switch.	**Check the ignition circuit breaker. Check that power is available from the ignition switch 'A' terminal to the power relay coil.**
Power circuit breaker or power relay defective	Power relay contact power is provided from the 30A power circuit breaker through.	**Check the power circuit breaker. Check the power relay.**

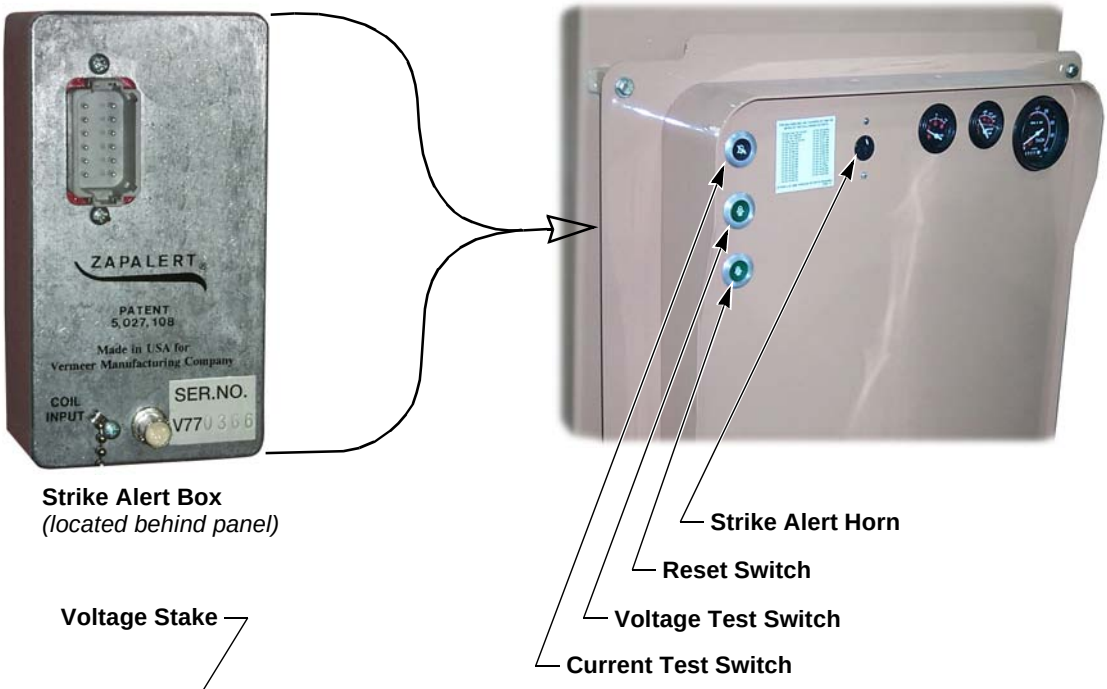
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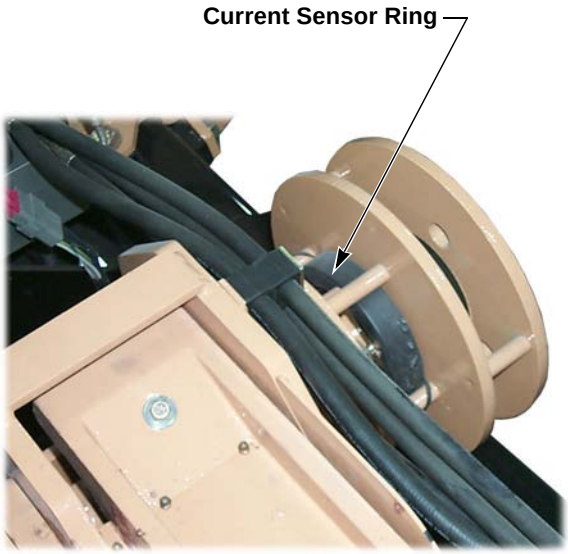
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Section 50-3: Strike Alert System

STRIKE ALERT SYSTEM







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OPERATION OVERVIEW

Operation

The Strike Alert system consists of an electronic module mounted inside the control console, a voltage stake, a current sensing coil, and an alarm mounted on the console. The Strike Alert system can detect an electrical strike by sensing a voltage potential or current flow.

When an electrical strike occurs, the boring machine becomes electrically charged and the machine will also allow current flow if a ground path is available.

The “voltage strike” circuit senses an electrically charged machine by the voltage difference between the *high-voltage machine* when it has struck a voltage source and *low voltage* at the voltage stake. The “current strike” circuit uses a current coil to sense current flow in the drill pipe.

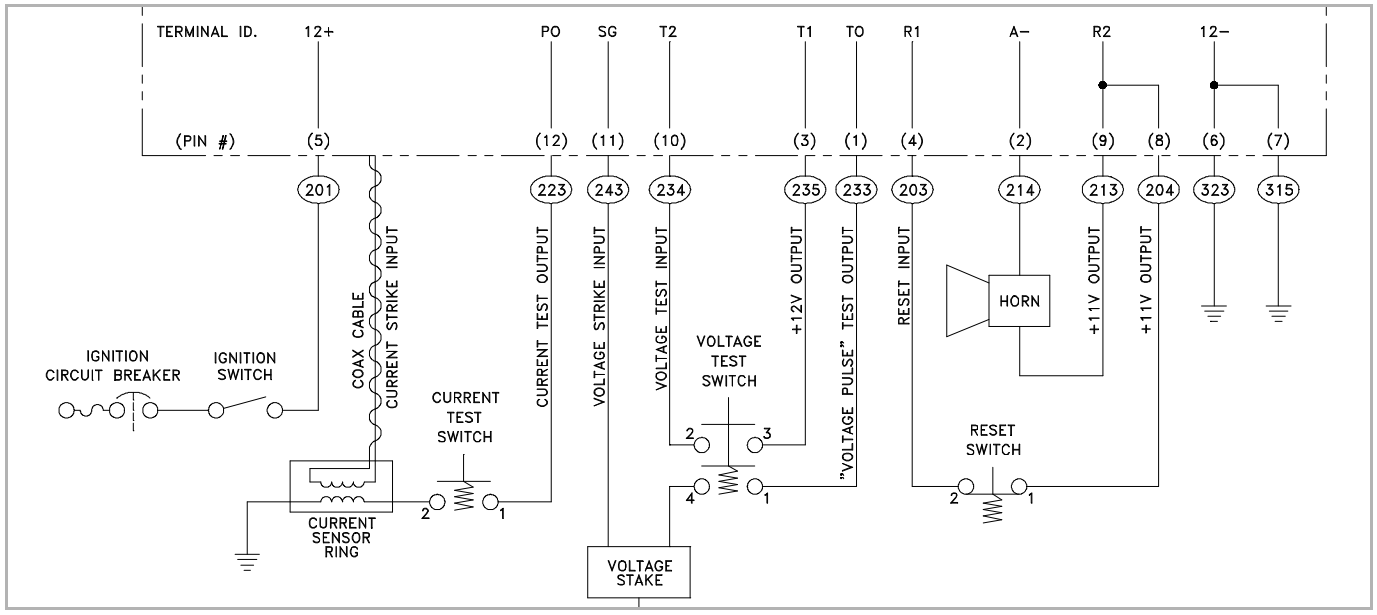
Circuit Action

Current Strike: Current induced into the sensing ring travels through the coax into the strike alert box. The box senses the current and grounds terminal ‘A-’, sounding the alarm.

Voltage Strike: Voltage present at the ground stake is sensed at terminal ‘SG’. The box grounds terminal ‘A-’, sounding the alarm.

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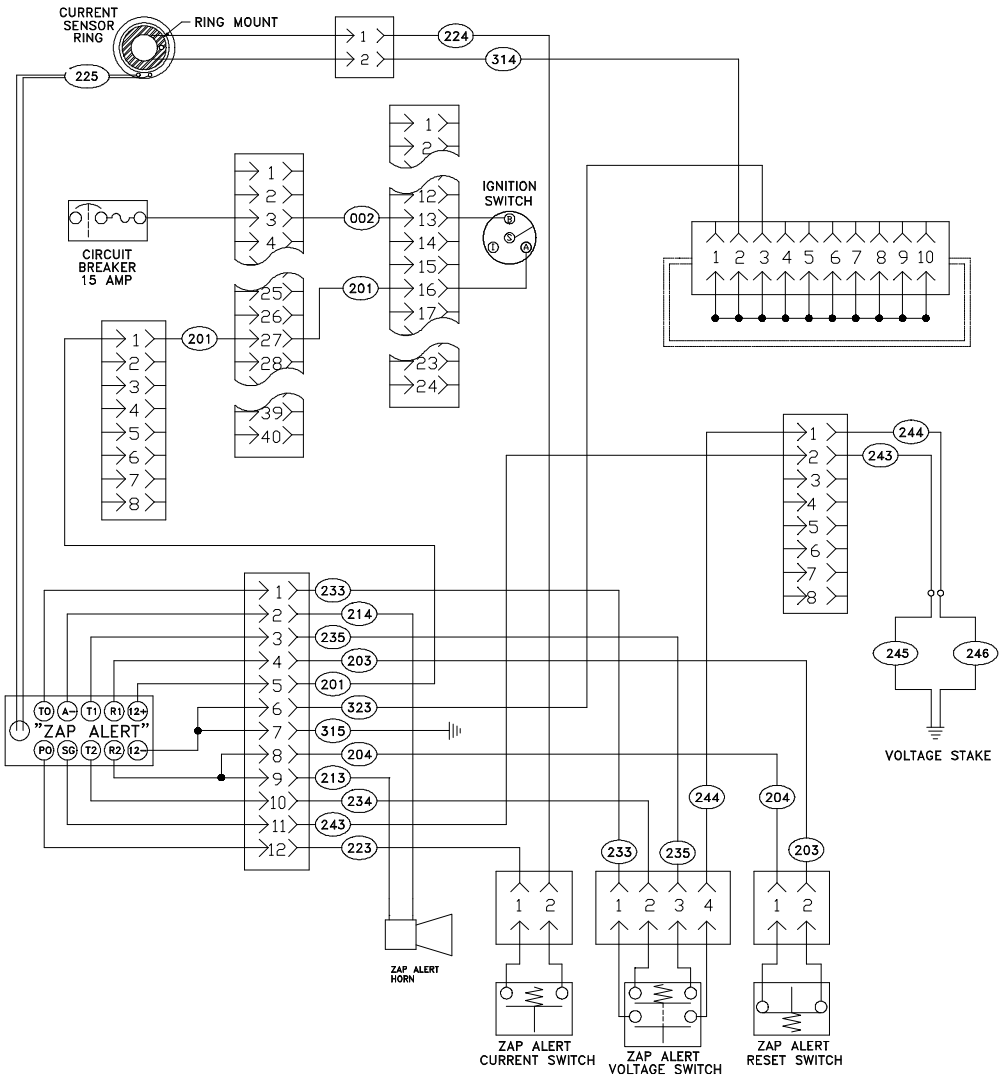
System Diagram



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Strike Alert Schematic



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COMPONENTS

Current Sensor Ring

The current sensor ring senses any current traveling through the drill rod and sends a signal through the coax cable to the strike alert box.

Strike Alert Reset Switch

The reset switch is a single-pole normally closed switch. Pushing the switch disconnects module terminals 'R1' and 'R2'. This interrupts power to the internal tester, shutting off the alarm and resetting the circuit.

Strike Alert Voltage Switch

The voltage test switch is a double-pole normally open switch. Pushing the switch accomplishes three results:

- it connects module terminals 'T1' and 'T2'
- it connects module terminal 'TO' to the voltage stake
- it triggers the internal test circuit to generate a voltage pulse at 'TO'. The test pulse travels through the test switch, through the voltage stake, and to module terminal 'SG', which triggers the alarm.

Strike Alert Current Switch

The current test switch is a a normally open single-pole switch. Pushing the switch allows a current spike to go from module terminal 'PO' through the switch to the current sensor ring. The ring coil senses the spike and sends a signal through the coax to the module, triggering the alarm.

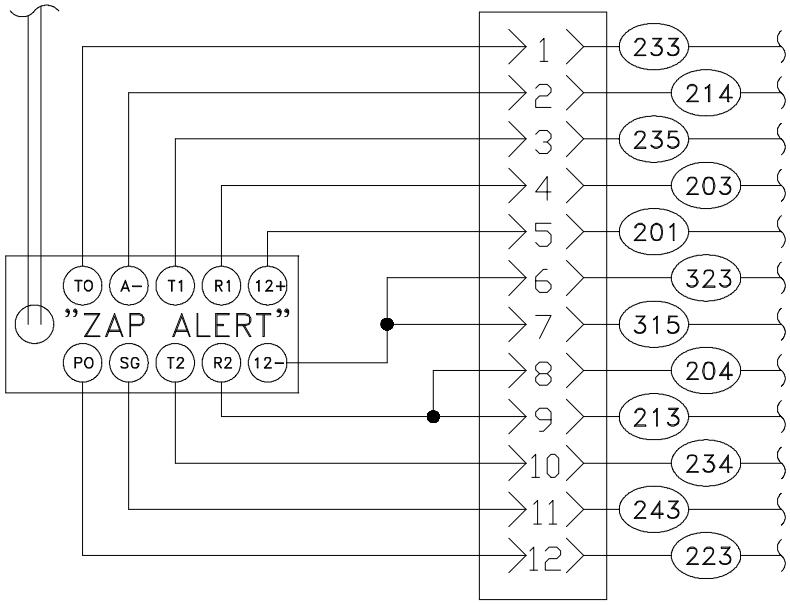
Strike Alert Horn

The strike alert horn sounds if current flow is sensed by the current coil, if a voltage difference is sensed between the machine and the voltage stake, or if the alarm is activated by a test.

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STRIKE ALERT BOX TERMINALS



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Deutsch Connector Pins	Strike Alert Box Terminals	Wire I.D.	Type	Function
1	TO	233 YL	test	Provides a brief voltage pulse at 60–150V to the voltage stake when the voltage test switch is pressed. Connected to terminal ‘1’ of voltage test switch.
2	A-	214 YL	control	Grounds horn when a strike is detected. Connected to horn ground terminal.
3	T1	235 BU	+12V	Provides +12V to terminal ‘3’ of voltage test switch.
4	R1	203 RD	voltage supply	Provides battery voltage (less 1/2–1V) to terminal ‘1’ of reset switch.
5	12+	201 OR	+12V	Receives +12V from ignition switch pins “AC”or “A” when key is in RUN or ACC.
6 and 7	12-	323 BK 315 BK	GND	Grounds strike alert box, and current test circuit in current sensor ring.
8	R2	204 RD/BK	test	Senses voltage from ‘R2’ (through reset switch). Connected to horn ‘+’ terminal.
9	R2	213 RD/BK	voltage supply	Provides battery voltage (less 1/2–1V) to the horn ‘+’ terminal.
10	T2	234 BU	test	Senses +12V from ‘T1’ terminal through voltage test switch. Connected to terminal ‘2’ of voltage test switch.
11	SG	243 YL	sensing	Senses “strike” or “voltage test” voltage at voltage stake . Connected to voltage stake.
12	PO	223 PK	test	Provides a +12V signal to induce a current in the current sensor ring.
Coax			sensing	Senses “strike” current in the drill stem. Connected to the current sensor ring.

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MAINTENANCE

Make sure the voltage stake cable connectors are clean and connectors are not damaged. The voltage stake cable must be securely attached to the strike alert box.

It is important for the voltage stake to be inserted in ground that conducts electrical current. If the voltage stake is in extremely dry soil or asphalt, the Strike Alert may not function. Soaking the soil around a stake with water may improve the soil conductivity to enable the Strike Alert to function. Be sure to fully insert the stake into ground.

Possible Causes for Failure

There are several conditions that could possibly cause a failure of the Strike Alert Box. These include:

- R1 or R2 is shorted to ground
- The horn has a direct short across its terminals
- A- shorts directly to +12V for several seconds (might not show up until unit is tested)
- TO shorted directly to +12V for several seconds.
- Direct ground on T1 or T2 (should also heat up the wires to 12+ and the voltage test switch

Grounding or applying +12V to SG or PO should not cause damage.

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TEST CONNECTOR FABRICATION

The strike alert box uses a 12-pin Deutsch connector instead of screw terminals. For testing, a jumper harness may be fabricated:

1. Cut twelve 12” (30 cm) lengths of wire. Install a Deutsch pin on one end and a Deutsch socket on the other end of each wire.
2. Insert the wires into the appropriate Deutsch plug and connector bodies, carefully matching pin number to pin number
3. Fabricate twelve 6” (15 cm) wires with Deutsch sockets. “Tee-splice” the 6” (15 cm) wires to the 12” (30 cm) wires.
4. Insert the socket ends of the 6” (15 cm) wires into a Deutsch connector to be used as a test location, carefully matching the wires to the appropriate socket numbers.
5. Check that the test wires travel from pin ‘1’ of the first connector to socket ‘1’ of the second connector, pin ‘2’ to socket ‘2’, and so forth. In addition, check that each “tee-splice” wire is connected to the correct socket location of the test plug.

Use the instructions that follow for diagnosis. Note that the pin numbers in the diagnostic procedure refer to the **pin locations on the fabricated connector** rather than the screw terminals on the old-style strike alert module.

OPERATION TEST

If Horn Sounds Constantly

If the horn sounds contantly whenever the key is on, go to the *Horn Won't Shut Off* test below.

Normal Operation Test

Unwind the cable for the voltage stake and lay the stake on the ground. It must not be in the ground, in its holder, or touching any part of the machine. With the key on and the engine not running, first press the current test button and then the voltage test button. The warning horn should sound for each test. Pressing the reset button after each test should shut off the horn. ***If OK, the machine may be used.***

If not OK, proceed to the *Strike Alert System Test* below.



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HORN WON'T SHUT OFF - TEST

If the horn will not shut off, either the coil is damaged or shorted OR the strike alert box has failed internally. While the horn is sounding, disconnect the coax connector and install the metal cap onto the BNC box terminal.

If the horn shuts off, the coil or coil wiring is damaged. Replace the coil and retest the strike alert system.

If the horn does not shut off, the coil is probably OK but the strike alert box is probably defective. Review the circuit diagram and the *System Test* procedures to verify that inputs to the strike alert box are OK.

- *If any input problem is found*, correct the condition and retest the strike alert system.
- *If no input problem is found*, replace the strike alert box and retest the strike alert system.

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SYSTEM TEST

Perform this check if the strike alert system does not sound the alarm when either the voltage test or the current test switches are pressed.

Power and Ground Test

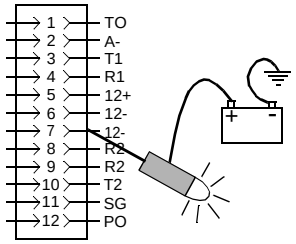
NOTE: Be alert for intermittent conditions; recheck all steps if results are inconsistent or do not make sense. (This test should diagnose most problems, however, intermittent conditions and shorts or opens that change during the course of the testing can give false or misleading results and cannot be anticipated by the tests.) Do not begin in the middle of any of the tests—each step must be performed in sequence. If "battery voltage" is specified, allow for battery voltage drop during the time period of testing with the key on and the engine not running.

*Perform all tests with the **key on** and the **engine not running**. Test points shown refer to Deutsch terminals on a fabricated test harness. Refer to system diagram for accuracy.*

Check grounding:

1. The strike alert box must be grounded, and terminal '12-' must be grounded securely to the engine frame and battery. Check all ground connections in the circuit; disconnect and clean if necessary. Check that a high current non-powered test light attached to battery '+' will light when grounded to box terminal '12-' (pin '7' on the test harness). Perform repairs as necessary. ***If OK, proceed to step 2.***

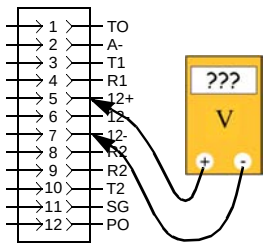
   If not OK, correct ground problem.



Check voltage supply:

2. Check the voltage between box terminals '+12' and '-12' (pins '5' and '7' on the test harness). It should be between 11.5 and 12.6V. ***If OK, proceed to step 3.***

   If not OK, correct voltage supply problem and retest strike alert system.



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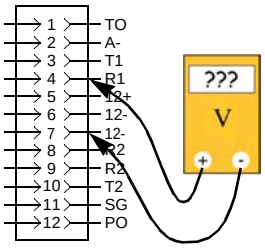
Reset and Horn Test

Perform this check if "Power and Ground Test" is OK but the horn does not sound when the voltage test or the current test button is pressed.

Check voltage output from R1:

3. Check the voltage between box terminals 'R1' and '12-' (pins '4' and '7' on the test harness). It should be approximately 0.5–1.0V less than battery voltage. ***If OK, proceed to step 4.***

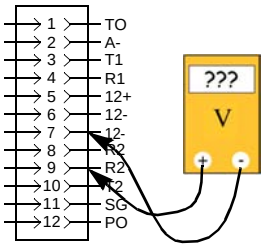
If not OK, wire '203' (RD) from 'R1' to the reset switch, or wire '204' from the reset switch to 'R2' has been shorted to ground. Install a new strike alert box. Before installing the box, be sure that wires '203' and '204' are no longer shorted to ground.



Check reset button continuity:

4. Check the voltage between box terminals 'R2' and '12-' (pins '9' and '7' on the test harness). It should be approximately 0.5–1.0V less than battery voltage. ***If OK, proceed to step 5.***

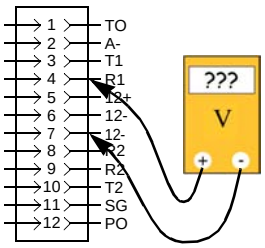
If not OK, fix the reset switch or wires.



Check reset button operation:

5. Check that voltage between box terminals 'R1' and '12-' (pins '4' and '7' on the test harness) drops to 0V when the RESET button is held in. ***If OK,*** **proceed to step 6**.

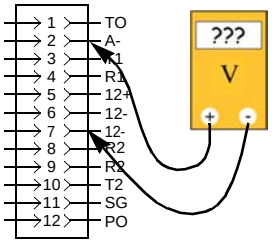
If not OK, the reset button is not opening the reset circuit. Replace the reset switch.



Check for complete circuit from 'R1' to horn:

6. Check voltage between box terminals 'A-' and '12-' (pins '2' and '7' on the test harness). This is an "open circuit voltage" check—this voltage is measured through the horn. It should be battery voltage minus 0.5–1.0V. ***If OK, proceed to step 7.***

If not OK, the horn may be open (or power is not available at the horn). Recheck that there is battery voltage minus 0.5–1.0V at the horn '+' terminal ***(see step 3)***, then check the horn for continuity. If no continuity, repair wiring or replace horn as indicated and retest Strike Alert.



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Check that horn can sound:

7. Touch '214' (YL) test wire to a frame ground. Horn should sound at full loudness until the wire is removed from ground or the RESET button is held in.

If not OK, replace horn and recheck strike alert.

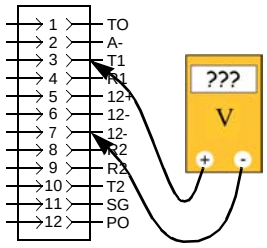
***If OK*, proceed to step 8**, *"Voltage Test Failed"*, **or to step 13**, *"Current Test Failed"*.

"Voltage Test" Failed

Perform this check if "Power and Ground Test" is OK and "Reset and Horn Test" is OK, but horn does not sound when VOLTAGE test button is pressed.

Check 'T1' output voltage:

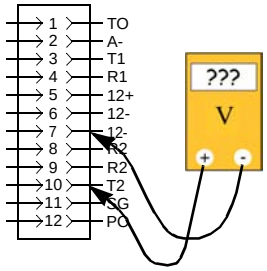
8. Check the voltage between box terminals 'T1' and '12-' (pins '3' and '7' on the test harness). It should read battery voltage. ***If OK, proceed to step 9.***



If not OK, check for wires '235' (BU) and '234' (BU) shorted to ground, which would damage the 'T1' output circuit of the strike alert box. Repair any suspected shorts to ground. Mark the box "**no output at 'T1'**" then install a new strike alert box.

Check voltage test switch operation:

9. Check voltage between box terminals 'T2' and '12-' (pins '10' and '7' on the test harness) while you press the VOLTAGE button. It should read battery voltage. ***If OK, proceed to step 10.***



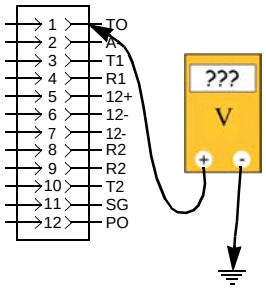
If not OK, replace the voltage test switch, or repair wiring between 'T1' and 'T2' as required and retest strike alert system.

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Check the "voltage pulse" output to 'TO':

10. ***SET UP:*** This test requires a DVOM with an AC voltage "peak and hold" function. Terminal 'TO' will put out a brief AC voltage that lasts only one or two microseconds, so a normal voltmeter setting will not capture the voltage peak. Set a DVOM to AC Volts. Hold the red (+) test lead on test harness pin '1' (box terminal 'TO'). Attach the black (-) test lead to a frame or battery ground.



TEST: Press the MIN/MAX button on the DVOM. Press the voltage test button on the machine. Press the MIN/MAX button and observe the MAX reading. It should be approximately 60–150V. (Repeat the test once or twice to ensure a good capture.) ***If OK, proceed to Step 11.***

If not OK (peak voltage is low), disconnect the test wire '233' (YL) from pin '1' of the test harness (terminal 'TO' of the box) and retest. If there is still *no output*, mark the strike alert box **"no output at 'TO'"** and install a strike alert box and retest. If there *is output* with the wire disconnected, check the resistance from the disconnected wire '233' (YL) to the frame both with the voltage test switch OPEN and also with the voltage test switch held CLOSED. If less than 1000 ohms, find the short and repair it, then retest the strike alert system.

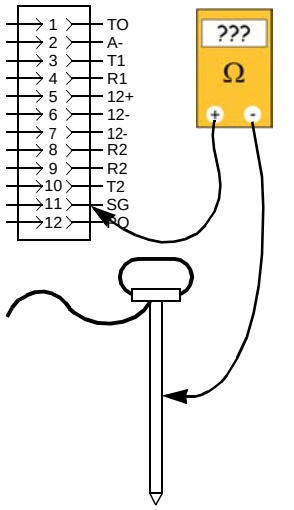
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Check 'SG' (voltage sensing) terminal:

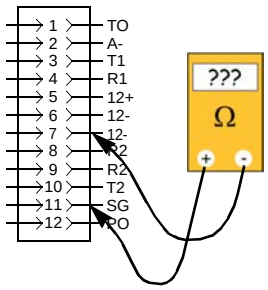
11. Position the voltage stake so it is not touching the machine and check that there is continuity from box terminal 'SG' (pin '11 on the test harness) to the voltage stake (should be less than 20 ohms). ***If OK***, proceed to step 12.

If not OK, check each section of the ground stake circuit for damage or short to ground and repair as necessary.



12. Check that there is more than 1 meg ohm impedance from box terminals 'SG' to '12-' (pins '11' to '7' on the test harness). ***If OK***, and the power, ground, reset, and horn tests were OK, replace the strike alert box and retest the Strike Alert system.

If not OK, check for anything shorting 'SG' to ground. If there is nothing external shorting to ground, mark the box **"no voltage strike,"** install a new strike alert box and retest the strike alert system.



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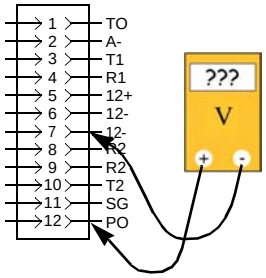
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"Current Test" Failed

Perform this check if "Power and Ground Test" is OK, "Reset and Horn Test" is OK, but horn does not sound when CURRENT test button is pressed.

Check 'PO' (current test switch) terminal for available battery voltage:

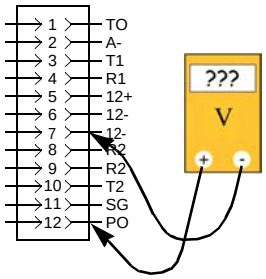
13. Wait several seconds after the current test switch has been pressed to perform this test. Check voltage between box terminals 'PO' and '12-' (pins '12' and '7' on the test harness. It should be battery voltage. ***If OK, proceed to step 14.***



If not OK, check if the 'PO' wire '223' (PK) is shorted to ground. *If it is shorted*, repair the harness and retest the strike alert system. *If it is not shorted*, mark the box **"no output at 'PO'"** and install a new strike alert box and retest the Strike Alert system.

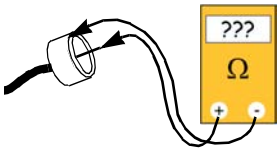
Check current test circuit and current coil continuity:

14. Make sure the current coil is connected. Check that voltage between box terminals 'PO' and '12-' (pins '2' and '7' on the test harness) drops to zero or nearly zero when you press the CURRENT test switch. ***If OK,*** mark the box **"no current strike,"** install a new strike alert box and retest the Strike Alert system.



If not OK, check the continuity of the coil test circuit. Check that there is continuity (very low resistance) between wire '224' (PK) at the current test switch and wire '314' (BK) at the console ground. If no continuity, repair the open condition and retest the strike alert system.

Also check continuity of the coil winding: Disconnect coax from box and test continuity between center wire and the outside metal connector. It should be an ohm or less. If no continuity, coil or coax is damaged. Replace coil and connect coax, then recheck strike alert system.



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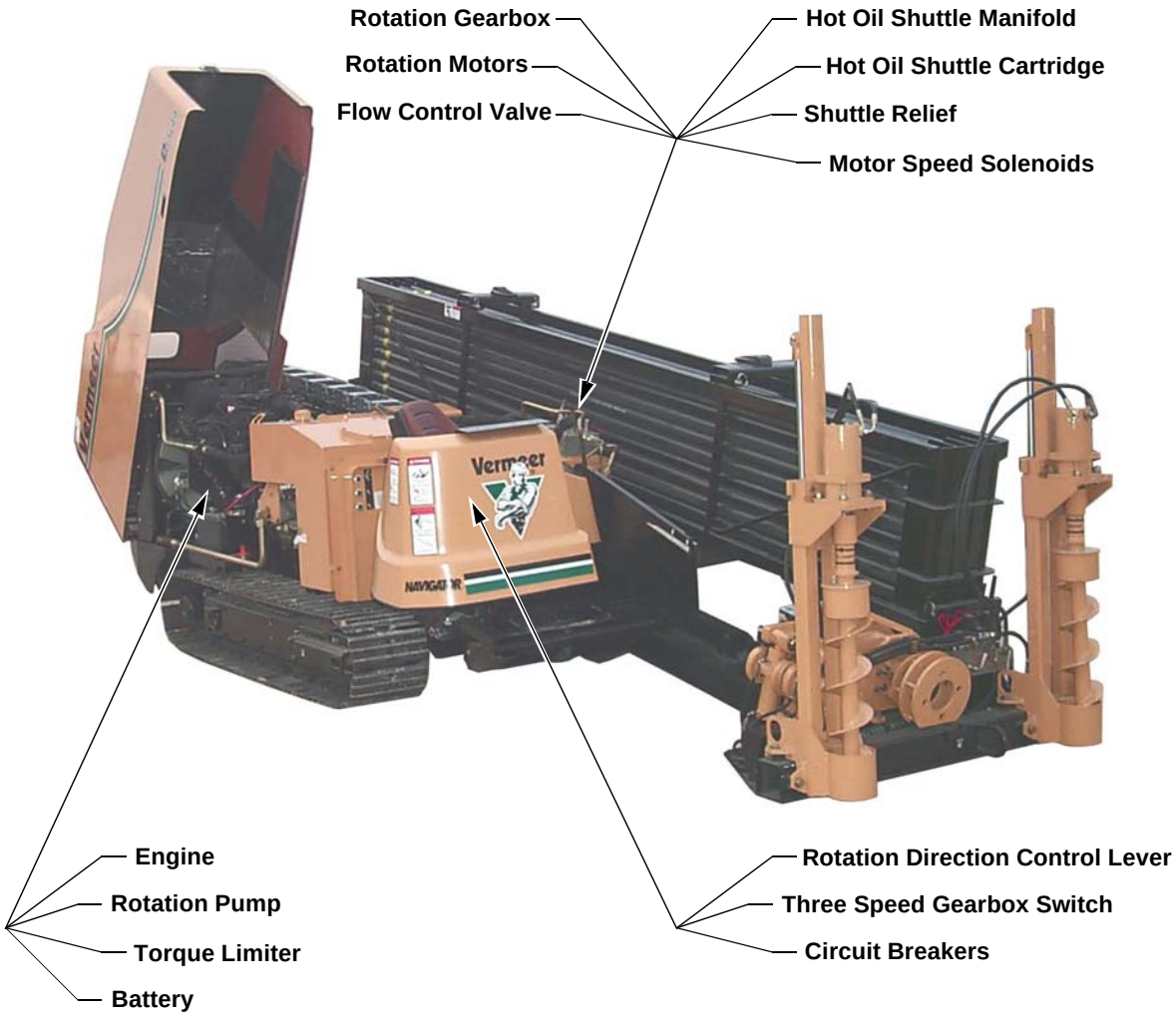
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Section 70-1: Rotation System Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Rotation System table of contents (will direct you to system and component information)	70-1-1
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OPERATION OVERVIEW

Engine

The engine drives the hydrostatic rotation pump which supplies oil to the rotation motors. The motors are splined to a common shaft in the drill gearbox. The gearbox reduces the speed and increases the torque available to the drive chuck.

Rotation Pump

The rotation pump provides a variable output to drive the chuck at speeds ranging up to the maximum available in each speed range. Three speed ranges may be selected by shifting one or both of the motors into reduced displacement mode.

Charge Pump

The rotation pump charge pump provides pilot oil pressure to shift the motors' speed and displacement. Oil from the charge pump is also supplied to the rotation closed loop to replace leakage and to allow a percentage of the closed loop oil to be sent to the hydraulic oil cooler by way of the shuttle valve.

3-speed/loop flush valve

The 3-speed/loop flush valve on top of the gearbox incorporates the hot oil shuttle valve, the hot oil shuttle relief valve, and the shift solenoids.

Oil from the shuttle is routed into the rotation motor cases, past the drive shaft of each motor into the rotation gearbox, and out the gearbox through the return line into the return manifold and into the tank. This oil is used to remove heat from the closed loop and to lubricate and cool the gearbox.

Operation

Correct operation of the system requires that the engine is turning at rated rpm, oil supply is unrestricted to the charge pump, and the charge filter is not plugged or "dirty". The hot oil shuttle must remove sufficient oil from the loop to keep the closed loop operating temperature within specifications and to keep the gearbox lubricated and cooled. Back pressure in the case return line must not exceed the maximum specified or the following may result - "blown" seals, insufficient hot oil shuttle flow, high case temperature, high loop temperature, or erratic operation of the speed shift function.

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SYSTEM SPECIFICATIONS

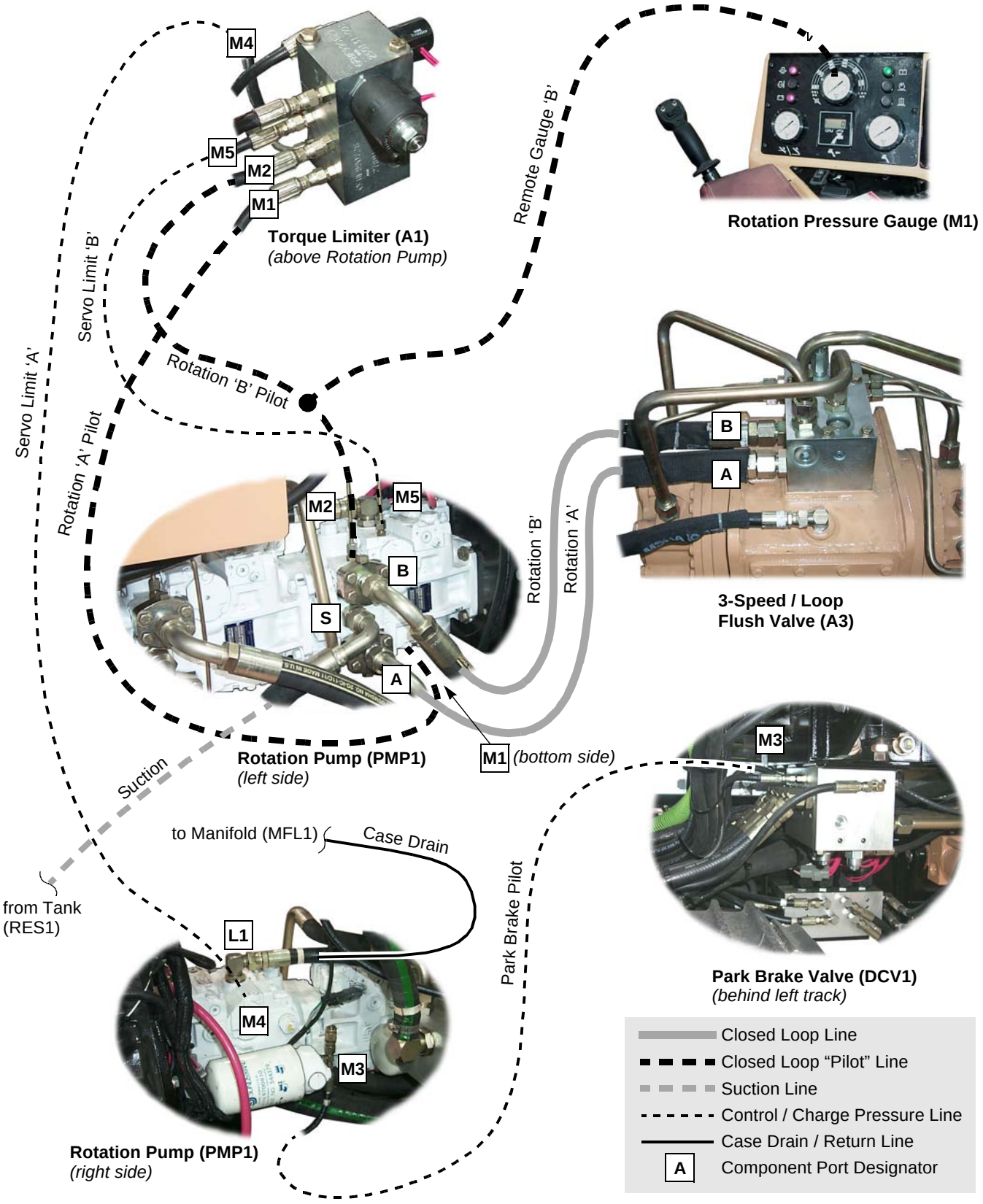
The following specifications are for the rotation system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
Rated engine RPM	2200 rpm
Gearbox	
Maximum allowable case pressure (cold)	100 psi (6.9 bar)
Typical case pressure (depending on ambient temperature and duty cycle)	60-25 psi (4.1 - 1.7 bar)
Rotation Speeds at 2200 Engine RPM	
LOW	117 rpm
MEDIUM	156 rpm
HIGH	234 rpm
Pump	
Make / Model	Sundstrand 90 series
Specification number 90R055 KP1CD 80P3S1 C00GBA 424224	
Pressure limiter setting (multifunction valve) for FORWARD rotation	6090 psi (420 bar)
Pressure limiter setting (multifunction valve) for REVERSE rotation	6090 psi (420 bar)
Torque limiter setting for FORWARD rotation	4100 psi (280 bar)
Torque limiter setting for REVERSE rotation	1500 psi (105 bar)
Displacement per revolution	3.35 cid (55 cc)
Nominal flow @ 2200 rpm	32 gpm (121 L/min)
Maximum allowable case pressure (cold)	73 psi (5 bar)
Maximum allowable case pressure (normal operating temperature)	44 psi (3 bar)
ISO oil cleanliness standard	ISO 18/13
Charge Pump (oil temperature must be 120°F (50°C) or more)	
Displacement per revolution	0.86 cid (14 cc)
Relief pressure setting (check in neutral)	350 ± 25 psi (24 ± 1.7 bar) @ 1750 rpm
Nominal flow at 2200 rpm	9.3 gpm (35 L/min)
Shuttle relief and flow	relief 300 psi flow 2.0 gpm (7.6 L/min) +/- 10%

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HOSE ROUTING - ROTATION PUMP



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Hoses

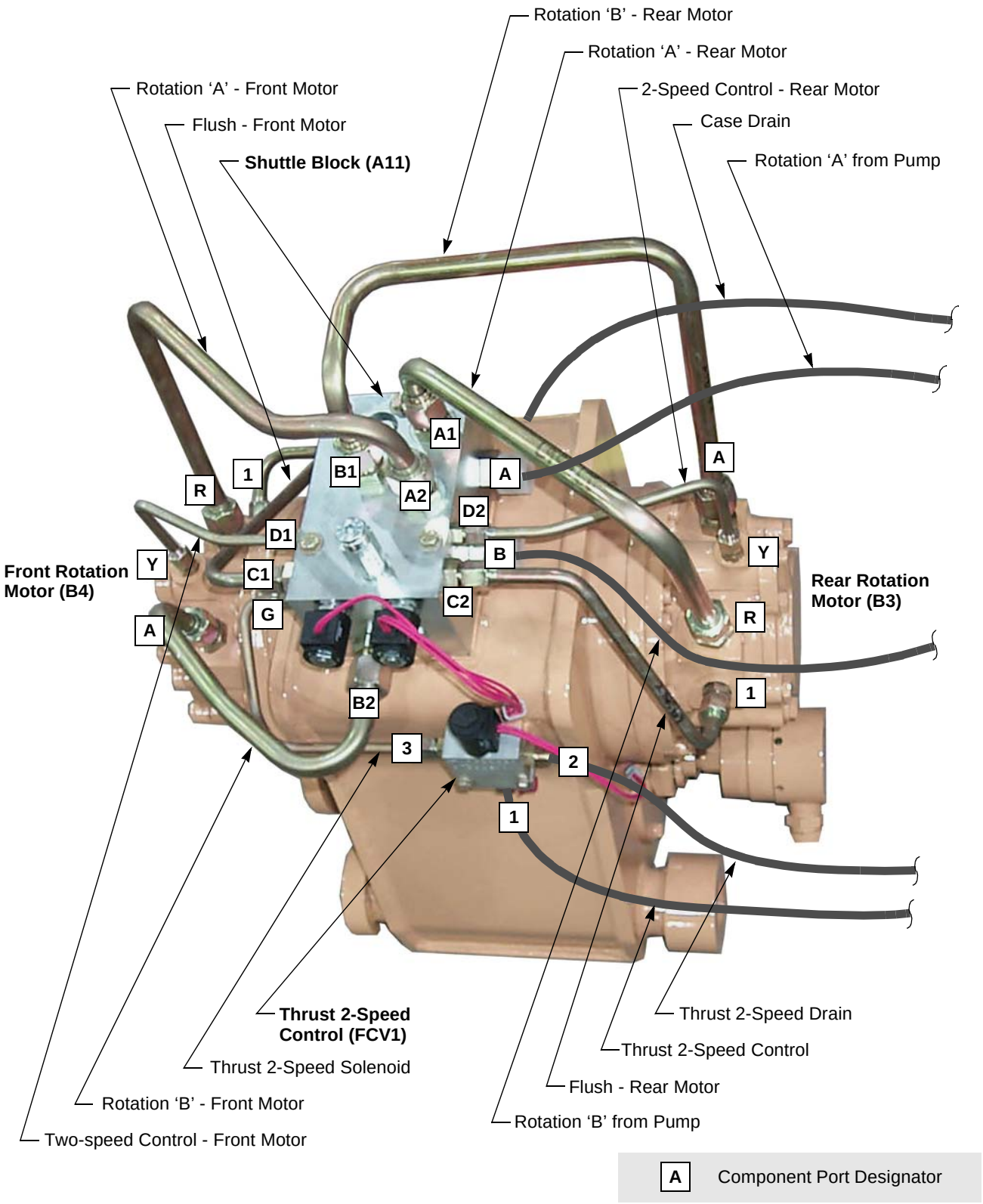
Hose ID/ Pressure	Circuit Type	Function
Rotation 'A' *forward*: low side pressure *reverse*: high side pressure	closed loop	Rotation pump (PMP1) closed loop 'A' circuit to 3-speed/loop flush valve (A3).
Remote Gauge 'B' 'B' side loop pressure	gauge	Provides 'B' side loop pressure signal to rotation pressure gauge (M1) at the operator's station.
Rotation 'B' *forward*: high side pressure *reverse*: low side pressure	closed loop	Rotation pump (PMP1) closed loop 'B' port to shuttle block (A3).
Case Drain nominal pressure	return	Drains rotation pump case drain (including excess charge flow) to the return manifold (MFL1) or to tank through the check valve.
Servo Limit B nominal pressure	pilot	Provides signal from torque limiter pressure relief to destroke the rotation pump (PMP1); limits 'B' side only.
Servo Limit A nominal pressure	pilot	Provides signal from torque limiter pressure relief to destroke the rotation pump (PMP1); limits 'A' side only.
Suction	suction	Supplies oil to charge pump inlet from tank (RES1) whenever engine is turning.
Park Brake Pilot charge pressure	pilot	Provides charge pressure to release the park brake.
Rotation 'B'Pilot *forward*: high side pressure *reverse*: low side pressure	pilot	Provides rotation 'B' pressure signal to torque limiter.
Rotation 'A'Pilot *forward*: low side pressure *reverse*: high side pressure	pilot	Provides rotation 'A' pressure signal to torque limiter .

*NOTE: under "standard operating conditions," the following pressures will normally be found in the circuits indicated:
"high side" pressures = 300–6090 psi (20–420 bar)
"low side" pressure = 300–500 psi (20–35 bar)
"nominal pressure" = 25–100 psi (1.7–6.9 bar)
"charge pressure" = 300–500 psi (20–35 bar) (same as "low side" pressure)

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HOSE ROUTING - ROTATION MOTORS



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Hoses

Hose ID/ Pressure*	Circuit Type	Function
Flush - Rear Motor **Flush - Front Motor** nominal pressure	flush	Carries oil from shuttle relief to flush (cool) the front or rear motor.
Rotation 'A' - Rear Motor **Rotation 'A' - Front Motor** *forward*: low side pressure *reverse*: high side pressure	closed loop	Rotation pump (PMP1) closed loop 'A' circuit. Common circuit with *Rotation 'A' - Front Motor*.
2-Speed Control - Rear Motor *apply*: charge pressure *release:* nominal pressure	pilot	Shifts 2-speed motor into high-speed/low displacement. Receives oil from hot oil shuttle when solenoid valve is energized. Common circuit with *Flush - Front Motor* and *Flush - Rear Motor* when solenoid is de-energized.
Rotation 'B' - Rear Motor **Rotation 'B'- Front Motor** *forward*: high side pressure *reverse*: low side pressure	closed loop	Rotation pump (PMP1) closed loop 'B' circuit.
Case Drain nominal pressure	return	Drains flush oil to return manifold (MFL1). Common circuit (through gearbox and motor cases) with *Flush - Front Motor* and *Flush - Rear Motor*.
2-Speed Control - Front Motor *apply*: charge pressure *release*: nominal pressure	pilot	Shifts two-speed motor into high-speed/low-displacement. Receives oil from hot oil shuttle when solenoid valve is energized. *Common circuit with Case Drain* when solenoid is de-energized.
Thrust 2-Speed Solenoid charge pressure	pilot	Provides charge pressure to shift thrust motors into high speed when Thrust 2-Speed Solenoid is energized. Common circuit with *Thrust 2-Speed Control* when solenoid is de-energized.
Thrust 2-Speed Control *apply*: charge pressure *release*: nominal pressure	pilot	Shifts 2-speed thrust motors into high-speed/low-displacement. Receives oil from hot oil shuttle when solenoid valve is energized.
Thrust 2-Speed Drain nominal pressure	return	Drains thrust two-speed shift oil to return manifold (MFL1).

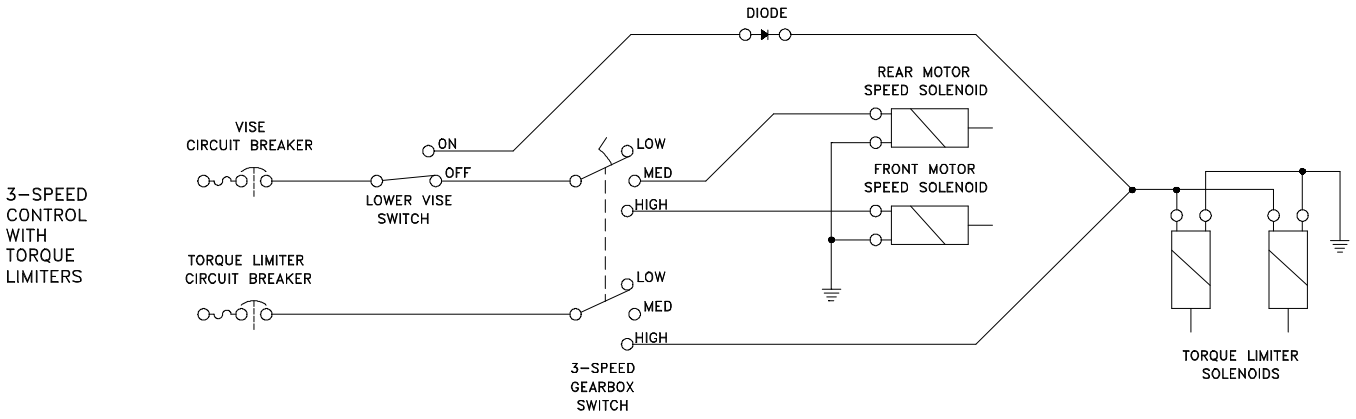
***NOTE:** under "standard operating conditions," the following pressures will normally be found in the circuits indicated:
"high side" pressures = 300–6000 psi (20–415 bar)
"low side" pressure = 300–500 psi (20–35 bar)
"nominal pressure" = 25–100 psi (1.7–6.9 bar)
"charge pressure" = 300–500 psi (20–35 bar) (same as "low side" pressure)

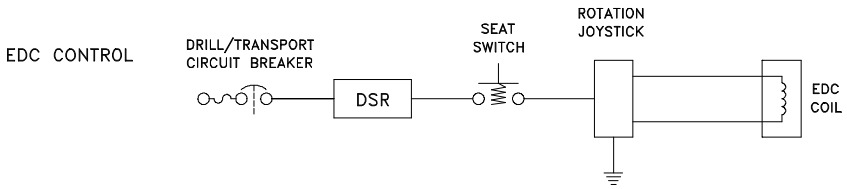
NOTE: In forward rotation, the pump 'B' port sends oil to the rotation motors 'A' ports; in reverse the rotation pump 'A' port sends oil to the rotation motors 'R' ports.

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ELECTRICAL DIAGRAM

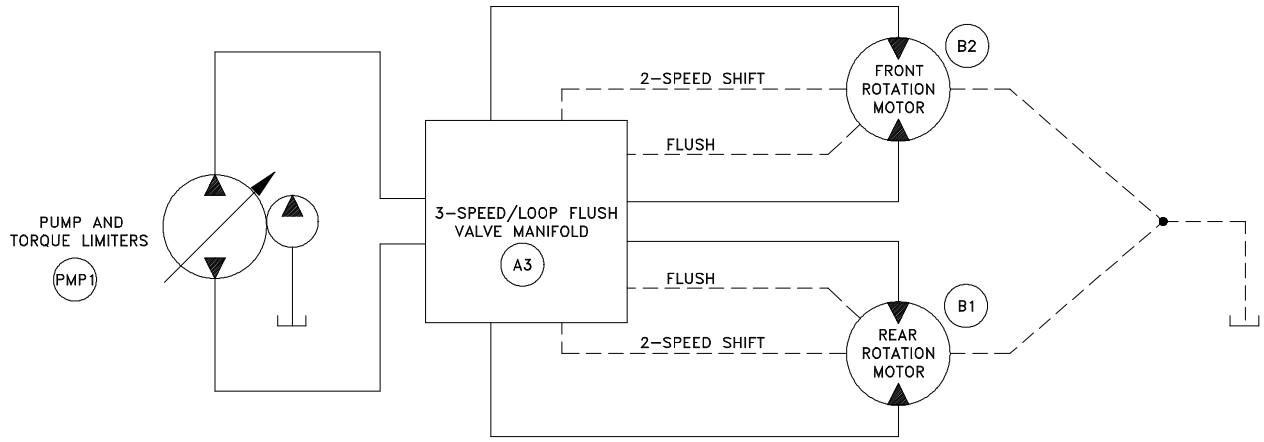




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HYDRAULIC DIAGRAM



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Section 70-2: Rotation System Troubleshooting

How To Do Troubleshooting

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***
5. ***Are the hydraulic components functioning correctly?***

Check out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, vise, torque limiter, and drill/ transport circuit breakers, and DSR) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are compromise.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** Rotation system switches include the seat switch, the lower vise switch, and the 3-speed gearbox switch,
5. ***Is any variable resistance OK?*** Make sure the resistance is within tolerances.
6. ***Are relay and solenoid coils OK?*** Make sure the current path is complete and the resistance is within tolerance, especially when the machine is hot.
7. ***Is the mechanical output OK?*** The solenoid valve or relay contacts—even if all electrical functions are OK, the valve may leak or fail to move, or the relay contacts may stick or not conduct current.
8. ***If a control module is used, are all of its circuits OK?*** Does a control module system have correct voltage and ground, inputs, and complete current paths on all circuits? Most “module failures” are the result of a problem in the voltage source, current path, ground, switch or resistor function, or actuator failure. Check all those items before replacing a module.

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Checking out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is a variable signal based on function demand being delivered to the compensator, either from a variable control such as the transport or water control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motors work ok unless the motors are worn, defective, incorrect replacements, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Some electrically controlled systems using variable current control of proportional solenoids might also change with temperature since current and temperature can be closely related.

Checking out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

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SYMPTOM: LOW ROTATION TORQUE OR PRESSURE, OR WILL NOT SHIFT

1. Are the machine common systems operating correctly? Operating the machine outside of intended parameters (i.e. in HIGH when it should be in MEDIUM or LOW) can lead to customer complaints. Also, oil level, operating temperature, oil cooler operation, engine speed and power outside of specifications can cause or contribute to faulty operation.

Possible Problem	Possible Effect	What to do
3-speed switch is set to HIGH or MEDIUM	If the drill is operated in HIGH speed, motor torque AND system pressure will be reduced. If the drill is operated in MEDIUM, motor torque output will be reduced.	**Use the appropriate switch setting.**
Hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
Engine RPM too low		**Check engine RPM** while operating under load.
Overheating	A blocked oil cooler, plugged hot oil shuttle valve, or other conditions causing overheating of the hydraulic oil can cause various problems.	**Check hydraulic oil cooler.**

2. Is the torque limiter applied or misadjusted? The torque limiter sends oil to the pump servo to destroke the pump. Faulty operation, or operation when it is not desired, will limit pump pressure.

Possible Problem	Possible Effect	What to do
3-speed switch malfunction	If an electrical signal is sent to the torque limiter causing the torque limiter to be applied, rotation pressure will be limited.	**Check for unintended torque limiter "ON" signal** from the 3-speed switch and replace switch if necessary (refer to page **70-4-9**).
Torque limiter solenoid valve is defective or dirty	If the solenoid valve leaks loop oil to the pressure relief, pump pressure will be limited to the pressure relief setting.	**Check solenoid valve for leaking:** Either cap off the torque limiter and pump ports to see if the pump will operate normally without the limiter OR check the torque limiter using a "pressure leak test" (refer to page **70-5-4**).
Torque Limiter pressure relief valve defective or dirty	If the pressure relief setting is incorrect, or the relief or an o-ring is leaking, pump pressure will be lower than desired whenever the torque limiter solenoid valve is energized.	**Check pressure relief for leaking:** O-rings, valve torque, valve cavity condition (refer to page **70-5-8**).

Continued on next page...

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3. Is the charge pressure low? Charge pressure and flow is needed to control the pump servo. Low charge pressure will lead to loss of pump control.

Possible Problem	Possible Effect	What to do
Low hydraulic oil level	Oil level must be within sight glass. Low oil level can cause air to enter the charge pump if the inlet screen is not fully covered with oil.	**Check hydraulic oil level** and fill if necessary.
Charge filter is plugged	A plugged filter will restrict charge flow.	**Check charge pressure** and replace the rotation charge filter if charge pressure is low (refer to page **70-3-7**).
Inlet screen is blocked OR air leak in inlet	A restriction (blocked screen or collapsed inlet hose) or suction leak (missing components, damage, or loose fittings) will restrict charge flow.	**Check inlet vacuum:** it should be between 8” and 2” Hg (75-100 kPa(a)) under standard conditions. If not, repair restriction or suction leak. Refer to *Common Hydraulic System*, page **40-0-1**.
Charge pressure relief is misadjusted or stuck	A misadjusted or defective relief can limit charge flow.	**Check charge pressure.** Adjust or replace charge relief if necessary (refer to page **70-3-7**).
Charge pump worn or defective	If the charge pump is worn or damaged, charge flow will reduced.	**Check charge pump condition.** Refer to page **70-3-7**..
Charge oil leaking to park brake system	The rotation charge pump supplies oil to release the ground drive park brake. If a malfunction at the park brake system such as a leaking park brake release cylinder seal allowed uncontrolled charge pressure flow, charge pressure could be reduced enough to cause control problems.	**Verify that there is NOT constant flow to the park brake system** by using a flow meter or by blocking the line (refer to page **110-1-2**).

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4. Are the controls or EDC stroking the pump? Power must travel from the *power relay* through the #401 orange 8 guage *main power wire*, through the *DSR-Drill/Transport circuit breaker*, through the *DSR*, through the *seat switch* and to the *joystick control*. The *joystick control* then sends a varying current signal (milliamp or mA) to the *EDC AB coil*. The EDC uses the milliamp signal from the controls to direct oil to either of the PCP control ports. The control oil from the PCP is applied to one of the servo pistons to stroke the pump. Approximately 65 mA is required to fully stroke the pump in either direction. If the control is not powered, or if it does not send a correct signal to the EDC, or if the EDC receives a good signal but is defective, an incorrect pressure signal will be sent to the servo pistons, and the pump will not go on stroke correctly.

Possible Problem	Possible Effect	What to do
No power to controls	If any of the following occur, the controls will not be powered correctly --*circuit breaker* is tripped --*wiring* is damaged --*DSR* defective --*seat switch* defective or operator not seated .	Check that power is available to pin 4 on the rotation joystick connector. Refer to wiring schematic and the *Rotation Controls,* page **70-4-1**.
Control circuit malfunction	There must be a complete current path for current to start from the joystick, travel to the EDC, and return to the joystick.	First check wiring, connectors and pins in all control harnesses. Check for milliamp (mA) signal to EDC. Full stroke current should be 65 mA.
EDC malfunction	If the EDC is receiving the correct signal but does not stroke the pump, it may be damaged internally or the flow of oil to the PCP may be blocked. If the internal screens in the PCP are blocked, EDC control will be limited or will not function.	Substitute a known good EDC and/or perform other steps found in *Hydrostatic Service*, page **40-5-7**, including checking the PCP screen condition.

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5. Are the shift solenoids applying shift oil to the motors? In LOW speed, no power is applied to either speed solenoid, so neither motor receives shift oil. In MEDIUM speed, the rear motor shift solenoid is energized, causing charge oil to be applied to the 'Y' (shift) port of the rear motor. In HIGH, both solenoids are energized and oil is applied to the shift ports of both motors.

If the speed solenoids do not receive power when they should, the motors will not shift into MEDIUM or HIGH. If the speed solenoids receive power when they should not, the motors will stay in MEDIUM or HIGH.

Possible Problem	Possible Effect	What to do
No power to one or both solenoids	If any of the following occur, shift operation will not be correct: power is not available to the 3-speed switch, the switch is bad, connector or plug defective or pin or socket not seated in connector, +12V solenoid ON wire is grounded or open, solenoid ground wire is open.	Check for power at the signal pins at the speed solenoid connector. Check coil continuity. Check for good ground. Check 3-speed switch. Check power supply circuit.
Power always to one or both solenoids	If the signal wire is shorted to +12V or if the 3-speed switch is defective, one or both solenoids could be ON at all times.	Check power at the signal pins at the speed solenoid connector. Check 3-speed switch.

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6. Is the 3-speed/loop flush valve defective? Malfunctions in the loop flush valve components, including the pressure compensated *flow control*, the *pressure relief*, and the *speed solenoids*, can cause incorrect operation of the rotation motors. Shuttle oil after the flow control valve is used to shift the motor speeds. Low or no shift pressure will cause the motors to remain in low speed. Shift pressure that is always high will prevent the motors from returning to low speed. Oil pressure incorrectly applied to the shift port could also cause the shift valve to "bypass" so that loop oil flows directly from the 'B' side to the 'A' side, without turning the motor.

Possible Problem	Possible Effect	What to do
Hot oil shuttle valve stuck	If the hot oil shuttle is stuck in one position, high pressure loop oil can bypass the motors, causing system heating and limiting the flow and pressure to the motors.	**Check that the shuttle is shifted properly.** Replace with a known good shuttle valve or perform a pressure leak test on the shuttle. Refer to page 70-5-13 for component information.
Speed solenoid valves leaking	A leaking speed solenoid valve could allow unwanted charge oil to flow to the motor shift ports.	**Check for a stuck spool, damaged O-ring, or damaged valve cavity in the loop flush valve.** Refer to page 70-5-21 for component information.
Flow control defective	If the flow control is stuck closed or blocked, it would prevent shift oil from being applied to the speed solenoids.	**Check shift pressure, shuttle pressure, and shuttle flow** (refer to page 70-3-3).
Pressure relief defective	If the pressure relief is defective or set too low, shift pressure might be also be too low.	**Check shift pressure, shuttle pressure, and shuttle flow** (refer to page 70-3-3).

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7. Are the pump or motors defective? The hydrostatic pump must deliver specified flow and pressure, and the motors must shift speeds correctly and function correctly internally for correct motor operation.The rotation motors use a spool valve to direct internal oil flow for low or high speed operation. If the spool valve does not move correctly, the motor can stay in low or high speed or may “bypass” causing no rotation operation at all.

Possible Problem	Possible Effect	What to do
Motor shift operation incorrect	If the shift spool valve is stuck or operates erratically, the motor can either remain in high speed/low torque OR bypass, preventing shaft rotation	Refer to page **70-5-25** for component information.
Pump malfunction or wear	If the pump is badly worn or damaged, it may not deliver sufficient flow or pressure.	After verifying correct operating conditions and controls, perform a pressure and flow check on the pump, bypassing the motor. If flow and pressure are low, replace the pump. If flow and pressure are sufficient, replace the motor.
Motor malfunction or wear	If the pump is delivering adequate pressure and flow and the shift operation is correct, a worn or damaged motor will cause incorrect operation.	

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Section 70-3: Rotation System Diagnosis

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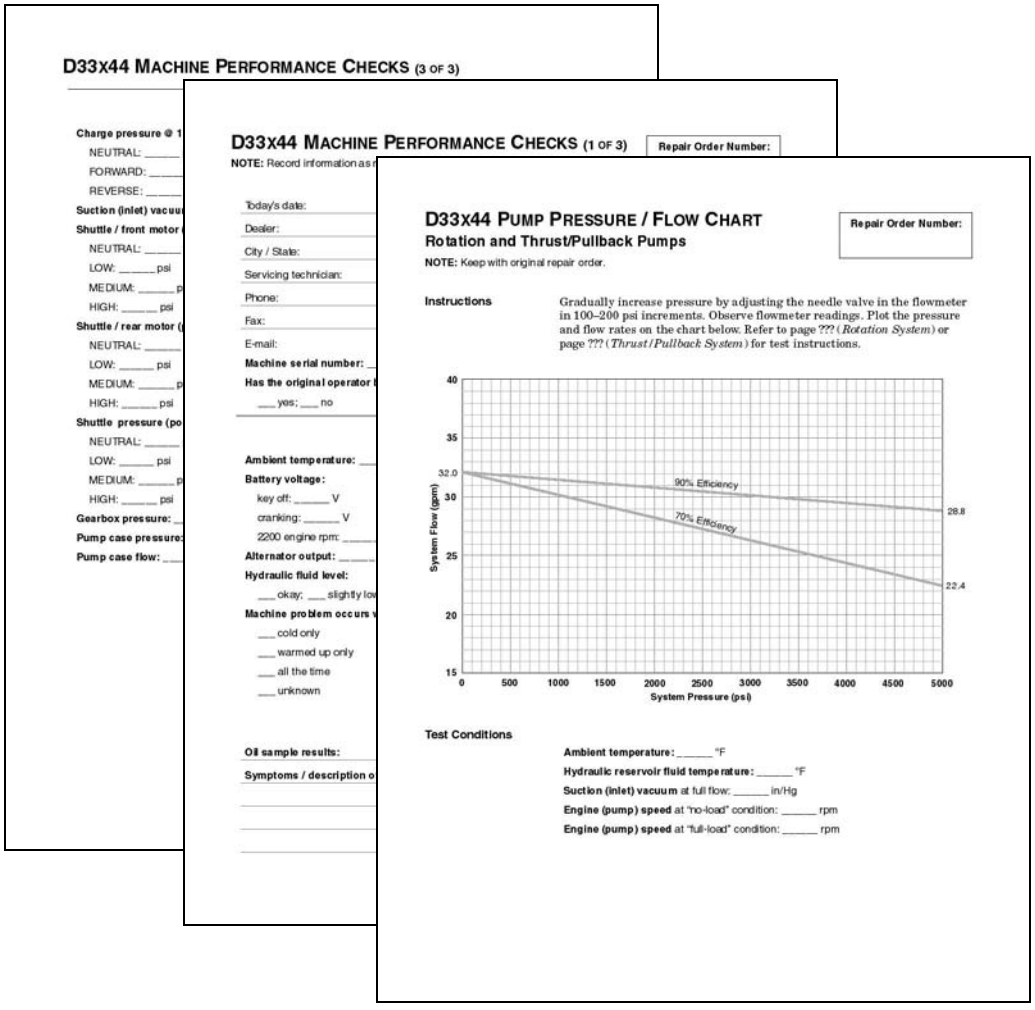
CHECKING AND RECORDING MACHINE PERFORMANCE INFORMATION

Rotation system specifications are found on page 70-1-3.

The following procedures are designed for diagnosing the rotation system, and are used in conjunction with the troubleshooting tables found on pages **70-2-4** and following. The results of any tests performed should be recorded on a **copy** of the *Machine Performance Checks* checksheet found in pages **20-5-1** and following. Recording the information will make the results of the tests easily available to the servicing technician while diagnosing a particular problem. A copy of this report should be kept with the repair order or machine file for future reference to the machine's past performance and, when appropriate, forwarded to the factory for warranty documentation.

- The *Machine Performance Checks* checksheet will look similar to the forms shown below.
- You will be prompted, by the pencil location, where to record information onto a **copy** of the checksheet whenever you see the icon to the left.





D33x44 MACHINE PERFORMANCE CHECKS (3 OF 3)

Charge pressure @ 1
NEUTRAL: _____
FORWARD: _____
REVERSE: _____
Suction (inlet) vacuu
Shuttle / front motor (
NEUTRAL: _____
LOW: _____ psi
MEDIUM: _____ p
HIGH: _____ psi
Shuttle / rear motor (
NEUTRAL: _____
LOW: _____ psi
MEDIUM: _____ p
HIGH: _____ psi
Shuttle pressure (po
NEUTRAL: _____
LOW: _____ psi
MEDIUM: _____ p
HIGH: _____ psi
Gearbox pressure: _
Pump case pressure:
Pump case flow: ___

D33x44 MACHINE PERFORMANCE CHECKS (1 OF 3) Repair Order Number:

NOTE: Record information as r

Today's date:
Dealer:
City / State:
Servicing technician:
Phone:
Fax:
E-mail:
Machine serial number: _
Has the original operator
___ yes; ___ no

Ambient temperature: ___
Battery voltage:
key off: _____ V
cranking: _____ V
2200 engine rpm: _____
Alternator output: ___
Hydraulic fluid level:
___ okay; ___ slightly low
Machine problem occurs
___ cold only
___ warmed up only
___ all the time
___ unknown

Oil sample results:
Symptoms / description o

D33x44 PUMP PRESSURE / FLOW CHART

Rotation and Thrust/Pullback Pumps

Repair Order Number:

NOTE: Keep with original repair order.

Instructions

Gradually increase pressure by adjusting the needle valve in the flowmeter in 100–200 psi increments. Observe flowmeter readings. Plot the pressure and flow rates on the chart below. Refer to page ??? (*Rotation System*) or page ??? (*Thrust/Pullback System*) for test instructions.

Test Conditions

Ambient temperature: _____ °F
Hydraulic reservoir fluid temperature: _____ °F
Suction (inlet) vacuum at full flow: _____ in/Hg
Engine (pump) speed at "no-load" condition: _____ rpm
Engine (pump) speed at "full-load" condition: _____ rpm

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CHECK MOTOR SHIFT / SHUTTLE PRESSURE

Test Objective

To determine if pressures applied to motor shift ports or to the thrust/ pullback 2-speed valve are outside of specifications under varying conditions—possibly indicating a problem in the shuttle, flow control or shuttle relief circuits, or a defective motor shift operation.

Special Tools and Materials

- a **copy** of the *Machine Performance Checks* worksheet
- tubing wrenches
- 1000 psi (70 bar) pressure gauge
- test hose with tee-in diagnostic fitting
- 1/4” and 5/16” Allen wrenches for shuttle relief

Conditions

WARNING: Entanglement in rotating drill chuck and drill rod can cause death or serious injury. Stay away from rotating equipment. Do not wear loose clothing that could catch on rotating equipment.

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

Warm up machine so the hydraulic oil in the tank is at least 100°F (40°C). Verify oil temperature with a non-contact thermometer.

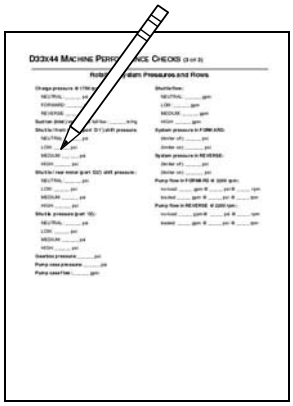
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Procedure

Check *Shift* Pressure

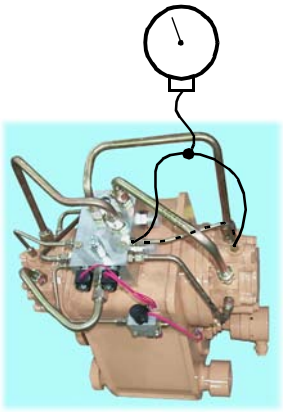


NOTE: 'D1' or 'D2' port oil pressure ("shift pressure") indicates *shift pressure before* the flow control when the motor speed solenoid is shifted, or *case drain pressure* when the motor is not shifted. Refer to page **70-1-6** for port reference information.

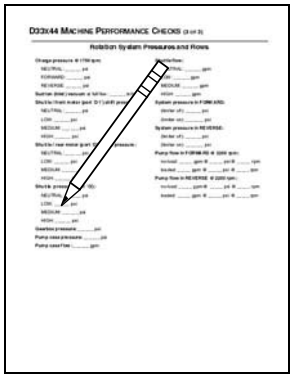
1. Install a test hose equipped with a diagnostic fitting in place of the steel tube to the front or rear motor 'Y' port.

   (Select port 'D2' and rear motor to check shift pressure in MED and HIGH. Select port 'D1' and the front motor to check shift pressure in HIGH only.) Install a 1000 psi (70 bar) pressure gauge at the diagnostic fitting.

2. Operate the rotation system in NEUTRAL and all three speed ranges with engine at 2200 rpm and record motor shift pressure.



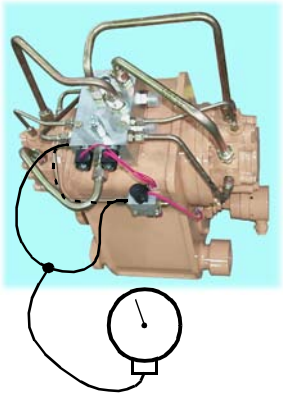
Check *Shuttle* Pressure



NOTE: 'G' port oil pressure indicates *shuttle pressure after* the pressure-compensated flow control and *before* the shuttle relief.

1. Replace the steel tube between port 'G' and the thrust/pullback 2-speed solenoid (port '3') with a test hose equipped with a diagnostic fitting.

2. Operate the rotation system in NEUTRAL and all three speed ranges with engine at 2200 rpm and record shuttle pressure.



Results

- ***If shift pressure ('D1' or 'D2') is OK but shuttle pressure is low,*** the flow control valve could be blocked. (Verify by checking shuttle flow.)
- ***If shift pressure ('D1' or 'D2') is low to either motor,*** check that the speed solenoids are being activated. If shift pressure is greater than nominal (case pressure) but motor shift action is erratic or the motors are bypassing, check for a leak to the shift port in the speed solenoid circuit.
- ***If shuttle pressure ('G') is low,*** it is possible to adjust the pressure. However, as long as shuttle pressure is maintained above approximately 150 psi (10 bar), the motors should shift satisfactorily, and the flow control will prevent case drain flow from becoming excessive.

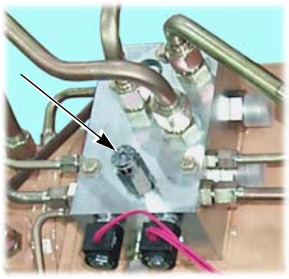
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Adjust *Shuttle* Pressure

NOTE: Pressurized oil will be present underneath the adjustment cap if there is backpressure in the case drain line. Shut off engine and verify that case drain pressure has dissipated before removing cap.

To adjust shuttle pressure, remove the cap using a 5⁄16" Allen wrench, and adjust the screw using a 1/4" Allen wrench.



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CHECK SHUTTLE FLOW

Test Objective

To determine if shuttle flow is outside of acceptable limits, indicating a possible flow control valve or shuttle relief valve defect.

Special Tools and Materials:

- a **copy** of the *Machine Performance Checks* worksheet
- 0.5 gpm 1.9 L/min) 3500 psi (240 bar) flow meter with hose
- tubing wrenches

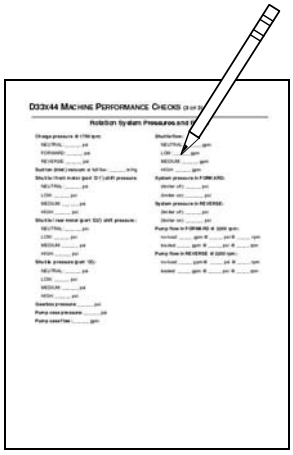
NOTE: Do not attempt to check flow into a container—the results will not account for back pressure in the line.

Conditions

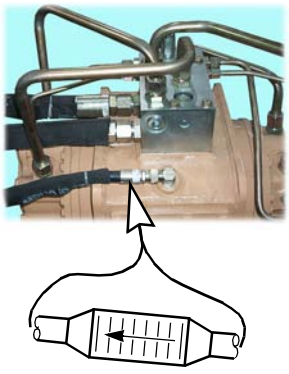
WARNING: Entanglement in rotating drill chuck and drill rod can cause death or serious injury. Stay away from rotating equipment. Do not wear loose clothing that could catch on rotating equipment.

Warm up machine so the hydraulic oil in the tank is at least 100°F (40°C). Verify oil temperature with a non-contact thermometer.

Procedure



1. Connect an in-line flow meter from the case drain port of the gearbox into the case drain line.
2. Run the engine at 2200 rpm and record the flow in NEUTRAL, then operate the rotation system in all three speed ranges and record shuttle flow.
3. ***Shuttle flow is not adjustable—if the flow is incorrect, either the shuttle relief setting may be too high (so that shuttle pressure is above charge pressure), or the flow control may be defective.***



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CHECK / ADJUST CHARGE PRESSURE

Test Objective

To determine if the rotation pump charge pressure is within specifications as part of a basic evaluation of machine performance—and to adjust charge pressure before performing other diagnostic checks.

Special Tools and Materials

- a **copy** of the *Machine Performance Checks* worksheet
- 7,000 psi (480 bar) pressure gauge
- 1000 psi (70 bar) pressure gauge
- 1-1/16” hex wrench
- 1/2” hex wrench
- photo-tachometer

Conditions

WARNING: Entanglement in rotating drill chuck and drill rod can cause death or serious injury. Stay away from rotating equipment. Do not wear loose clothing that could catch on rotating equipment.

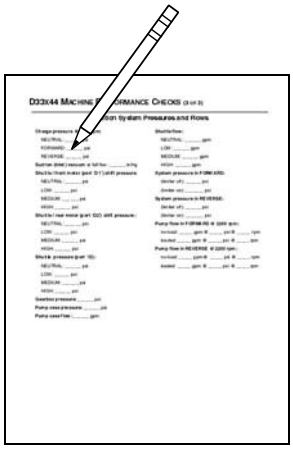
Warm up machine so the hydraulic oil in the tank is at least 100°F (40°C). Verify oil temperature with a non-contact thermometer.

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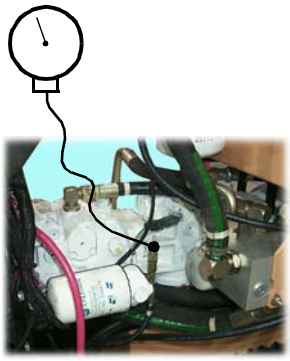
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Procedure



1. Install a 1000 psi (70 bar) pressure gauge at the rotation pump charge pressure diagnostic fitting located on the charge filter housing or remote location.
2. Check and record charge pressure with engine at 1750 rpm and the pump in NEUTRAL.



WARNING: Entanglement in rotating drill chuck and drill rod can cause death or serious injury. Stay away from rotating equipment. Do not wear loose clothing that could catch on rotating equipment.

3. Maintain 1750 rpm. Stroke pump forward and record charge pressure.
4. Maintain 1750 rpm. Stroke pump reverse and record charge pressure.
5. Follow the *Shutdown Procedure* (refer to **10-2-1**)
6. **To adjust the charge pressure,** loosen the lock nut using a 1-1/16" wrench and adjust the pressure screw with a 1/2" hex wrench. Adjust to 350 ±10 psi (24 bar ±0.7 bar). Hold the adjustment screw while tightening the lock nut to 38 ft-lb (52 Nm)



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CHECK / ADJUST SYSTEM AND TORQUE LIMITER PRESSURES

Test Objective

The objective of this test is to determine the pressure settings and condition of the multifunction valves and forward and reverse torque limiter in the rotation pump circuit.

Checking system and torque limiter pressure requires several steps to enable and disable forward and reverse torque limiters. Follow these steps to check pressures, then refer to the *Check/Adjust System and Torque Limiter Pressure* (page **70-3-9**) for adjustment procedures. Record pressures on the *Machine Performance Checks* worksheet (refer to page **20-5-1**.

Special Tools and Materials

- a copy of the *Machine Performance Checks* worksheet
- 7,000 psi (480 bar) pressure gauge
- 1000 psi (70 bar) pressure gauge
- 19 mm hex wrench
- 5 mm Allen wrench

Conditions

WARNING: Entanglement in rotating drill chuck and drill rod can cause death or serious injury. Stay away from rotating equipment. Do not wear loose clothing that could catch on rotating equipment.

Always check charge pressure and shuttle pressure before checking or adjusting system pressure, since low charge pressure will adversely affect system pressure, and since system pressure will change when charge pressure is adjusted.

Always use a calibrated pressure gauge for diagnosis and adjustments. Gauges on machine are subject to loss of calibration since they are constantly exposed to loop pressure.

Warm up machine so the hydraulic oil in the tank is at least 100°F (40°C). Verify oil temperature with a non-contact thermometer.

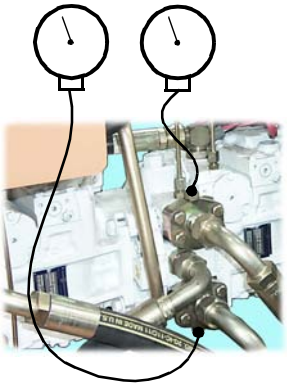
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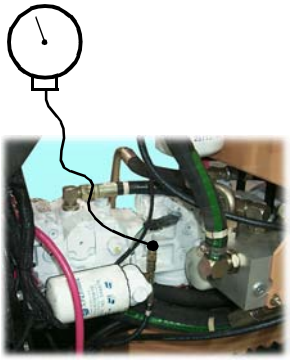
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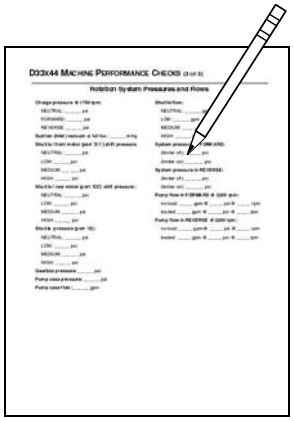
Procedure

1. Install high pressure test ports in the code 62 fittings for both the ‘A’ and ‘B’ ports of the rotation system pump.
2. Install a 7,000 psi (480 bar) pressure gauge onto the high pressure test ports for both the ‘A’ and ‘B’ sides of the loop



3. Install a 1000 psi (70 bar) pressure gauge in the pump charge pressure test port.
4. Install a rod on the drive chuck. Run the drill head forward and close both vises so the rear (upper) vise clamps on the drive chuck and the front (lower) vise clamps on the starter rod.
5. Maintain 2200 engine rpm while checking pressure.





6. Check and record the *forward torque limiter* setting by stroking the pump in the forward direction (‘B’ side). Pressure should increase, then level off and remain steady. Return the pump to NEUTRAL.
7. Check and record the *reverse pump pressure* setting by stroking the pump in the reverse direction (‘A’ side). Pressure should increase, then level off and remain steady. Return the pump to NEUTRAL.
8. Disconnect the torque limiter electrical connector.



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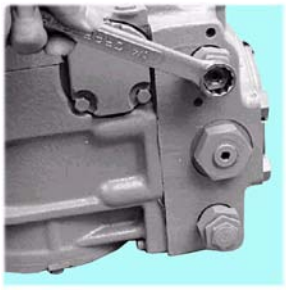
Disconnecting the torque limiter disables the forward torque limiter and enables the reverse torque limiter.

9. **With the torque limiter disconnected,** check and record the *forward* pump pressure setting by stroking the pump in the forward direction ('B' side). Pressure should increase, then level off and remain steady. Return the pump to NEUTRAL.
10. **With the torque limiter disconnected,** check and record the *reverse torque limiter* setting by stroking the pump in the reverse direction ('A' side). Pressure should increase, then level off and remain steady. Return the pump to NEUTRAL.
11. Follow the *Shutdown Procedure* (refer to **10-2-1**).

Adjustments

Adjust Pump Pressure

1. If system pressure must be adjusted: remove plastic dust cap on the appropriate multifunction valve and loosen locking nut (smallest hex on multifunction valve) with a 19 mm wrench .



2. Adjust the multifunction valve pressure limiter setting by rotating the pressure adjusting screw with a 5mm Allen wrench. Rotate clockwise to increase, counterclockwise to decrease.
3. While holding the pressure adjusting screw stationary, tighten the pressure adjusting screw lock nut to 12 ft-lb (16 Nm). **Do not overtorque.**



4. Repeat the adjustment for the other side of the loop, using the other multifunction valve.
5. Follow the *Shutdown Procedure* (page **10-2-1**) and remove the gauges. Replace the plastic dust plugs.

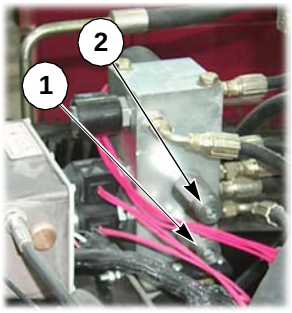
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Adjust Forward or Reverse Torque Limiter

1. Refer to page 70-3-9 for pressure checking procedure.
2. Remove the forward **(1)** or reverse **(2)** torque limiter pressure relief cap using a 5/16” Allen wrench wrench.
3. Adjust the pressure screw with a 1/4" Allen wrench. (Turn clockwise to increase, counterclockwise to decrease. After adjusting, install the cap.



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CHECK ROTATION PUMP FLOW

Test Objective

To determine the ability of the rotation pump to deliver rated flow at rated pressure, RPM, and operating conditions, for the purpose of determining operating condition of the pump, and by process of elimination, the rotation motors.

Special Tools and Materials

- a **copy** of the *Machine Performance Checks* checksheet
- tubing wrenches
- 40 gpm (150 L/min) 5000 psi (345 bar) flow meter with loading valve and reverse flow capability

Conditions

IMPORTANT: This procedure requires specialized training. Do not perform this test if you are not trained in the use of flow meters on high pressure systems.

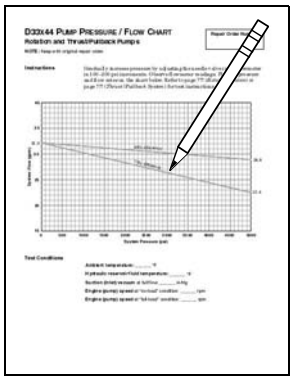
Testing may be done initially with cold oil but must conclude with oil tank temperature at normal working temperature, (at least 100°F (40°C)). Verify oil temperature with a non-contact thermometer.

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Procedure

1. **The system pressure must not be allowed to exceed the rating of the flow meter.** To avoid overpressurizing the flow meter, verify that the rotation torque limiter limits pressure to 4100 psi (280 bar), or else temporily adjust the multifunction valve pressure setting to a setting below the flow meter rating.
2. Carefully clean the area around the 'A' and 'B' hoses. Disconnect the 'A' and 'B' loop hoses from the loop flush valve. Plug the ports on the loop flush valve.
3. Install a 40 gpm (150 L/min) 5000 psi (345 bar) flow meter with loading valve and reverse flow capability between the hoses so that the flow meter will read flow from the 'B' hose to the 'A' hose to test forward rotation or from the 'A' hose to the 'B' hose to test reverse rotation.
4. Verify that the flow meter needle is completely open.
5. Start the engine and run at 2200 rpm.



6. Stroke the pump and record pump flow and pressure at no load.

IMPORTANT: This test will heat the hydraulic oil very quickly. Do not run the test at full pressure longer than is necessary to obtain the pressure and flow readings.

7. Have an assistant maintain full flow in the appropriate direction using the rotation joystick. Gradually adjust the needle valve to load the pump. Observe the flow meter and record flow compared to pressure until 5000 psi (345 bar) or the flow meter working pressure limit (whichever is less) is reached.

Results

Compare the flow at no-load to the loaded flow.

- ***If the flow is within 10% of no load,*** pump wear is minimal and any problem with lack of power (assuming other diagnostic steps have been performed correctly) is the result of one or both motors being worn or defective.
- ***If flow is reduced by approximately 15–25%,*** the indicated wear reduces machine efficiency and increases heat rejection, but does not require replacement.
- ***If flow is reduced by 30% or more from the no-load reading,*** pump damage or significant wear is indicated. Further continued operation of the pump/motor combination may result in system failure.

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PUMP CASE PRESSURE TEST

Test Objective

To determine if the pump case pressure exceeds specifications, indicating either a restriction in the case drain line or some condition causing excess flow to the pump case.

Special Tools and Materials

- a **copy** of the *Machine Performance Checks* checksheet
- 1000 psi (70 bar) pressure gauge
- diagnostic fitting with 1-1/16"–12 thread to install in pump case pressure port

Conditions

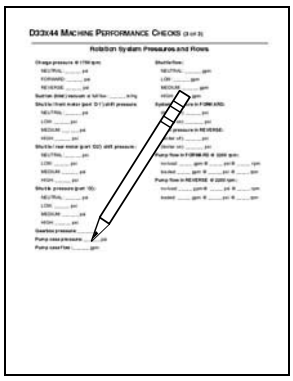
Testing may be done initially with cold oil but must conclude with oil tank temperature at normal working temperature, (at least 100°F (40°C)). Verify oil temperature with a non-contact thermometer.

IMPORTANT: This procedure requires specialized training. Do not perform this test if you are not trained in the use of flow meters on high pressure systems.

IMPORTANT: Never test case pressure by removing the drain line and plugging the case with a pressure gauge. This can lead to pump case failure and does not provide an accurate test.

Continued on next page...

Procedure



1. Remove the plug from the case drain port (port 'L2') in the underside of the pump.
2. Install the diagnostic fitting and connect the pressure gauge.
3. Operate the machine at full throttle with the rotation pump in neutral; observe and record pressure.
4. ***If pressure exceeds the specification for a cold or warm machine,*** either there is a restriction in the case drain circuit or there is a condition causing excessive flow to the pump case. Check case drain circuit for restriction, then check case drain flow (see page **70-3-17**).



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PUMP CASE FLOW TEST

Test Objective

To determine if the hydrostatic pump case drain flow is excessive. If pressure is excessive, seal damage can result. This test is normally not required since case drain flow should be equal to or less than total charge pump flow.

Special Tools and Materials:

- a **copy** of the *Machine Performance Checks* checksheet
- 10–15 gpm (35–60 L/min) 5000 psi (345 bar) flow meter

Conditions

Testing may be done initially with cold oil but must conclude with oil tank temperature at normal working temperature, (at least 100°F (40°C)). Verify oil temperature with a non-contact thermometer.

IMPORTANT: This procedure requires specialized training. Do not perform this test if you are not trained in the use of flow meters on high pressure systems.

IMPORTANT: Do not test to a container. If the rotating group separates from the backplate, sudden and massive oil flow to the case drain line can result.

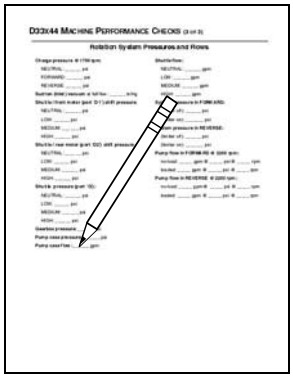
IMPORTANT: Never test case pressure by removing the drain line and plugging the case with a pressure gauge. This can lead to pump case failure and does not provide an accurate test.

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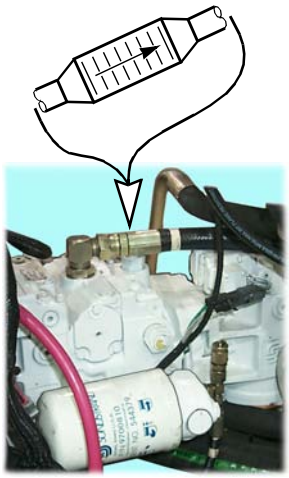
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Procedure



1. Disconnect case drain line at the top of the hydrostatic pump.
2. Connect a 10–15 gpm (35–60 L/min) flow meter between the case and the case drain line to measure flow from the case to the reservoir.
3. Operate machine and observe flow.
4. ***Case flow should be approximately 9.3 gpm (35 L/min) or less. If flow is greater than approximately 10 gpm,*** check for any condition that would cause additional flow into the pump case. ***If flow is very low,*** check for possible loss of fluid from the closed loop circuit or excessive flow from the loop flush valve.



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Section 70-4: Rotation System Controls

ROTATION CONTROLS LOCATION



Left Side of Seat

Rotation Joystick
Push - counterclockwise
Pull - clockwise



Right Side of Seat

Lower Vise Switch
Up - clamp
Down - release

Circuit Breakers

3-speed Gearbox Switch
Push Right - LOW
Centered - MEDIUM
Pull Left - HIGH

Operation Overview

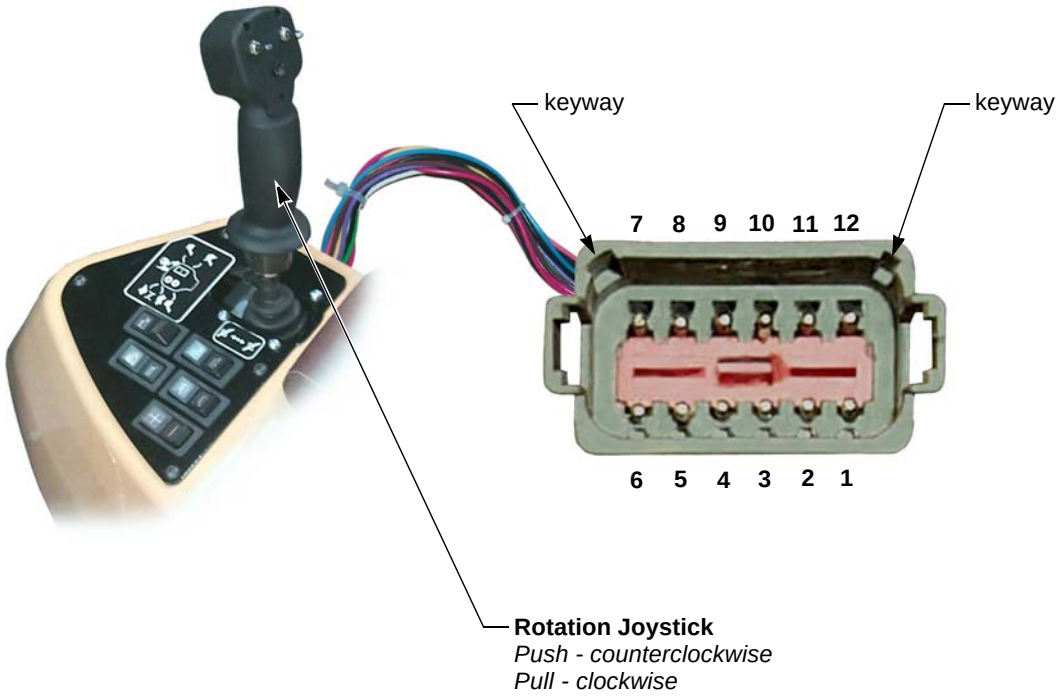
The rotation system controls includes three basic systems:

1. **The EDC controller circuit** (rotation joystick) controls speed and direction of the rotation motors.
2. **The torque limiter circuit** limits the amount of pressure available to the rotation motors under certain conditions.
3. **The 3-speed motor circuit** shifts displacement on one or both of the rotation motors to provide 3-speed operation of the rotation gearbox.

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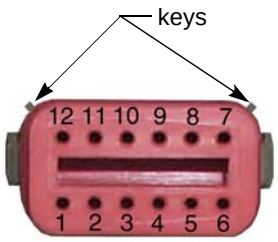
ROTATION JOYSTICK



Controller Pin Identification

Pin	Wire I.D.	Type	Function
1	BK	GND	Supplies ground from thrust joystick pin ‘12’ to EDC controller terminal ‘1’.
2	GR	control	Carries EDC control current from/to EDC controller terminal ‘2’.
3	WH	control	Carries EDC control current from/to EDC controller terminal ‘3’.
4	RD	+12V	+12V (from thrust joystick pin ‘9’) to EDC controller terminal ‘4’.
5	---	---	(not used)
6	BK	control	Trigger signal from joystick switch.
7	---	---	(not used)
8	---	---	(not used)
9	RD	+12V	Unused +12V from EDC controller terminal ‘4’
10	VL	starter	Neutral start circuit (from thrust joystick pin ‘11’) to joystick neutral switch. Receives current when thrust joystick is in NEUTRAL and ignition switch is in START (power to ‘S’ terminal).
11	BR	starter	Neutral start circuit (to starter relay terminal ‘86’) from joystick neutral switch. Receives current when joystick is in NEUTRAL and current is supplied to pin ‘10’.
12	BK	GND	Unused ground to EDC controller terminal ‘1’.

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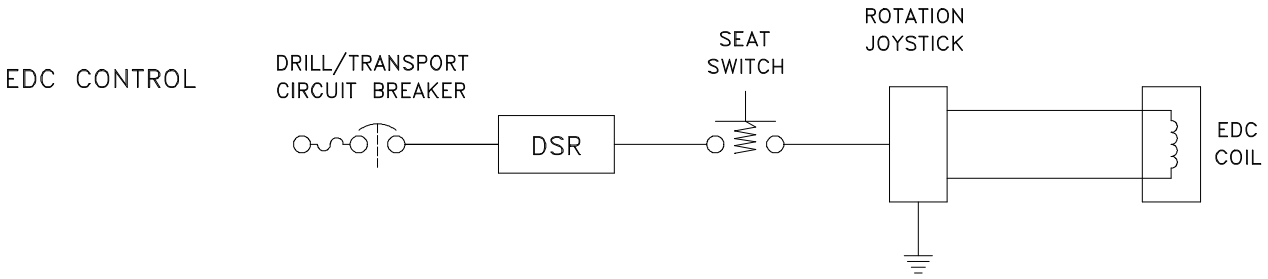
Harness Connector Pin Identification

Pin	Wire I.D.	Type	Function
1	331 BK	GND	Ground to terminal ‘2’ of console ground strip.
2	503 BU	control	Carries rotation pump EDC control current from/to EDC coil terminal ‘A’.
3	505 LT. BU	control	Carries rotation pump EDC control current from/to right EDC coil terminal ‘B’.
4	507 RD	+12V	+12V from thrust joystick pin ‘9’.
5	---	---	(not used)
6	825 PK/BK	control	Rod loader trigger signal to pin ‘4’ of rod loader controller (prior to S⁄N 108). (Not used on S/N 109 and up.)
7	---	---	(not used)
8	---	---	(not used)
9	---	---	(not used)
10	605 VL	starter	Neutral start circuit from thrust joystick pin ‘11’ (to rotation joystick neutral switch). Receives current from ignition switch terminal ‘S’ when thrust joystick is in NEUTRAL and ignition switch is in START
11	007 WH/BK	starter	To starter relay terminal ‘86’. Energized when ignition is in START and both joystick controls are in NEUTRAL.
12	095 OR	---	(not used)

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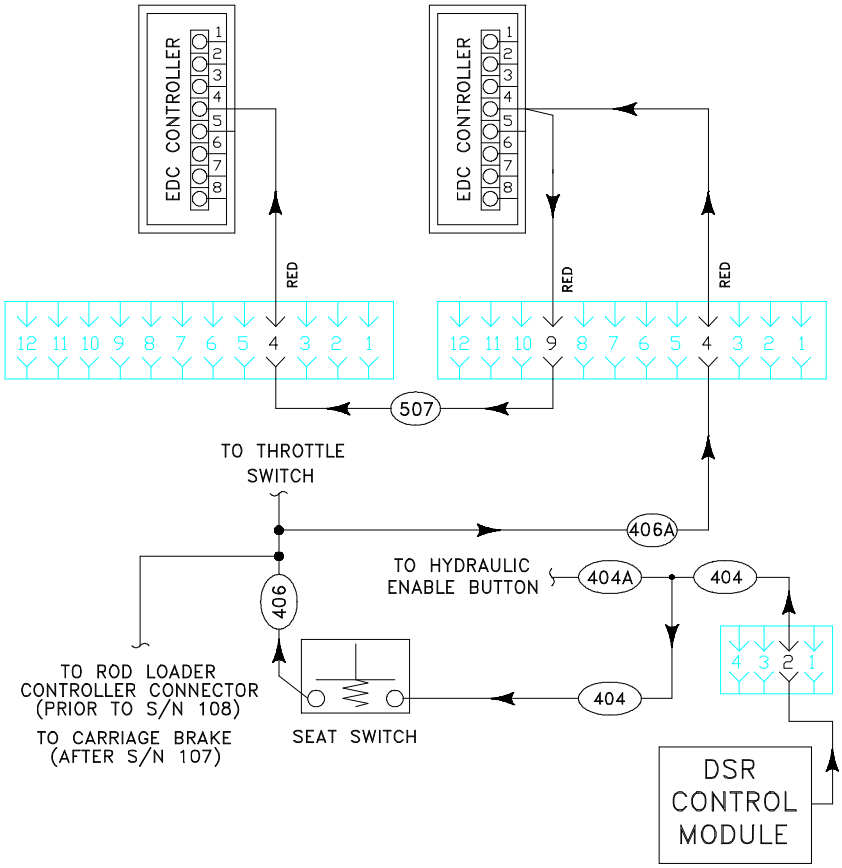
EDC Controller Operation



The EDC circuit controls uses the left (rotation) joystick to control oil flow and direction from the pump. Current from the DSR is sent through the seat switch to the EDC controller in the joystick. The EDC controller sends a current signal to the 'AB' coil of the rotation pump EDC which causes the pump to stroke in forward or reverse.

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EDC Power Circuit

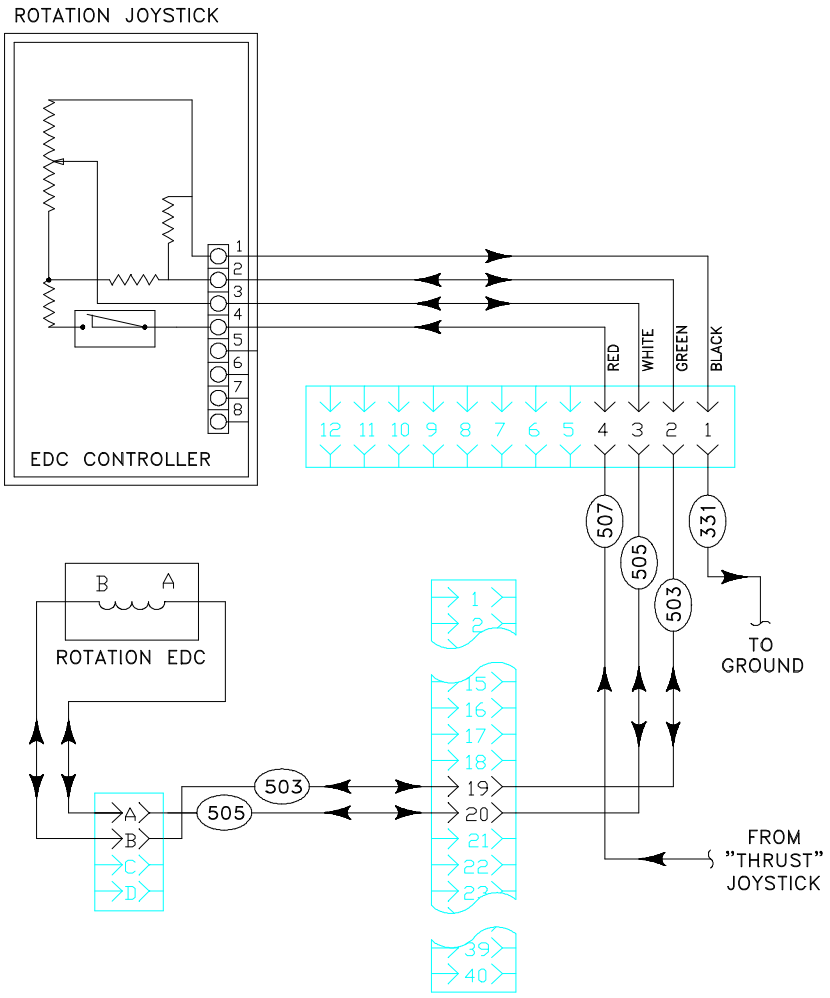


Power travels from the DSR, through the seat switch, to the right joystick, to the left joystick, and to pin '4' of the EDC controller. The operator must be seated in order for the pump to stroke.

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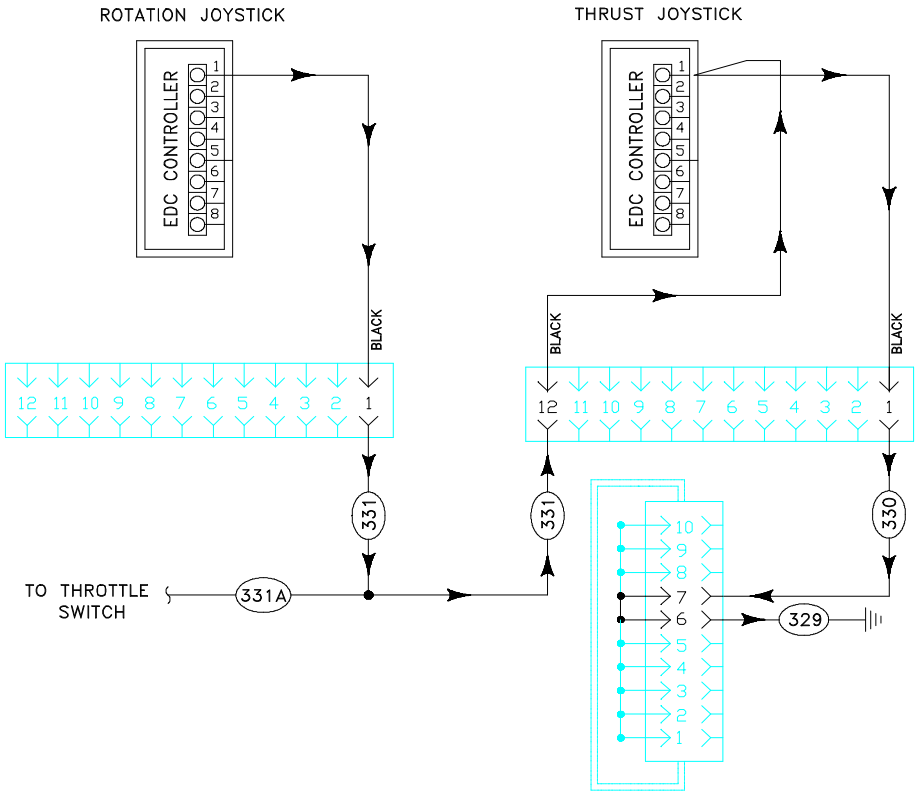
EDC Control Circuit



The EDC controller sends a current signal through wires '505' and '503' to the EDC 'AB' coil. This causes the pump to stroke forward or reverse.

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EDC Ground Circuit



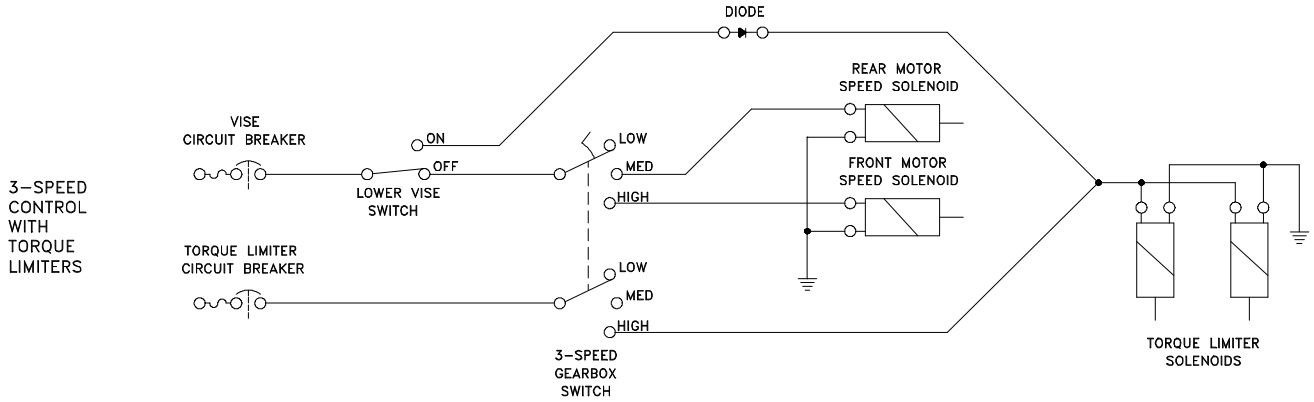
The EDC circuit ground path is from the EDC controller pin 1 to the left joystick connector, through the right joystick, and to the operator console ground buss.

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TORQUE LIMITERS

Operation Overview

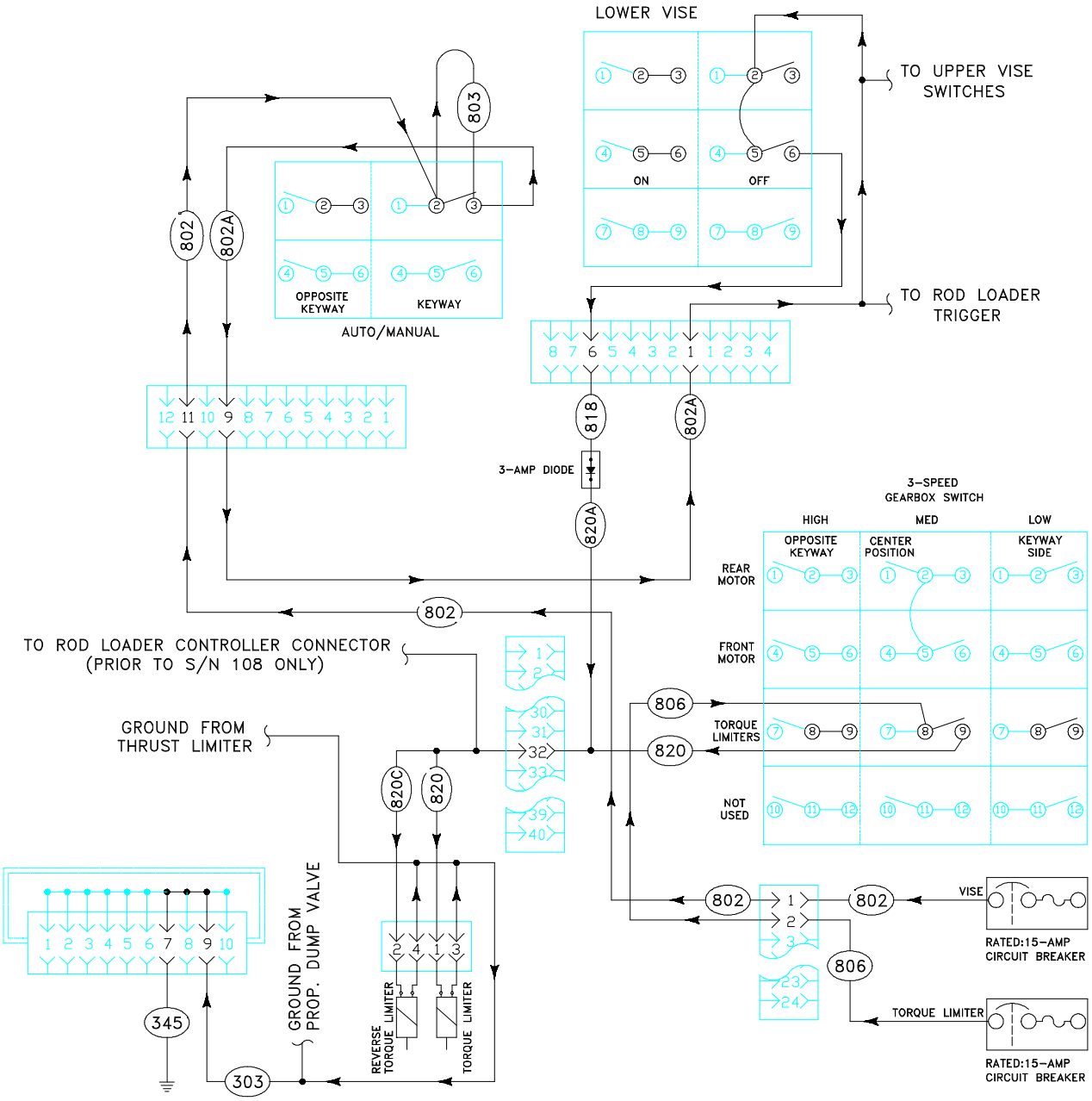


The forward and the reverse torque limiters limit the loop pressure of the 'B' and 'A' sides of the pump by sending oil to the pump servo circuit whenever the pressure exceeds the torque limiter relief setting. The forward torque limiter is designed to limit pressure whenever the lower vise is ON or the 3-speed switch is in HIGH. The reverse torque limiter limits pressure whenever the lower vise is OFF and the 3-speed is in LOW or MED.

Both solenoid valves are energized at the same time, either by the lower vise switch ON or by the 3-speed switch in HIGH. The forward torque limiter valve ***allows*** oil to flow (opens) only if the solenoid is energized. The reverse torque limiter valve ***shuts off*** oil to the pressure limiter (closes) if the solenoid is energized.

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Torque Limiters Control Circuit



Both torque limiters are on the same circuit. The forward torque limiter valve is *normally open ("normally passing");* the reverse torque limiter is *normally closed ("normally non-passing").* Under normal drilling conditions the circuit is *de-energized* and the *reverse* limiter is applied. When the lower vise is ON, or the 3-speed switch is in HIGH, the circuit is *energized* and the *forward* limiter is applied.

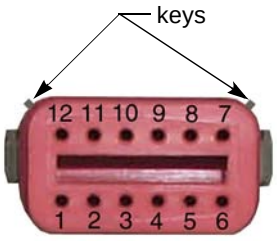
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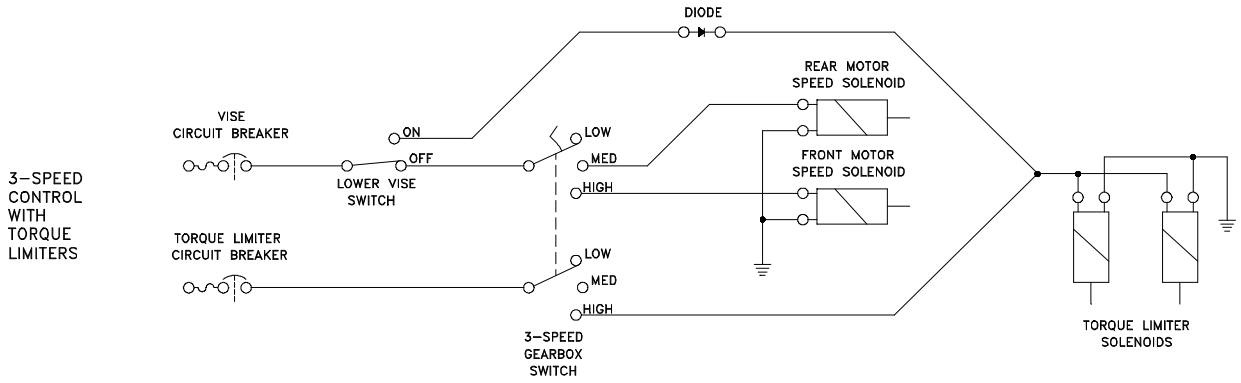
3-Speed Gearbox Switch



3-Speed Gearbox Switch
Right - LOW
Centered - MEDIUM
Left - HIGH



Operation Overview

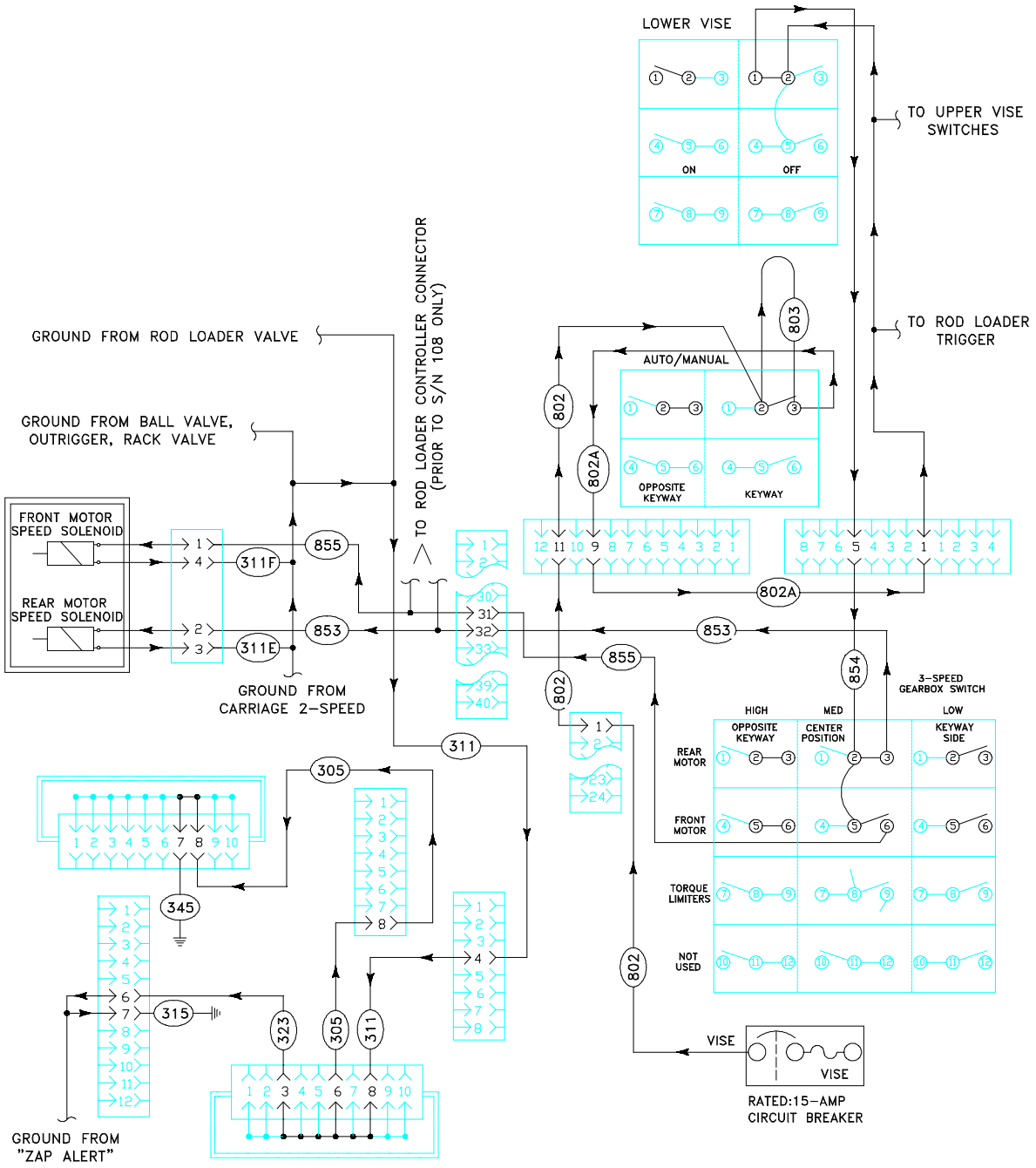


Switch Pin Identification

Pin	Wire I.D.	Type	Function
1	---	---	(not used)
2	845 OR/RD	+12V	Receives +12V from the lower vise switch terminal ‘1’ through thrust 8-pin connector pin ‘5’ when lower vise is OFF
3	853 LT BU/ RD	control	Provides +12V to rear motor speed solenoid. Energized in MEDIUM and HIGH.
4	---	---	(not used)
5	---	+12V	Connected to terminal ‘2’ by way of a jumper.
6	855 BU/RD	control	Provides +12V to front motor speed solenoid. Energized in HIGH.
7	---	---	(not used)
8	806 WH/RD	+12V	Receives +12V from the torque limiter circuit breaker.
9	820 OR/BK	control	Provides +12V to forward and reverse torque limiter. This circuit is also energized through a diode from lower vise switch terminal ‘6’ through thrust/pullback 8-pin connector pin ‘6’.
10	---	---	(not used)
11	---	---	(not used)
12	---	---	(not used)

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3-Speed Gearbox Switch Control Circuit



Power from the vise circuit breaker is provided to the 3-speed switch from the lower vise switch whenever the lower vise is OFF. The 3-speed switch applies power to the rear speed solenoid in MED and to both the front and rear speed solenoids in HIGH

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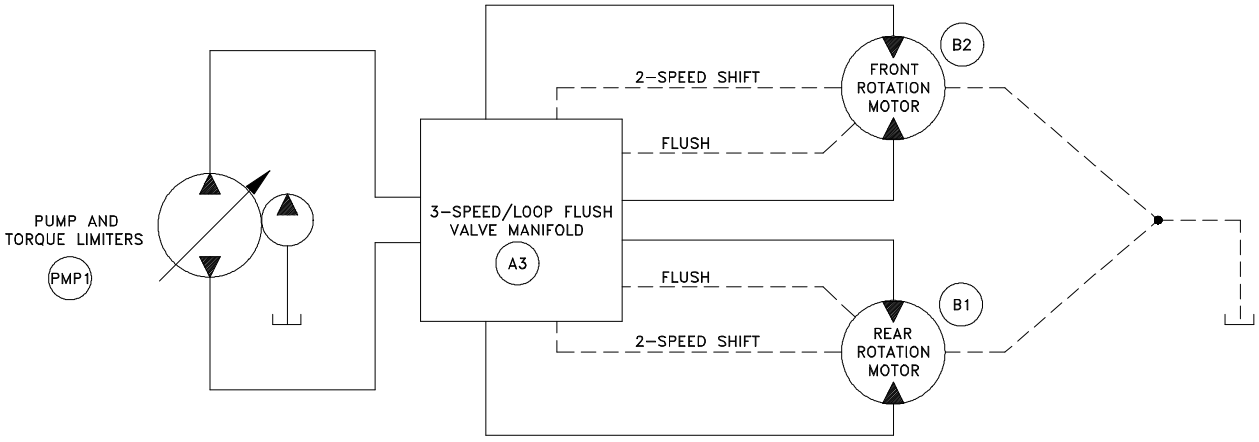
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Section 70-5: Rotation System Hydraulic Circuit

ROTATION HYDRAULIC CIRCUIT DIAGRAM



Operation Overview

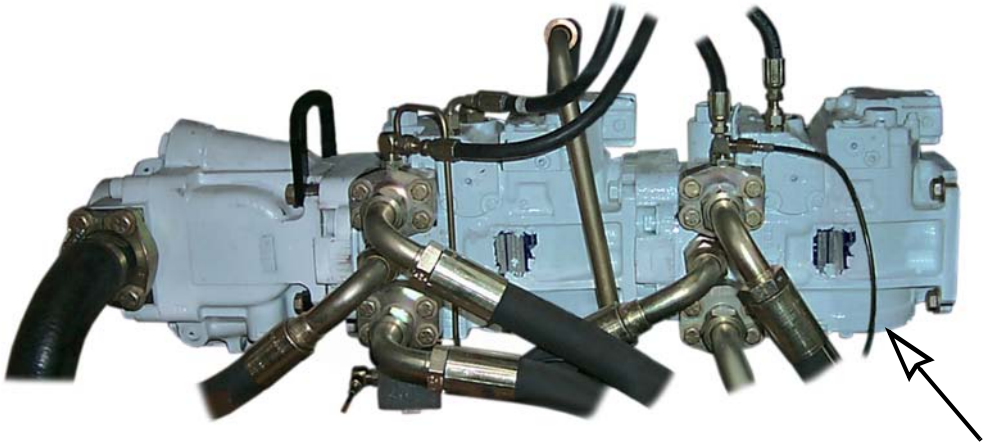
The rotation hydraulic system includes three basic circuits:

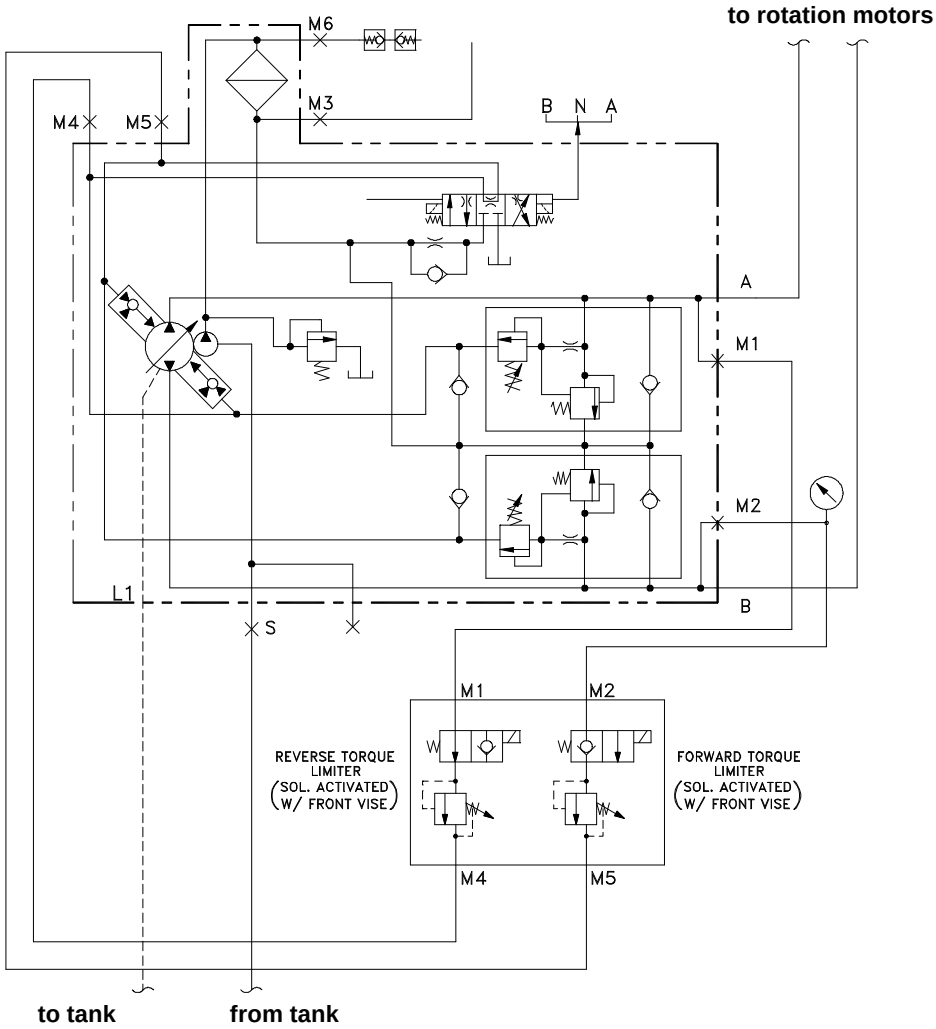
1. **The hydrostatic pump and torque limiter** supply oil flow within a specified pressure range to the rotation motors.
2. **The 3-speed/loop flush valve** directs oil to the rotation motors, provides an exit path for loop flush oil, and directs the speed shift function of the motors.
3. **The rotation motors** receive hydraulic oil flow and drive a common gearbox input shaft.

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ROTATION PUMP





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Operation

NOTE: The function of the rotation pump is discussed here as it relates to the rest of the rotation system. For information on internal pump components, refer to page **40-5-1**

The rotation hydrostatic pump provides oil flow from either the 'A' or the 'B' port to the rotation motors. The rotation joystick controls pump stroke and direction by an electrical signal to the EDC, using charge pressure to supply force to change the swashplate angle. A combined pressure limiter and pressure relief limits pump output by destroking the pump or relieving excess pressure. A forward and reverse torque limiter limits pump pressure when required.

IMPORTANT: When working on closed loop components, special procedures and extreme cleanliness standards are required (refer to *Hydrostatic Service Procedures,* page **40-6-1**).

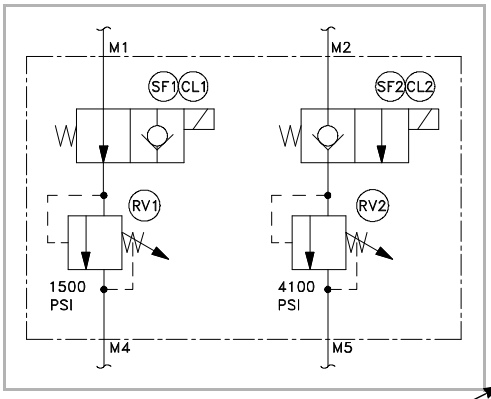
Multifunction Valve (System Pressure) Testing

Testing the pump multifunction valves requires a detailed procedure which includes the torque limiter valves, charge pressure adjustment, and multifunction valve testing. Refer to page **70-3-9**.

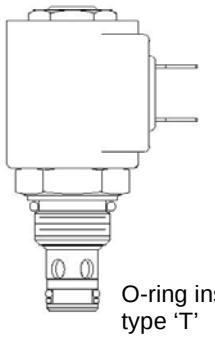
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TORQUE LIMITER - SOLENOID VALVE







O-ring installation: type 'T'

Forward Torque Limiter

Reverse Torque Limiter

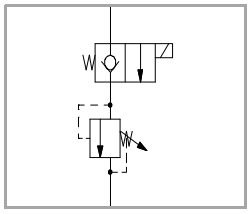
Operation

The **forward** torque limiter limits forward rotation pressure whenever the front vise is ON or the rotation motors are shifted to HIGH speed. The **reverse** torque limiter limits reverse pressure whenever the front vise is off and the motors are in MED or LOW.

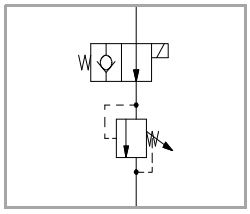
Action

The torque limiter applies loop oil to the pressure relief when the solenoid is energized (forward) or de-energized (rear). If the loop oil is at a higher pressure than the torque limiter pressure relief setting, the oil that passes over the relief is used to destroke the pump, limiting torque applied to the drill rod.

Forward Limiter

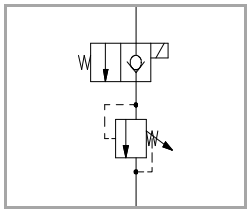


not limited

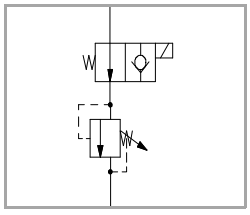


limited

Reverse Limiter



not limited



limited

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Specifications

Torque Limiter Solenoid Coil Specifications	
type	'08' (P/N 251117-009)
initial coil current draw at 70°F (20°C)	1.07 A at 10.5 VDC 1.2 A at 12 VDC 1.48 A at 14.5 VDC
resistance	9.8 ohms at 70°F (20°C)
nominal power rating	14.7 W
coil installation torque	5 ft-lb (6.8 Nm) maximum
Diagnostic notes: *The coil contains a bipolar diode for spike suppression. Either lead may be connected to +12V since the diode only conducts at higher voltage. The coil may be checked in either direction with an ohmmeter. If the diode is bad, a voltage "spike" will occur everytime the coil is turned off, which could cause the strike alert to sound. The diode cannot be checked with an ohmeter but a scope-meter or oscilloscope will display voltage spikes caused by a failed diode.*	

Torque Limiter Solenoid Valve and Body Specifications	
forward limiter	
model	SF08-20
type	solenoid-operated, normally *passing*, piloted poppet-type
reverse limiter	
model	SF08-21
type	solenoid-operated, normally *non-passing*, piloted poppet-type
O-ring position (forward and reverse)	type 'T'
internal leakage	5 drops/min (0.25 cc/min)
valve body port size (all)	SAE 04
Diagnostic notes: *Since it is a poppet-type valve, the solenoid valve is a "non-leaker". When a pressure-leak test is performed, it should exhibit virtually "zero" leakage. If it is not possible to perform a pressure-leak test, any indication that the valve internal components are not free to move means that the valve cannot perform properly. Make sure that the inner poppet is free to move either by physical inspection or manipulation of the valve tip, or by energizing the solenoid and feeling the results of internal movement.*	

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TORQUE LIMITER SOLENOID VALVE BENCH TEST

Test Objective

- To determine if the torque limiter solenoid valve is holding pressure (not leaking) until energized (forward) or de-energized (reverse). If it is leaking, the maximum pressure that the pump can reach may be limited by the pressure relief setting at all times. Leakage should be **less than 5 drops/min (0.25 cc/min).**

NOTE: The forward torque limiter solenoid is identical to the thrust limiter on/off solenoid. They may be interchanged for diagnostic purposes.

Special Tools and Materials

- handpowered test pump capable of 3000 psi (210 bar)

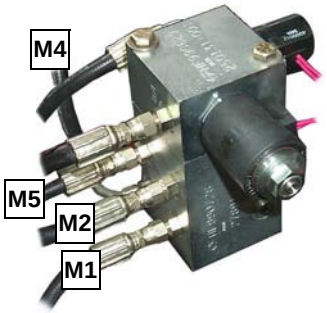
Conditions

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Remove hoses from ports 'M2' and 'M5' (forward limiter), or the hoses from ports 'M1' and 'M4' (reverse limiter).
2. Remove the pressure relief for the circuit being tested to ensure that any solenoid valve leakage can be noticed.

NOTE: If testing the reverse solenoid, energize the solenoid when performing the test.

3. Connect a hand pump to port 'M2' (forward) or 'M1' (reverse). Pressurize with the hand pump to approximately 3000 psi. Pressure should build up and hold steady with minimum pumping required to maintain pressure.

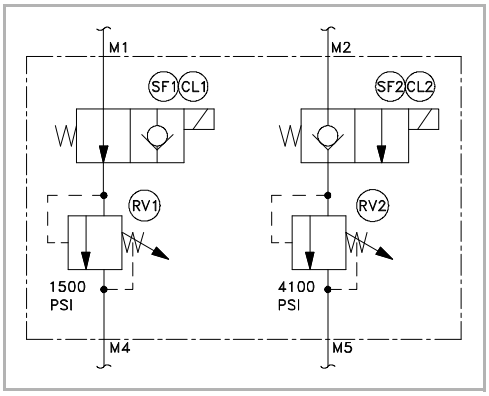
Results

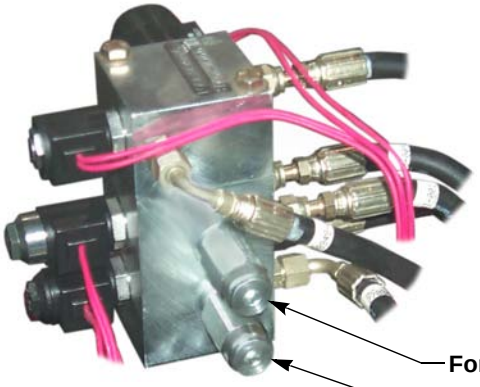
- ***If pressure builds up and stays steady,*** the solenoid valve is OK.
- ***If pressure leaks down rapidly or pressure cannot be built up,*** there is a problem with the solenoid valve, O-rings, or the valve cavity sealing surfaces. Leakage should be less than **5 drops/min (0.25 cc/ min).**

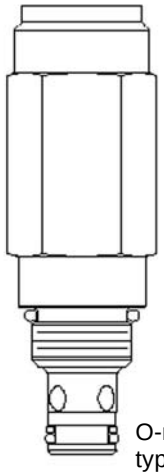
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TORQUE LIMITER PRESSURE RELIEF







O-ring installation: type 'B'

Forward Pressure Relief

Reverse Pressure Relief

Operation

The **forward** torque limiter limits forward rotation pressure whenever the front vise is ON or the rotation motors are shifted to HIGH speed. The **reverse** torque limiter limits reverse pressure whenever the front vise is off and the motors are in MED or LOW.

Action

The torque limiter applies loop oil to the pressure relief when the solenoid is energized (forward) or de-energized (rear). If the loop oil is at a higher pressure than the torque limiter pressure relief setting, the oil that passes over the relief is used to destroke the pump, limiting torque applied to the drill rod.

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Specifications

Torque Limiter Relief Valves Specifications	
forward limiter	
model	RV58-20H0-P-46/41
type	direct-acting poppet-type
relief setting	4100 psi (280 bar)
spring adjustment range	400–4600 psi (27.6–317.2 bar)
reverse limiter	
model	RV08-20H-0-N-33/15
type	direct-acting poppet-type
relief setting	1500 psi (105 bar)
spring adjustment range	100–3300 psi (6.9–227.5 bar)
O-ring position (forward and reverse)	type ‘B’ (O-ring is beneath backup ring)
maximum leakage to 75% of nominal setting	5 drops/min (0.25 cc/min)
diagnostic notes: *Since it is a direct acting poppet type valve, the relief valve is a “non-leaker”. When a pressure-leak test is performed it should exhibit virtually “zero” leakage. If it is not possible to perform a pressure-leak test, any indication that the valve internal components are not free to move means that the valve cannot perform properly.*	

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TORQUE LIMITER PRESSURE RELIEF BENCH TEST

Test Objective

To determine if the pressure relief valve is holding pressure (not leaking) until the pressure relief setting is reached. If it is leaking, the maximum pressure that the pump can reach will be limited whenever loop oil is applied to the relief.

- Cracking pressure should be within **100–200 psi (7–14 bar)** of the torque limiter pressure specification.
- Leakage should be **less than 5 drops/min (0.25 cc/min)**.

Special Tools and Materials

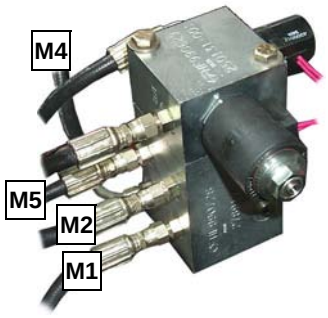
- handpowered test pump capable of 3000 psi (210 bar)

Conditions

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Remove hoses from ports 'M2' and 'M5' (forward limiter), or the hoses from ports 'M1' and 'M4' (reverse limiter).
2. Remove the solenoid valve for the circuit being tested and plug the port.
3. Connect a hand pump to 'M2' (forward limiter) or 'M1' reverse limiter. Pressurize with the hand pump. Pressure should build up and hold steady with minimum pumping required to maintain pressure, until you reach cracking pressure **(within 100–200 psi (7–14 bar)** of the torque limiter pressure specification).

Results

- ***If pressure builds up and stays steady up to the cracking pressure,*** the pressure relief valve is OK.
- ***If pressure builds up and stays steady until a certain pressure is reached but cracking pressure is not approximately 300 psi less than the torque limiter pressure specification,*** the valve is functioning correctly but is adjusted incorrectly. Adjust the pressure relief valve initially so that cracking pressure using the hand pump is 3800 psi (260 bar) (forward) or 1200 psi (83 bar) (reverse).

IMPORTANT: After restoring the machine, *verify* the pressure setting by operating the machine, and adjust as necessary.

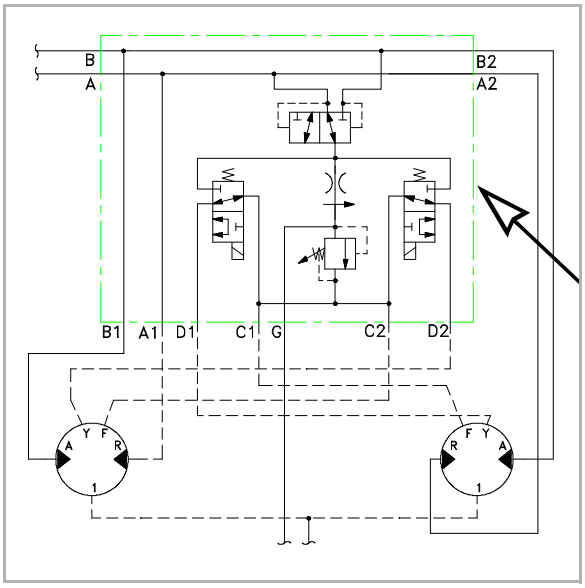
IMPORTANT: Do not use a hand pump to adjust a pressure relief unless specifically directed to do so. Cracking pressure with a hand pump does not indicate the pressure that can be obtained with a high flow hydraulic pump in the circuit.

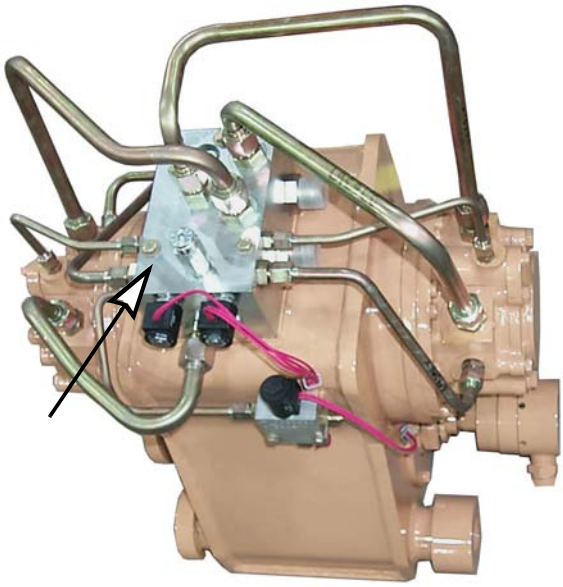
- ***If pressure leaks down rapidly or pressure cannot be built up,*** there is a problem with the pressure relief valve, O-rings, or the valve cavity sealing surfaces. Leakage should be **less than 5 drops/min (0.25 cc/min)**.

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3-SPEED/LOOP FLUSH VALVE

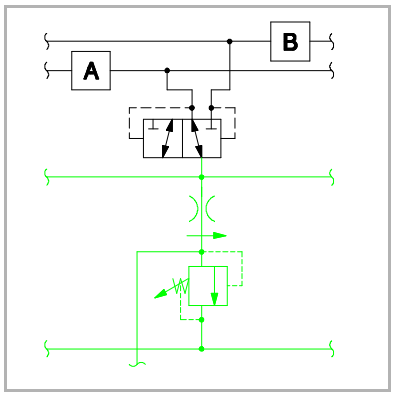


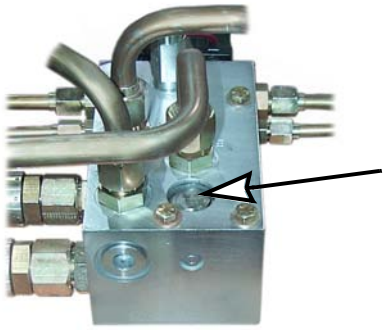


The 3-speed/loop flush valve is a manifold that directs oil to several valves and ports. It is important to follow torque instructions for each valve and fitting to avoid distorting or damaging the precision-machined valve cavities. Refer to the following pages for information on the components contained within the manifold.

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HOT OIL SHUTTLE CARTRIDGE



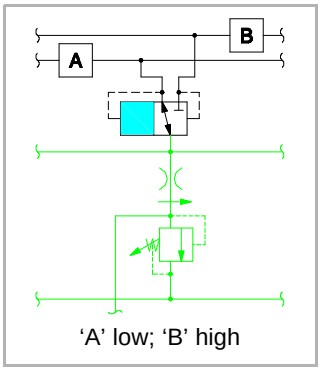


Operation

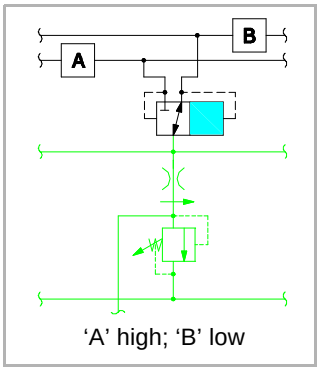
The hot oil shuttle cartridge is connected between the 'A' and 'B' ports. When the pump is stroked, oil from the "low" side of the loop flows to the shuttle relief and to the two motor shift solenoids.

Action

Oil from the 'A' and 'B' lines is applied to the shuttle valve spool. When the pump is in forward or reverse, high side oil shifts the spool valve so that oil flows from the low side of the loop, through the shuttle valve, to the shuttle relief valve and the motor speed solenoids.



'A' low; 'B' high



'A' high; 'B' low

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Specifications

Hot Oil Shuttle Specifications	
shuttle valve type	HS50-42-0-P
shuttle valve O-ring position	**top:** type 'T' **bottom:** type 'B'
maximum leakage	4 fluid oz/min (115 cc/min
Diagnostic notes: *Since the hot oil shuttle valve is a spool type valve, it is a "leaker" that will exhibit controlled leakdown during a pressure-leak test.*	

HOT OIL SHUTTLE BENCH TEST

Test Objective

To determine if the hot oil shuttle is leaking from the high side of the loop—causing inefficiency and high heat generation. Leakage should be **less than 4 fl-oz/min (115cc)**.

Special Tools and Materials

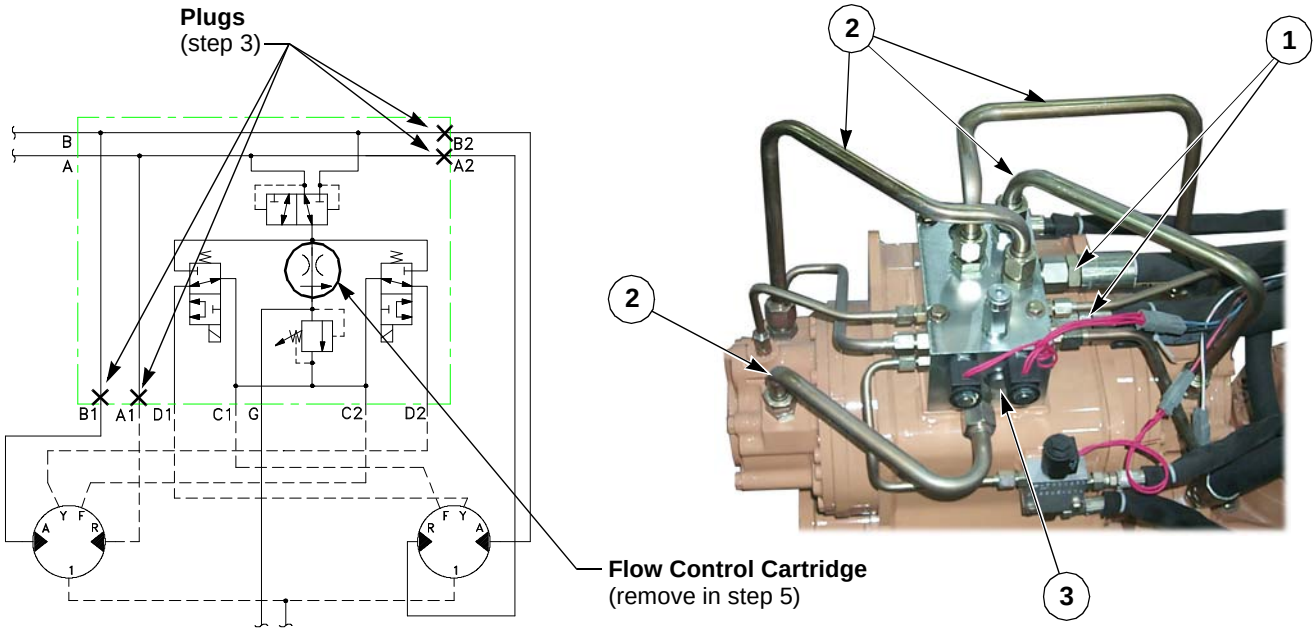
- handpowered test pump capable of 3000 psi (210 bar)

Conditions

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Follow the *Shutdown Procedure* (refer to page **10-2-1**) and verify there is no pressure in the loop.
2. Remove hoses **(1)** from ports 'A' and 'B' of the loop flush valve. Cap the hoses and tubes but leave the ports open.
3. Remove tubes **(2)** that go from ports 'A1', 'A2', 'B1', and 'B2' of the loop flush valve and go to the motors. Plug the open ports on the motors to prevent contamination. Install plugs rated for 5000 psi (345 bar) in ports 'A1', 'A2', 'B1', and 'B2'.

Since the shuttle valve is a spool type valve, it will have controlled leakdown just like a directional control valve.

4. Fill the loop flush valve with filtered oil and connect a handpowered test pump to the 'A' (reverse) or 'B' (forward) port (whichever is suspected of leaking) and pressurize using the hand pump. The hot oil shuttle should block flow (this may require vigorous pumping at first to shift the valve). Pressure should then build up.
5. Relieve pressure and remove the flow control valve **(3)**.
6. Resume pumping to test the shuttle; try to develop and maintain approximately 3000 psi (210 bar).

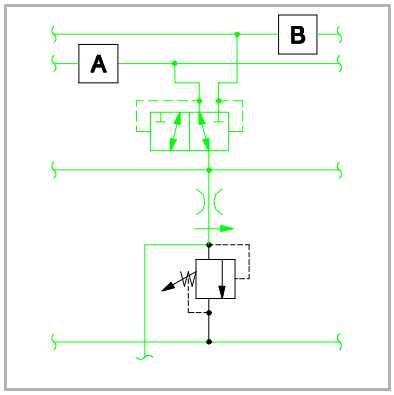
Results

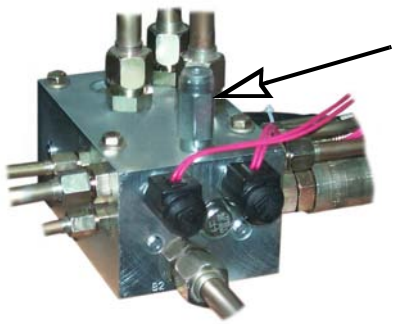
- ***If pressure builds up and stays steady*** with low to moderate pumping required to maintain pressure, the shuttle valve is okay.
- ***If pressure leaks down rapidly*** or pressure cannot be built up, there is a problem with the shuttle valve, O-rings, or the valve cavity sealing surfaces. Leakage should be **less than 4 fl-oz/min (115 cc/min)**.

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SHUTTLE RELIEF





Operation

Removing hot oil: The shuttle relief allows pressurized oil to flow from the low side of the loop. This removes a portion of the heated oil from the loop so that it can be replaced with cooler oil from the tank. (Without this cooling function, oil in the loop can become too hot, causing heat-related problems and oil viscosity breakdown.)

Cooling the rotation motors and gearbox: Oil from the shuttle valve that passes over the relief flows through the rotation motors and gearbox to lubricate and cool the motors and gearbox.

Providing Oil to Motor Speed Solenoids: The drive motors require approximately 95 psi (6.5 bar) oil to shift their displacement from high to low. The relief ensures that adequate pressure is provided to the motor shift solenoids to be applied to the motor shift ports.

Action

The shuttle relief should be set to relieve approximately 50–100 psi (3.5–7.0 bar) below the charge pump relief setting. When the shuttle valve is shifted to either loop port, low side loop pressure is applied to the relief. Oil flows across the relief based on the difference between the relief setting and the back pressure found in the case drain/return circuit.

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Specifications

Shuttle Relief Valve Specifications	
type	2-stage, pilot-operated
maximum leakage	4 fluid oz/min (115 cc/min)
relief valve type	RV10-26H-0-N-04/0.3
relief valve O-ring position	type ‘B’
spring adjustment range	100–400 psi (6.9–27.6 bar)
Diagnostic notes: *Since the relief valve is a spool type valve, it is a “leaker” that will exibit controlled leakdown during a pressure-leak test. Because of the design of the manifold in which it is installed, it is not possible to recommend a pressure-leak test for the relief valve as it is installed. The valve may be removed and installed in a separate manifold which will allow performing a pressure leak test. (However, since this valve exibits acceptable operation as long as shuttle pressure is within the range of approximately 150–300 psi (10–20 bar), and as long as shuttle flow is satisfactory, this test should rarely be performed.)*	

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SHUTTLE RELIEF BENCH TEST

Test Objective

To determine if the pressure relief valve is maintaining shuttle pressure high enough to operate the motor shift function and low enough to allow charge pump flow from the hot oil shuttle though the flow control valve. If pressure is too low, motor shift operation may be incorrect. If it is too high, hot oil shuttle flow may be limited, possibly causing overheating of the loop oil. Cracking pressure of the pressure relief should be approximately **350 psi ±25 (24 bar ±2)**

Special Tools and Materials

- handpowered test pump capable of 3000 psi (210 bar)
- cartridge test body from P/N 278950-001 (thrust/pullback thrust limiter)

Conditions

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Remove the pressure relief from the loop flush valve body and install in the cartridge test body. Plug the port corresponding to the on/off solenoid port and install the shuttle relief in the port corresponding to the thrust limiter proportional valve.
2. Connect the handpowered test pump to the 'IN' port. Apply pressure until **350 psi ±25 (24 bar ±2)** (cracking pressure) is reached. Pressure should build up and hold steady with minimum pumping required to maintain pressure.

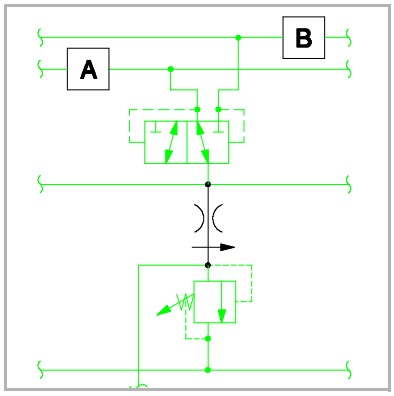
Results

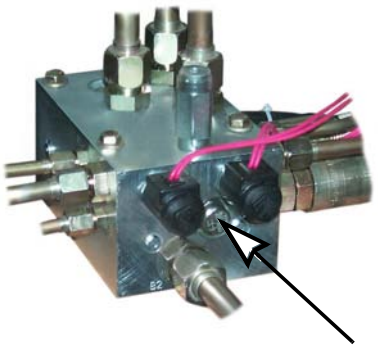
- ***If pressure builds up and stays steady,*** the pressure relief is OK.
- ***If pressure leaks down rapidly or pressure cannot be built up,*** there is a problem with the pressure relief valve, O-rings, or the valve cavity sealing surfaces.

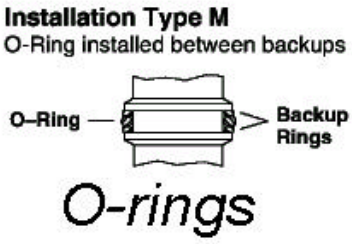
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FLOW CONTROL VALVE







Operation

The fixed control orifice is factory preset and is non-adjustable. The valve begins to respond to load changes when the flow through the valve creates a pressure differential across the control orifice greater than 80 psi (5.5 bar), with control in a working range of 110–3500 psi (7.6–240 bar).

Action

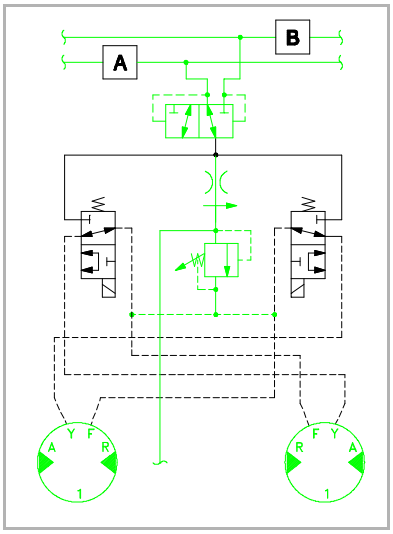
Oil from the hot oil shuttle travels through the flow control valve. The flow control valve allows any flow up to approximately 2.0 gpm (7.5 L/min).

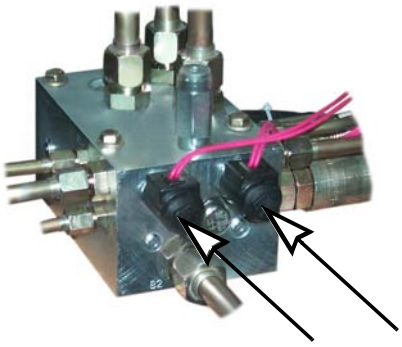
Specifications

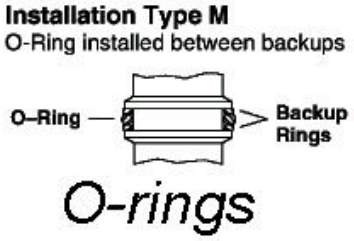
Flow Control Valve Specifications	
type	fixed orifice, pressure-compensated, hydraulic flow regulating valve (restrictive type)
regulated flow (flow control allows any flow up to the regulated limit but cannot force oil to flow)	2.0 gpm (7.5 L/min) ±10%
flow control type	FR08-20F
flow control O-ring position	type ‘M’ (O-ring is located between backup rings)
Diagnostic notes: *there is no practical bench test for the flow control valve. Refer to hot oil shuttle flow test, page* **70-5-14**	

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MOTOR SPEED SOLENOIDS





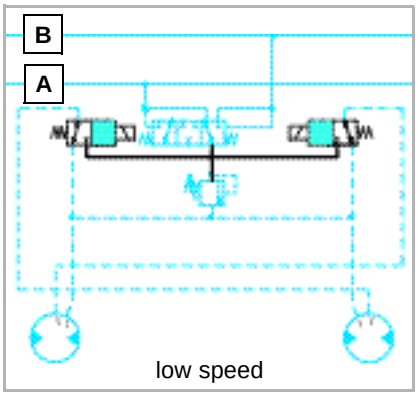


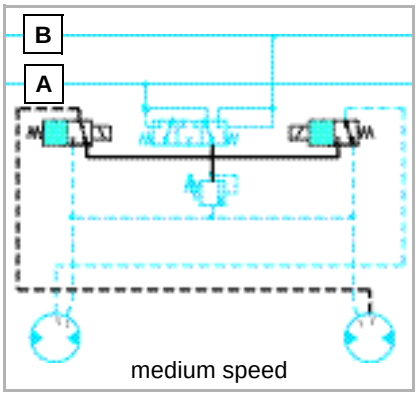
Operation

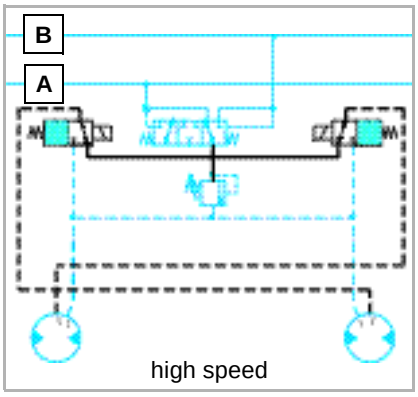
Each motor speed solenoid valve controls flow of oil to the 'Y' (shift) port of one rotation motor. Energizing the solenoid shifts the motor into high speed, and de-energizing it shifts the motor into low speed.

Action

When a solenoid is energized the spool applies charge pressure from the shuttle valve to the motor '1' port and blocks flow to the case drain circuit inside the shuttle block. When a solenoid is de-energized, charge pressure is blocked from the motor '1' port, which is opened to the case drain circuit inside the shuttle block. This allows shift oil from the speed solenoid valve to drain off, allowing the motors to shift back to low-speed/high-displacement.







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Specifications

Motor Speed Solenoid Coil Specifications	
type	'08' (P/N 251117-009)
initial coil current draw at 70°F (20°C)	1.07 A at 10.5 VDC 1.2 A at 12 VDC 1.48 A at 14.5 VDC
resistance	9.8 ohms at 70°F (20°C)
nominal power rating	14.7 W
coil installation torque	5 ft-lb (6.8 Nm) maximum
Diagnostic notes: *The coil contains a bipolar diode for spike suppression. Either lead may be connected to +12V since the diode only conducts at higher voltage. The coil may be checked in either direction with an ohmmeter. If the diode is bad, a voltage "spike" will occur everytime the coil is turned off, which could cause the Strike Alert to sound. The diode cannot be checked with an ohmmeter but a scope-meter or oscilloscope will display voltage spikes caused by a failed diode.*	

Motor Speed Solenoid Valve Specifications	
model	SV08-31-W-0-N-00
type	solenoid operated, 3-way, direct acting, spool-type
O-ring position	type 'M' (both O-rings) (O-ring is located between backup rings)
maximum leakage	5 in3/min (82 cc/min) at 3000 psi (207 bar)
valve installation torque	20 ft-lb (27 Nm)

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MOTOR SPEED SOLENOID VALVE BENCH TEST

Test Objective

To determine if the motor speed solenoid valve is holding pressure (not leaking) until energized. If it is leaking, the motors may shift erratically or may be shifted into high speed/low torque at all times. Leakage should be **less than 3 fl-oz/min (82 cc/min) at 3000 psi (207 bar).**

Special Tools and Materials

- handpowered test pump capable of 3000 psi (210 bar)
- solenoid valve body Vermeer P/N 239443-003 (identical to the valve body used for the thrust/pullback 2-speed solenoid valve)

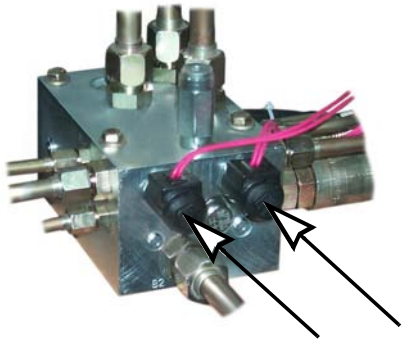
Conditions

WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible. Relieve pressure before working on system. When searching for a leak, use an object like cardboard - not your hand. Fluid injected under the skin must be removed immediately by a surgeon familiar with this type of injury.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

The solenoid valves must be removed from the 3-speed/loop flush valve for pressure-leak testing since the porting of the valve manifold will not allow individual testing in a reasonable amount of time.

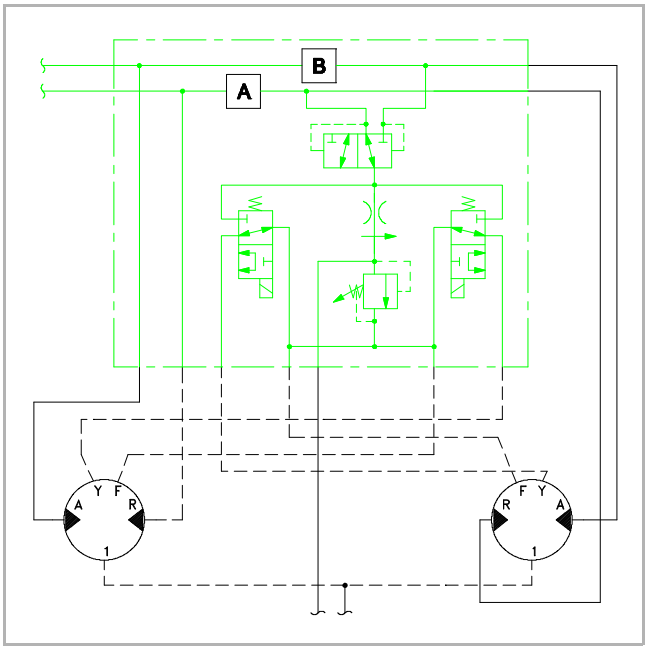
1. Remove the solenoid valve to be tested from the three-speed/loop flush valve.
2. Install the solenoid valve in a valve body Vermeer P/N 239443-003 (This valve body is identical to the valve body used for the thrust/pullback two-speed solenoid valve.)
3. Connect a hand pump to port '3'. Do not plug ports '1' or '2'. Pressurize with the hand pump to approximately 3000 psi. Pressure should build up and hold steady with minimum pumping required to maintain pressure.

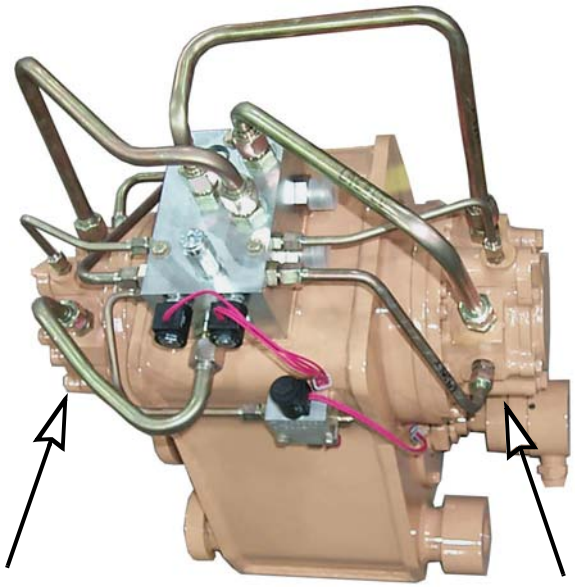
Results

- ***If pressure builds up and stays steady,*** the solenoid valve is OK.
- ***If pressure leaks down rapidly or pressure cannot be built up,*** there is a problem with the solenoid valve or O-rings. (Note that this test does not test the 3-speed/loop flush valve cavity sealing surfaces.) Leakage should be **less than 3 fl-oz/min (82 cc/min) at 3000 psi (207 bar).**

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ROTATION MOTORS





Operation

The rotation motors are splined onto a single shaft in the gearbox. They receive oil from the rotation pump to turn the gearbox input shaft. Each motor may be shifted from high-displacement/low-speed to low-displacement/high-speed. This allows the drill head combined motors to have *high*, *medium*, and *low* displacements which corresponds to *low*, *medium*, and *high* speeds.

Action

Forward: Oil from the rotation pump (PMP1) 'B' port flows to the 'B' port at the hot oil shuttle block. Oil then flows to the 'A' ports of the rotation motors. Exhaust (low side) oil from the 'R' ports of the motors travels to the 'A' ports on the shuttle block and into the 'A' loop hose.

Reverse: Oil from the rotation pump (PMP1) 'A' port flows to 'A' port at the hot oil shuttle block. Oil then flows to the 'R' port of both motors. Exhaust (low side) oil from the 'A' ports of the motors travels to the 'B' ports on the shuttle block and into the 'B' loop hose.

NOTE: The motor 'A' port is the primary inlet port and receives pressure oil from the pump 'B' port. This requires different internal valving inside the front and rear motors to allow opposite rotation to result from pressurizing the 'A' port.

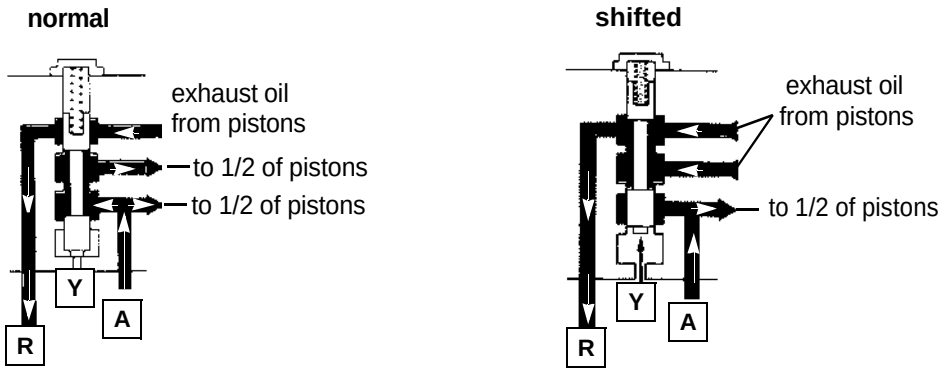
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Displacement shift: During normal operation, out of *ten* pistons in each motor, *four* are receiving pressurized oil from the 'A' port and applying torque to the drive shaft, *four* are exhausting to the 'R' port, and *two* are in transition between exhaust and pressure.

Applying shuttle oil pressure to the 'Y' port of either motor shifts a spool valve. This exhausts half of the motor pistons directly to the 'R' port, which prevents them from applying torque to the drive shaft. Now only two out of the ten pistons are receiving pressurized oil and the rest are either connected to exhaust oil at the 'R' port or are in transition between pressure and exhaust. This reduces motor displacement by 1/2 and increases motor speed.

The motor is shifted back to normal by removing shuttle oil pressure through the case drain circuit, which allows the spool valve to return to normal and allows use of all the motor pistons.



Dual Motor Operation

Shift Operation: Although the motors shift displacement independently so that both can be in low speed, both in high speed or one in low speed and one in high speed, they act together by splitting oil flow and applying torque according to their displacement. Since they turn on a common shaft, their rotation speed will always be the same. Their contribution to overall torque and power will depend on their displacement.

Rotation Direction: Front and rear motors are identical except that the internal distribution block is indexed for clockwise or counterclockwise rotation when oil is applied to the 'A' port which is intended to be the primary inlet or feed port. If necessary, motors can be changed for opposite rotation (refer to page 70-6-11).

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Specifications

Rotation Motor Specifications	
Drill Chuck RPM (no load)	The pump must be fully stroked and the engine at 2500 rpm (check with a photo tachometer)
LOW speed	117 rpm (approximate)
MEDIUM speed	156 rpm (approximate)
HIGH speed	234 rpm (approximate)
Motor Shift Pressures	
beginning of spool movement	50 psi (3.5 bar)
spool bypass stage	75 psi (5.2 bar)
fully shifted to high speed	95 psi (6.6 bar)
NOTE: The “bypass” stage allows oil pressure to vent between ports ‘A’ and ‘R’ as the motor goes through its transition from full displacement to half displacement. Residual pressure at 75–85 psi (5.2–5.9 bar) above case pressure could cause the spool to float in the transitional bypass stage which would prevent the motor from operating in either LOW or HIGH speed.	
Diagnostic note: *Any case drain flow check must be done while the motor is operating. An indication of excess case drain flow when the motor is stopped may be the result of component valve position, not wear or damage.*	

Testing Motors

Since it is not practical to provide a calibrated load in the field, diagnosis of motor operation must be through a process of elimination. Verify that the rotation pump is delivering specified pressure and flow to the motor inlets and that the loop flush/3-speed system is working correctly. If the other systems are operating correctly, one or both rotation motors are at fault.

Motor Repair / Replacement

Refer to *Gearbox Repair* (page 70-6-9) for motor replacement and to reverse motor rotation direction)

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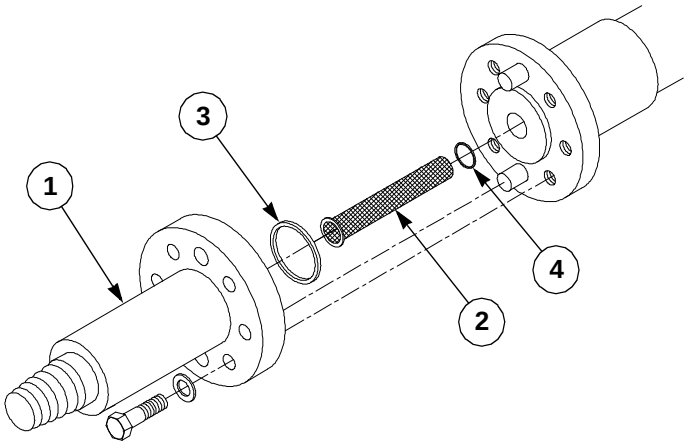
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Section 70-6: Gearbox Repair

DRIVE CHUCK REPLACEMENT



Special Tools and Materials

- torque wrench capable of producing 90 ft-lb (122 Nm)

Replace Drive Chuck

1. Remove the six bolts and washers, and remove drive chuck **(1)**. Remove screen **(2)** if the rotation shaft is so equipped.
2. Cap or plug the end of the rotation shaft to keep the bore clean.
3. Always use a new O-ring **(3)** and rubber washer **(4)** during re-assembly. Lightly lubricate them before installation. Seat the O-ring in the drive chuck groove and the rubber washer against the screen lip.



4. Mount the drive chuck on the rotation shaft. Use a gradual cross pattern tightening sequence to evenly seat the drive chuck against the rotation shaft. Then, final torque the bolts to 90 ft-lb (122 Nm) in a cross pattern sequence.

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DRIVE CHUCK SUB-SAVER INSTALLATION / REMOVAL

Special Tools and Materials

- acetylene heating torch
- wire brush
- Formula “C” BAKERLOCK, or Plusco 170 Thread Locking Compound (Vermeer P/N 235804-001)

Thread Locking Compound Considerations

Thread locking compound has a shelf life of three years as long as the hermetically sealed containers are not opened. Prolonged storage at temperatures above 100°F (38°C) may cause some settling of the fillers and require careful, thorough re-mixing for best results. Freezing has no detrimental affects on the components.

The optimum drive chuck casing temperature for applying mixed compound to the threads is 70°–150°F (21°–66°C). The compound will not cure at temperatures beneath 40°F (4°C).

Once the compound has been mixed, it has a limited usable life—apply as soon as possible.

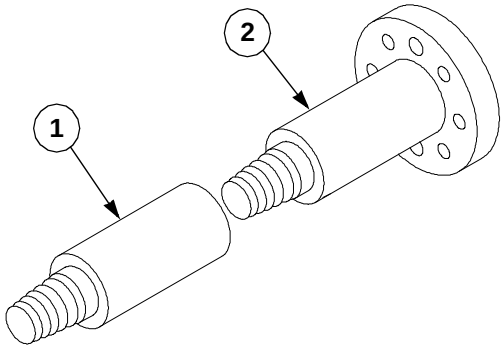
Temperature	Usable Life	Full Strength Cure Time
70°F (21°C)	90 minutes	48 hours
100°F (38°C)	40 minutes	17 hours
120°F (50°C)	---	6 hours
150°F (65°C)	---	2 hours

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Install Sub-Saver



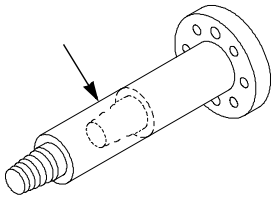
1. Clean all threads on sub-saver **(1)** and drive chuck **(2)** with solvent and rinse with water. Remove all grease, moisture, and foreign matter. Remove any rust with a wire brush.
2. Thoroughly mix the can of thread locking compound with the applicator. Shake the vial of hardener and add to the compound. Mix until completely blended and no streaks are visible in the mixture.
3. Apply the compound to the entire circumference of the first 2/3 of the drive chuck threads.
4. Clamp the sub-saver in the upper rod vise and make up the joint with maximum torque (gearbox set to LOW).

IMPORTANT: Do not use put the sub-saver into use until the thread locking compound has cured to full strength.

Remove Sub-Saver

To prevent damage to the drive chuck, do not apply heat directly to its surface.

1. Clamp the sub-saver in the upper rod vise
2. Using an acetylene heating torch, evenly and quickly apply heat to the threaded joint to the loosen the threads. Apply heat only to the box end of the sub-saver. The thread locking compound will release at 500°–600°F (260°–315°C)

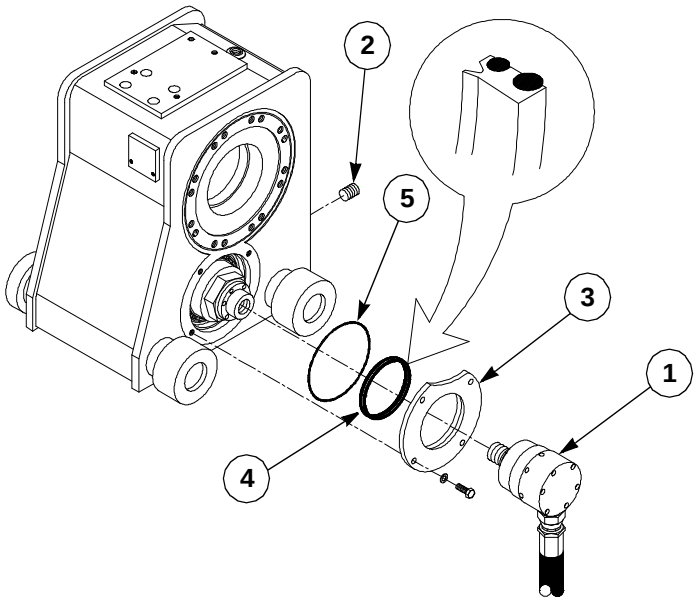


3. Quickly back the drive chuck out of the sub-saver before the heat transfers to the drive chuck.

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REAR SEAL REMOVAL / INSTALLATION



Special Tools and Materials

- torque wrench capable of producing 35 ft-lb (47 Nm)
- wire brush
- Loctite ODC-Free Cleaner and Degreaser
- Loctite Primer N 7649
- Loctite 515 Gasket Eliminator
- pipe sealant

Remove Seal

Because oil from the motors is used to flush the gearbox, cleanliness is extremely important when working on the gearbox.

1. Verify that there is no residual pressure in the drill string. Remove water swivel **(1)** and clean old sealant from the threads.
2. Remove drain plug **(2)** and drain the oil. Thoroughly remove old sealant from the plug.
3. Remove the four bolts and washers and pull rear seal gland **(3)** from the gearbox.
4. Remove original high pressure seal **(4)** and O-ring **(5)** from the gland and discard them.
5. Thoroughly remove old sealant from the bolts, gland and gearbox machined surface.

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Install Seal

1. Clean the drain plug and bolts using Loctite ODC-Free Cleaner and Degreaser, and then spray them with Loctite Primer N 7649. Follow the manufacturer's instructions to obtain the best results.
2. Apply a film of grease to the inner and outer diameters of the replacement high pressure seal **(4)**. Orient the seal as shown and fully seat it in the gland.
3. Lightly oil the replacement O-ring **(5)** and roll it into the groove.
4. Mount the rear seal gland **(3)**. Slide the washers on the bolts; apply Loctite 515 to the bolts' threads; and finger tighten them in the gearbox.
5. Use a gradual cross pattern tightening sequence to evenly seat the rear seal gland against the gearbox. Then, final torque the bolts in a cross pattern sequence to 35 ft-lb (47 Nm).
6. Apply Loctite 515 to the drain plug threads and tighten it in the gearbox.
7. Apply pipe sealant to the threads of the water swivel **(1)**. Thread the swivel into the rotation shaft and tighten it.

GEARBOX REMOVAL / INSTALLATION

Special Tools and Materials

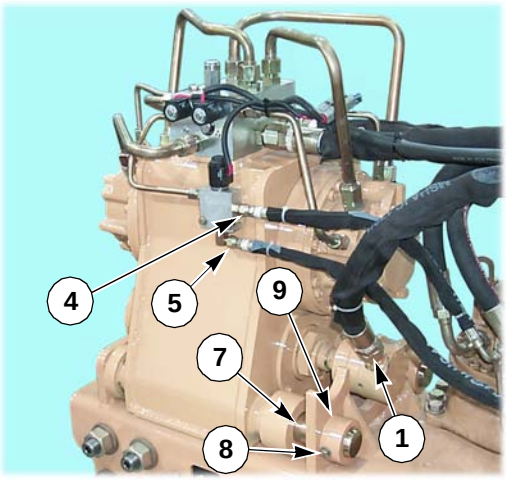
- torque wrench capable of producing 30 ft-lb (40 Nm) and 90 ft-lb (122 Nm)
- wire brush
- pipe sealant

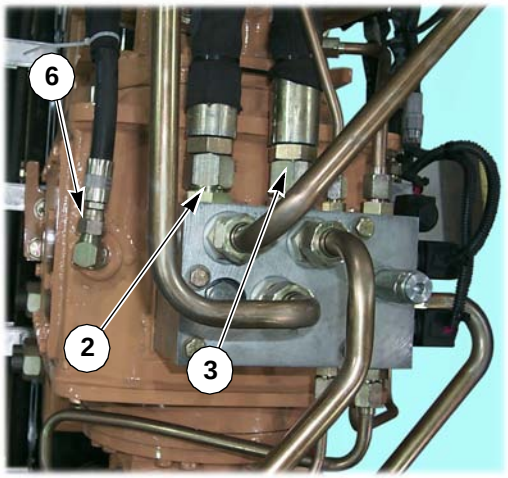
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Remove Gearbox





1. Level the drill rack and move the gearbox to the rear of the rack.
2. Follow the *Shutdown Procedure* (refer to page 10-2-1).

IMPORTANT:

3. Since you will be opening the hydrostatic closed-loop system, thoroughly clean the gearbox and surrounding area.
4. Remove the hose **(1)** from the water swivel and clean residual sealant from the threads. Cap or plug the hose and swivel.
5. Label and disconnect any wire connectors secured to hoses and tubes. Remove all of the ny-ties that secures the harness to the gearbox.
6. Label and remove the 'A' port hose **(2)**, 'B' port hose **(3)**, two-speed valve assembly hoses **(4)** and **(5)**, and case drain hose **(6)**. Cap or plug all ports and fittings.
7. Install a suitable lifting sling beneath the hydraulic motors. Attach an adequate lifting device to the sling, and lift enough to remove the weight of the gearbox from the floating head pins **(7)**.

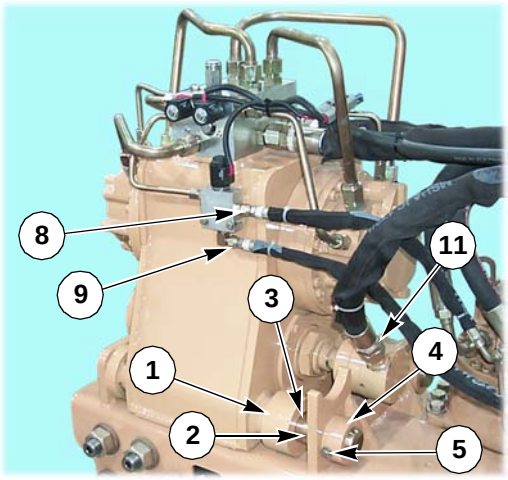
When removing the floating head pins, be careful not to damage the sliding surfaces.

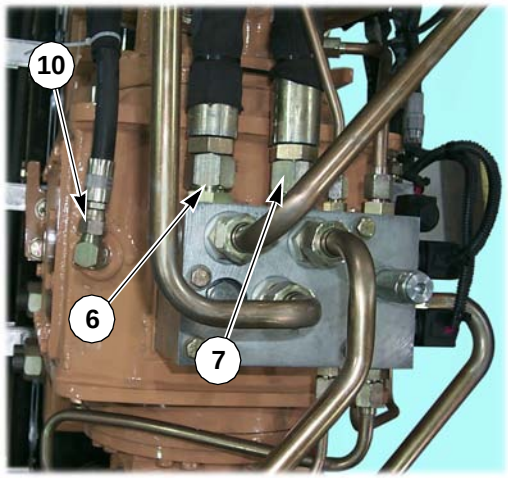
8. Remove the two retaining bolts **(8)** and pin caps **(9)**.
9. Carefully remove the floating head pins.
10. Lift the gearbox from the drill rack.

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Install Gearbox





1. Install a suitable lifting sling beneath the hydraulic motors. Attach an adequate lifting device to the sling, and lift the gearbox onto the gearbox carriage.

When installing the floating head pins, be careful not to damage the sliding surfaces.

2. Align the sliding bearings **(1)** on the gearbox with the corresponding holes **(2)** in the carriage.
3. Install the floating head pins **(3)**, pin caps **(4)** and retaining bolts **(5)**.

When connecting hoses to ports, carefully oil the threads and seats of the hoses or fittings so that correct torque values can be achieved as hoses are tightened.

4. Install the 'A' port hose **(6)**and 'B' port hose **(7),** torquing each hose to 87.5 ft-lb (118.7 Nm).
5. Install the two-speed valve assembly hoses **(8)** and **(9)**, and torque them to 19 ft-lb (25.8 Nm).
6. Install the case drain hose **(10)** and torque it to 28.5 ft-lb (38.6 Nm).
7. Connect the wire connectors and secure the harness to a hose or tube. Replace all of the ny-ties.
8. Apply pipe sealant to the threads of the hose **(11).** Thread the hose into the water swivel and tighten it.
9. Refer to the *Returning System to Service* procedures (refer to page **40-6-3**) before starting the engine or running the machine.

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MOTOR REMOVAL / INSTALLATION

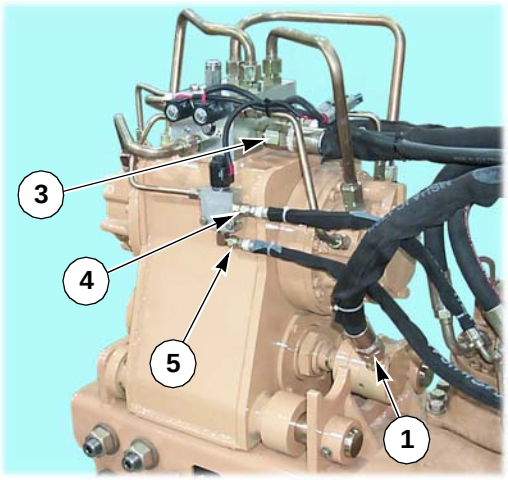
Special Tools and Materials

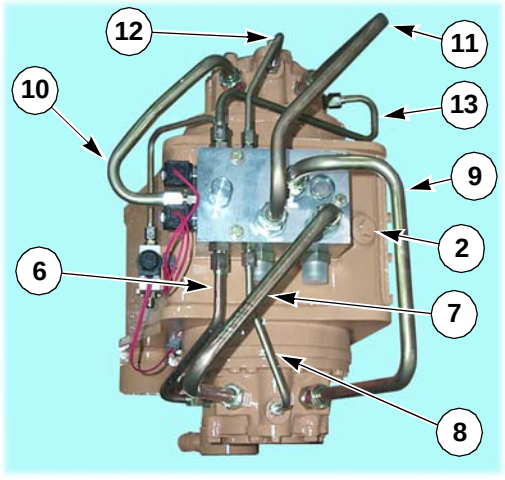
- torque wrenches capable of producing 30 ft-lb (40 Nm) and 90 ft-lb (122 Nm)
- tubing wrenches
- two fabricated guide pins:
  overall length: 5" (127 mm)
  thread length: 1-1⁄4" (32 mm)
  thread specifications: M12x1.75
- petroleum jelly

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Remove Motors





1. Level the rack and move the gearbox to the back of the rack.
2. Follow the *Shutdown Procedure* (refer to page 10-2-1).
3. Since you will be opening the hydrostatic closed-loop system, thoroughly clean the gearbox.
4. Label and disconnect any wire connectors secured to hoses and tubes.

Because cleanliness is extremely important when working on the gearbox, cap or plug all of the hoses, tubes and fittings during disassembly.

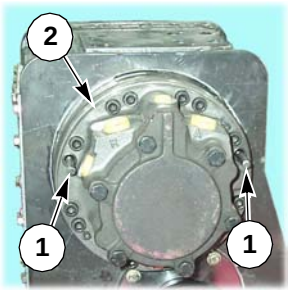
5. If necessary, label and remove:
   - hose **(1)** to water swivel
   - case drain hose at location **(2)** (hose shown removed)
   - 'A' port and 'B' port hoses **(3)** (hoses located next to each other)
   - two-speed valve assembly hoses **(4)** and **(5)**
6. Label and remove the tubes in the suggested order for the particular motor being serviced as follows:
   - rear motor tubes **(6)**, **(7)**, **(8)** and **(9)**
   - front motor tubes **(10)**, **(11)**, **(12)** and **(13)**

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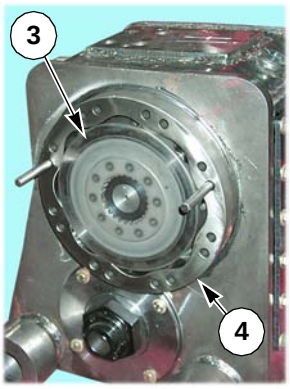
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7. Remove two screws and thread two fabricated guide pins **(1)** into the holes. Remove the remaining fourteen screws and pull valving cover assembly **(2)** from the gearbox.



8. Remove cylinder block **(3)** and then cam ring **(4)**.



9. Discard O-ring **(5)**.

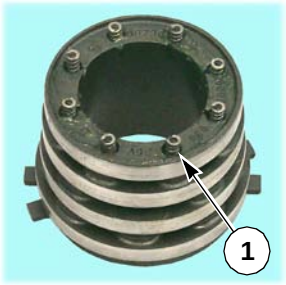


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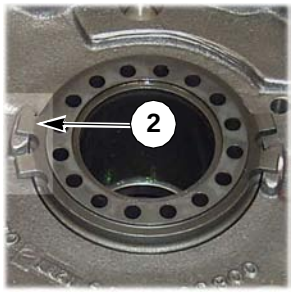
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Change Motor Direction

IMPORTANT: When positioning the valving in the valving cover assembly for correct motor rotation, do not lift the valving any higher than the height of the notch. Otherwise, springs **(1)** will fall out of the valving holes. Coat the springs with petroleum jelly to retain them in the holes.



1. Orient **rear** motor valving tab **(2)** in the notch as shown for correct rotation direction.



2. Orient **front** motor valving tab **(3)** in the notch as shown for correct rotation direction.



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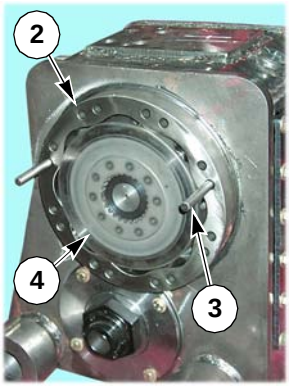
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Install Motors

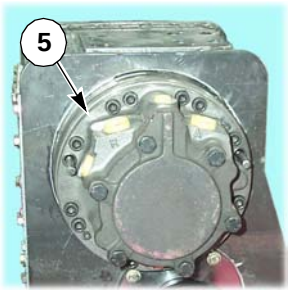
1. Thoroughly clean the machined motor mounting surface on the gearbox.
2. Coat the new O-ring **(1)** with petroleum jelly and firmly seat it in the groove.



3. Inspect cam ring **(2)** for visible wear. Thread two guide pins **(3)** into the gearbox. Mount the cam ring on the pins with the chamfered holes toward the gearbox.
4. Inspect cylinder block **(4)** for visible wear and slide it on the shaft. Apply clean filtered hydraulic oil to the surface of the cylinder block to provide startup lubrication against the valving.



5. Mount valving cover assembly **(5)** on the guide pins and finger tighten fourteen mounting screws. Remove the guide pins and finger tighten the two remaining screws.
6. Use a gradual cross pattern tightening sequence to evenly seat the valving cover assembly against the gearbox. Then, final torque the screws to 87 ft-lb (118 Nm) in a cross pattern sequence.

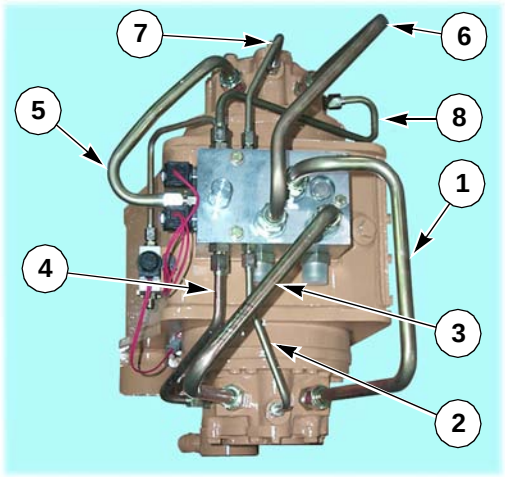


NOTE: If plug **(6)** is removed, discard the O-ring. Lubricate the new O-ring and replace the plug. Torque it to 28 ft-lb (39 Nm).



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When connecting tubes to ports, carefully oil the threads and seats of the tubes or fittings so that correct torque values can be achieved as the tube nuts are tightened. Always use lightly lubricated new O-rings during re-assembly.

7. Install the tubes in the following suggested order for the particular motor being serviced:

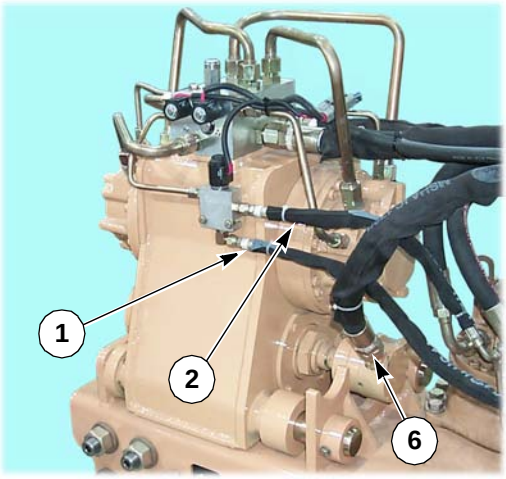
Rear Motor		
Sequence	**Ports**	**Torque**
(1)	'B1' (valve) to 'A' (motor)	92 ft-lb (124.7 Nm)
(2)	'D2' (valve) to 'Y' (motor)	18.0 ft-lb (24.4 Nm)
(3)	'A1' (valve) to 'R' (motor)	92 ft-lb (124.7 Nm)
(4)	'C2' (valve) to 'F' (motor)	27.0 ft-lb (36.6 Nm)

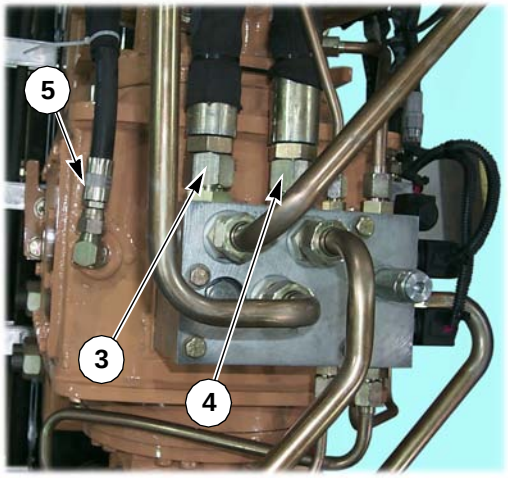
Front Motor		
Sequence	**Ports**	**Torque**
(5)	'B2' (valve) to 'A' (motor)	92 ft-lb (124.7 Nm)
(6)	'A2' (valve) to 'R' (motor)	92 ft-lb (124.7 Nm)
(7)	'D1' (valve) to 'Y' (motor)	18.0 ft-lb (24.4 Nm)
(8)	'C1' (valve) to 'F' (motor)	27.0 ft-lb (36.6 Nm)

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When connecting hydraulic hoses to ports, carefully oil the threads and seats of the hoses or fittings so that correct torque values can be achieved as the hoses are tightened.

8. Install the following hoses:
   - 2-speed valve assembly hoses **(1)** and **(2)** and torque to 19 ft-lb (25.8 Nm)
   - A' port hose **(3)** and 'B' port hose **(4)** and torque to 87.5 ft-lb (118.7 Nm)
   - case drain hose **(5)** and torque to 28.5 ft-lb (38.6 Nm)
   - water hose **(6)** to water swivel using anaerobic pipe sealant on threads
9. Connect the wire connectors and secure the harness to a hose or tube. Replace all of the ny-ties.
10. Refer to the *System Startup* procedures (refer to page **40-6-3**) before starting the engine or running the machine.

ROTATION SHAFT AND FRONT SEAL REMOVAL / INSTALLATION

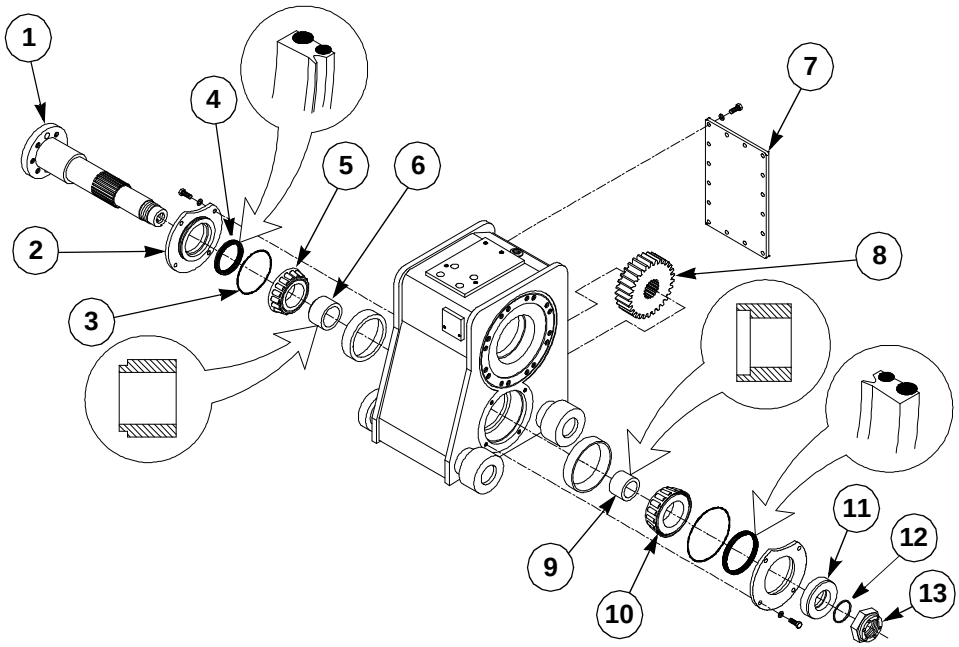
Special Tools and Materials

- torque wrenches capable of producing 5 ft-lb (7 Nm), 35 ft-lb (47 Nm) and 145 ft-lb (197 Nm)
- pry bar
- wire brush
- Loctite ODC-Free Cleaner and Degreaser
- Loctite Primer N 7649
- Loctite 515 Gasket Eliminator

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Remove Rotation Shaft and Front Seal



Because oil from the motors is used to flush the gearbox, cleanliness is extremely important when working on the gearbox.

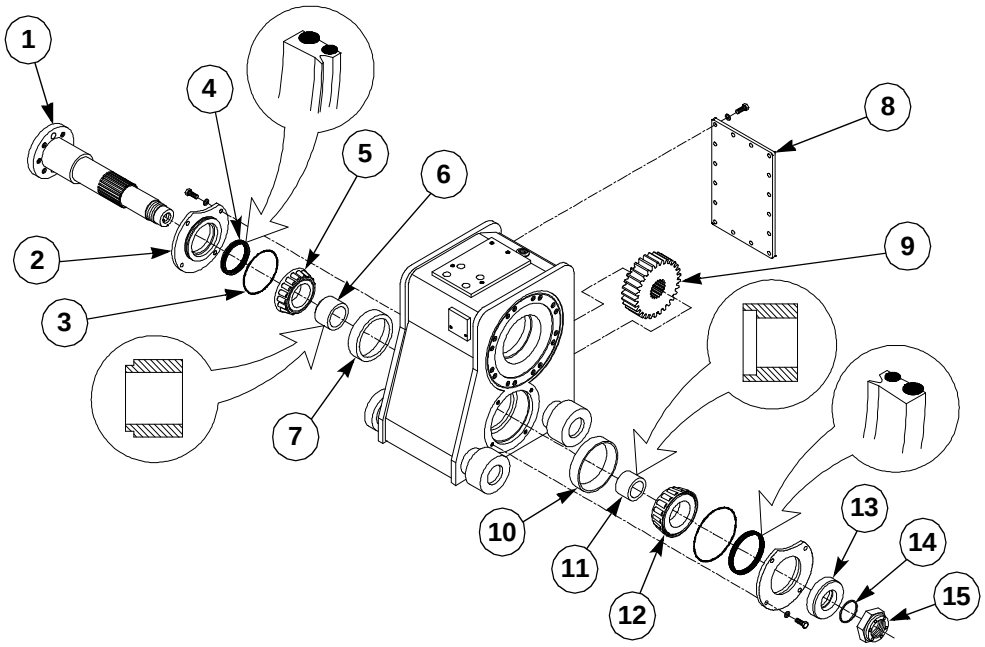
1. Remove the drive chuck. Refer to *Drive Chuck Replacement*, page 70-6-1
2. Remove the rear seal. Refer to *Rear Seal Removal*, page 70-6-4
3. Remove plate **(7)**. Thoroughly remove old sealant from the bolts, plate surface and gearbox machined surface.
4. Remove the four bolts and washers and pull front seal gland **(2)** from the gearbox, allowing it to hang on the rotation shaft.
5. Loosen the six screws in the flange of locking nut **(13)** and remove the nut. Remove sleeve **(11)** from the rotation shaft, and discard O-ring **(12)** from the inner diameter. Remove cone bearing **(10)** and tube spacer **(9)**.
6. Pull out rotation shaft **(1)**, allowing gear **(8)** to remain in the gearbox. Remove tube spacer **(6)**, cone bearing **(5)** and front seal gland **(2)** from the shaft.
7. Remove original high pressure seal **(4)** and O-ring **(3)** from the gland and discard them. Thoroughly remove old sealant from the bolts, gland and gearbox machined surface.

Continued on next page...

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Install Rotation Shaft and Front Seal



1. Clean the following parts with Loctite ODC-Free Cleaner and Degreaser, following the manufacturer's instructions to obtain the best results:
   - bolts for plate **(8)** and front seal gland **(2)**
   - gearbox machined surfaces for the plate and front seal gland
   - surface of the plate and front seal gland that seals against the gearbox
2. Spray the above parts with Loctite Primer N 7649. Follow the manufacturer's instructions to obtain the best results.
3. Inspect rotation shaft **(1)** for visible wear in the areas where the seals and bearings seat.

The high pressure seal must be seated in the front seal gland after the gland is mounted on the rotation shaft.

4. Slide the front seal gland **(2)** (machined step up) on the rotation shaft. Apply a film of grease to the inner and outer diameters of the replacement high pressure seal **(4),** orienting it as shown. Slide the seal down the rotation shaft toward the gland, and then fully seat it in the gland.
5. Lightly oil replacement O-ring **(3)** and roll it into the groove.

Replace the cone bearing and press-fit bearing cup at the same time.

6. Inspect cone bearing **(5)** and bearing cup **(7)** for visible wear, replacing them as needed. Seat the cone bearing against the rotation shaft shoulder. Mount tube spacer **(6)** with the machined step against the bearing.

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7. Align the sub-assembled rotation shaft with the splines of gear **(9)** and push it through the gearbox. Install tube spacer **(7)** with the machined step against the gear.

8. Inspect cone bearing **(6)** and bearing cup **(15)** for visible wear, replacing them as needed. Slide the cone bearing on the rotation shaft. Inspect sleeve **(4)** for visible wear; lightly oil the new O-ring **(5)**; and seat the O-ring in the sleeve groove. Mount the sleeve with the chamfered edge (outer diameter) facing outward.

9. Thread the lock nut **(3)** on the rotation shaft. Hold the gear in position with a pry bar and torque the nut to 142 ft-lb (193 Nm). Rotate the shaft two revolutions and re-torque the nut to 142 ft-lb (193 Nm). Repeat the procedure until the parts are seated and the torque is achieved.

10. Use a gradual cross pattern tightening sequence to tighten the six screws in the flange of locking nut **(3)**. Then, final torque the screws in a cross pattern sequence to 37 in-lb (4 Nm)

11. Mount the front seal gland **(2)**. Slide the washers on the bolts; apply Loctite 515 to the bolts' threads; and finger tighten them in the gearbox. Use a gradual cross pattern tightening sequence to evenly seat the front seal gland against the gearbox. Then, final torque the bolts in a cross pattern sequence to 35 ft-lb (47 Nm).

12. Apply a continuous bead of Loctite 515 from hole to hole and around each hole on the gearbox machined mounting surface for plate **(1)**. Slide the washers on the sixteen bolts; apply Loctite 515 to the bolts' threads; position the plate against the gearbox; and finger tighten the bolts. Use a gradual cross pattern tightening sequence to evenly seat the plate. Then, final torque the bolts in a cross pattern sequence to 35 ft-lb (47 Nm).

13. Install the rear seal. Refer to *Rear Seal Installation*, page **70-6-4**

14. Mount the drive chuck. Refer to *Drive Chuck Replacement*, page **70-6-1**

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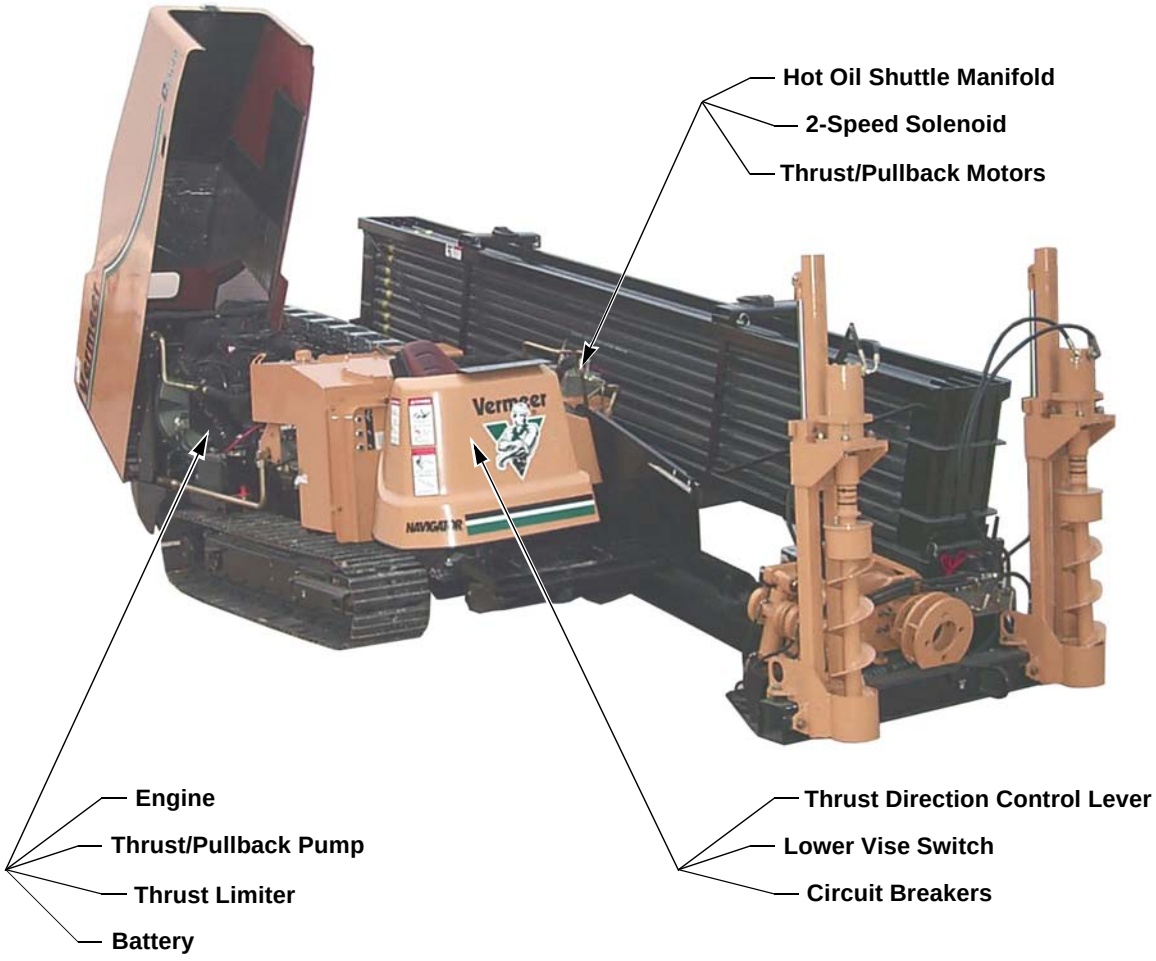
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Section 80-1: Thrust / Pullback System Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

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OPERATION OVERVIEW

Engine

The engine drives the hydrostatic thrust/pullback pump which supplies oil to the thrust/pullback motors. The motors are are geared to a common pinion rack and provide thrust and pullback force to the drill rod.

Thrust/Pullback Pump

The thrust/pullback pump provides a variable output to drive the motors. The thrust/pullback motors are automatically shifted to half-displacement high-speed mode whenever the lower vise is ON.

Thrust/Pullback Charge Pump

Thrust/pullback charge oil is supplied to the thrust/pullback closed loop to replace leakage. There is no shuttle valve on the thrust/pullback circuit. The thrust/pullback charge pump oil also provides a pilot signal to the proportional water pump control valve.

Rotation Charge Pump

Rotation charge oil provides pilot oil pressure to shift the thrust/pullback motors' speed and displacement by way of the loop flush valve and the thrust 2-speed solenoid valve.

Thrust Limiter (Rockfire)

The thrust limiter limits thrust pressure whenever the Rockfire switch is ON. The Rockfire control module energizes the thrust limiter on/off solenoid valve whenever the Rockfire switch is ON. The control switch varies the actual pressure available by signalling the rockfire control module to control the proportional solenoid within the thrust limiter. The greater the output from the control module, the higher the relief setting since the proportional solenoid acts to add pressure to the relief valve base setting. **Important:** the setting of the the variable pressure relief must be at least 350 psi (=/< charge pressure) or the carriage may creep when the control is not stroked, due to charge pressure going past the pressure relief to the pump servo system

Hot Oil Shuttle

The 3-speed/loop flush valve on top of the rotation gearbox incorporates the hot oil shuttle valve, the hot oil shuttle relief valve, and the shift solenoids for the rotation motor. These components influence the delivery of pilot oil from the rotation charge pump to thrust/pullback 2-speed solenoid.

Anti-Crash and Slowdown Circuits

The slowdown/anti-crash module is inserted in the Thrust/Pullback EDC control circuit. Based on inputs from the front and rear slowdown and stop switches, the module slows down the carriage at each end of its travel, then cuts the circuit at the appropriate travel limit to prevent overtravel.

2-Speed Solenoid

The 2-speed solenoid shifts both carriage motors into HIGH speed whenever the lower vise is on.

Operation

Correct operation of the system requires that the engine is turning at rated RPM, oil supply is unrestricted to the charge pump, and the charge filter is not plugged or "dirty".

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SYSTEM SPECIFICATIONS

The following specifications are for the thrust/pullback system in general. For individual component specifications, refer to the appropriate section in this manual.

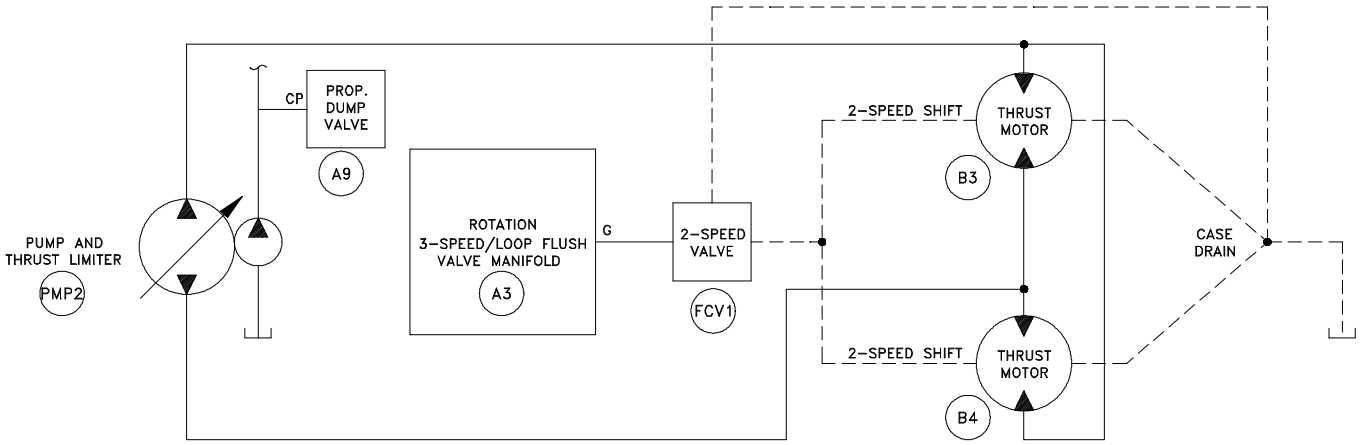
Specification	Value
General	
governed engine RPM	2200 rpm
Thrust/Pullback Force at Maximum Pump Pressure	
maximum thrust	20,000 pounds (9070 kg)
maximum pullback force	33,000 pounds (14970 kg)
Pump	
make / model	Sundstrand 90 series
specification number..... 90R055 KP1CD 80P3S1 C00GBA 424224	
pressure limiter setting (multifunction valve) for PULLBACK	4900 psi (338 bar)
multifunction valve pressure setting (THRUST)	3100 psi (214 bar)
thrust limiter setting (Rockfire mode) for THRUST	400-3000 psi (28-207 bar)
displacement per revolution	3.35 cid (55 cc)
nominal flow @ 2200 rpm	32 gpm (121 L/min)
maximum allowable case pressure (cold)	73 psi (5 bar)
maximum allowable case pressure (normal operating temperature)	44 psi (3 bar)
Charge Pump (oil temperature must be 120°F (50°C) or more)	
displacement per revolution	0.86 cid (14 cc)
relief pressure setting (check in NEUTRAL)	350 ± 25 psi (24 ± 1.7 bar) @ 1750 rpm
nominal flow at 2200 rpm	9.3 gpm (35 L/min)
maximum *continuous* inlet vacuum 9.8 in Hg (0.7 bar absolute)	
maximum *cold start* inlet vacuum (at reduced maximum pump speed) 24.1 in Hg (0.5 bar absolute)	

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HOSE ROUTING - THRUST/PULLBACK PUMP

NOTE: A detailed hose routing diagram was unavailable at time of publication.



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Hoses

Hose ID/ Pressure	Circuit Type	Function
Thrust/Pullback 'A' *pullback:* high side pressure *thrust:* low side pressure	closed loop	Thrust/pullback pump closed loop 'A' circuit to thrust/ pullback motors 'R' ports
Remote Gauge 'A' or 'B' 'A' or 'B' side loop pressure	gauge	Provides'A' or 'B' side loop pressure signal to gauge shuttle valve.
Remote Gauge 'A' or 'B' side loop pressure	gauge	Provides loop pressure signal from the gauge shuttle valve to the thrust pressure gauge at the operator's station.
Thrust/Pullback 'B' *thrust:* high side pressure *pullback:* low side pressure	closed loop	Thrust/pullback pump (PMP2) closed loop 'B' port to thrust/pullback motors 'A' ports
Case Drain nominal pressure	return	Drains thrust/pullback pump case drain (including excess charge flow) to the return manifold (MFL1) or to tank through the check valve.
Servo Limit B nominal pressure	pilot	Provides signal from thrust limiter pressure relief to destroke the rotation pump (PMP1); limits 'B' side only.
Suction	suction	Supplies oil to charge pump inlet from tank (RES1) whenever engine is turning.
Proportional Valve Pilot charge pressure	pilot	Provides charge pressure to control the water pump rotation speed.
Rotation 'B' Pilot *forward:* high side pressure *reverse:* low side pressure	pilot	Provides rotation 'B' pressure signal to thrust limiter.

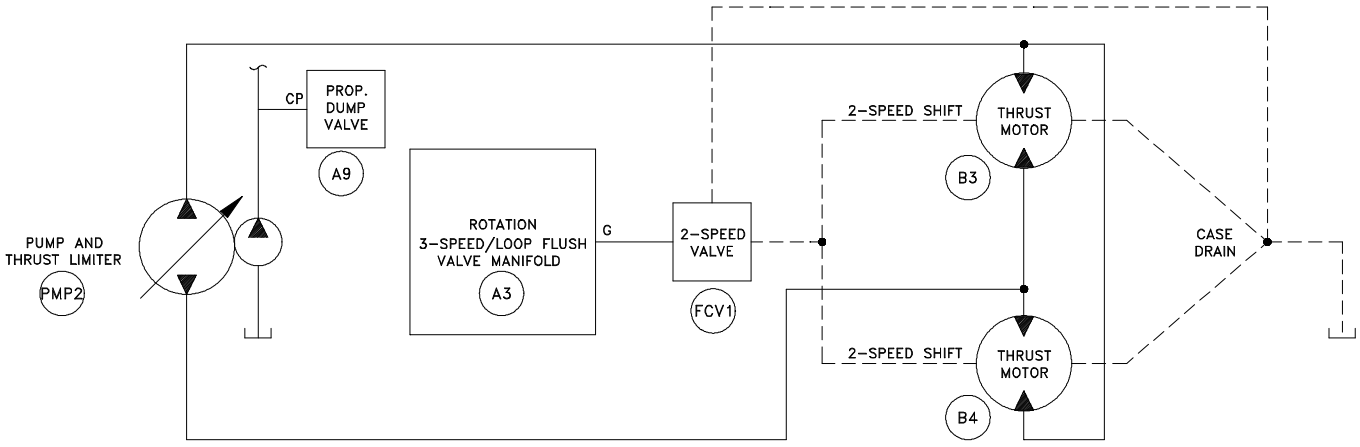
*__NOTE:__ under "standard operating conditions," the following pressures will normally be found in the circuits indicated:
"high side" pressures = 300–6090 psi (20–420 bar)
"low side" pressure = 300–500 psi (20–35 bar)
"nominal pressure" = 25–100 psi (1.7–6.9 bar)
"charge pressure" = 300–500 psi (20–35 bar) (same as "low side" pressure)

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HOSE ROUTING - THRUST/PULLBACK MOTORS

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Hoses

Hose ID/ Pressure*	Circuit Type	Function
Thrust 'A' *thrust:* low side pressure *pullback:* high side pressure	closed loop	Thrust pump (PMP2) closed loop 'A' circuit. Common circuit with *Rotation 'A' - Front Motor*.
Thrust 'B' *thrust:* high side pressure *pullback:* low side pressure	closed loop	Thrust pump (PMP2) closed loop 'B' circuit.
Case Drain nominal pressure	return	Drains flush oil to return manifold (MFL1).
Thrust 2-Speed Solenoid charge pressure	pilot	Provides charge pressure to shift thrust motors into high speed when thrust 2-speed solenoid is energized. Common circuit with *Thrust 2-Speed Control* when solenoid is de-energized.
Thrust 2-Speed Control *apply:* charge pressure *release:* nominal pressure	pilot	Shifts 2-speed thrust motors into high-speed/low-displacement. Receives oil from hot oil shuttle when solenoid valve is energized.
Thrust 2-Speed Drain nominal pressure	return	Drains thrust 2-speed shift oil to return manifold (MFL1).

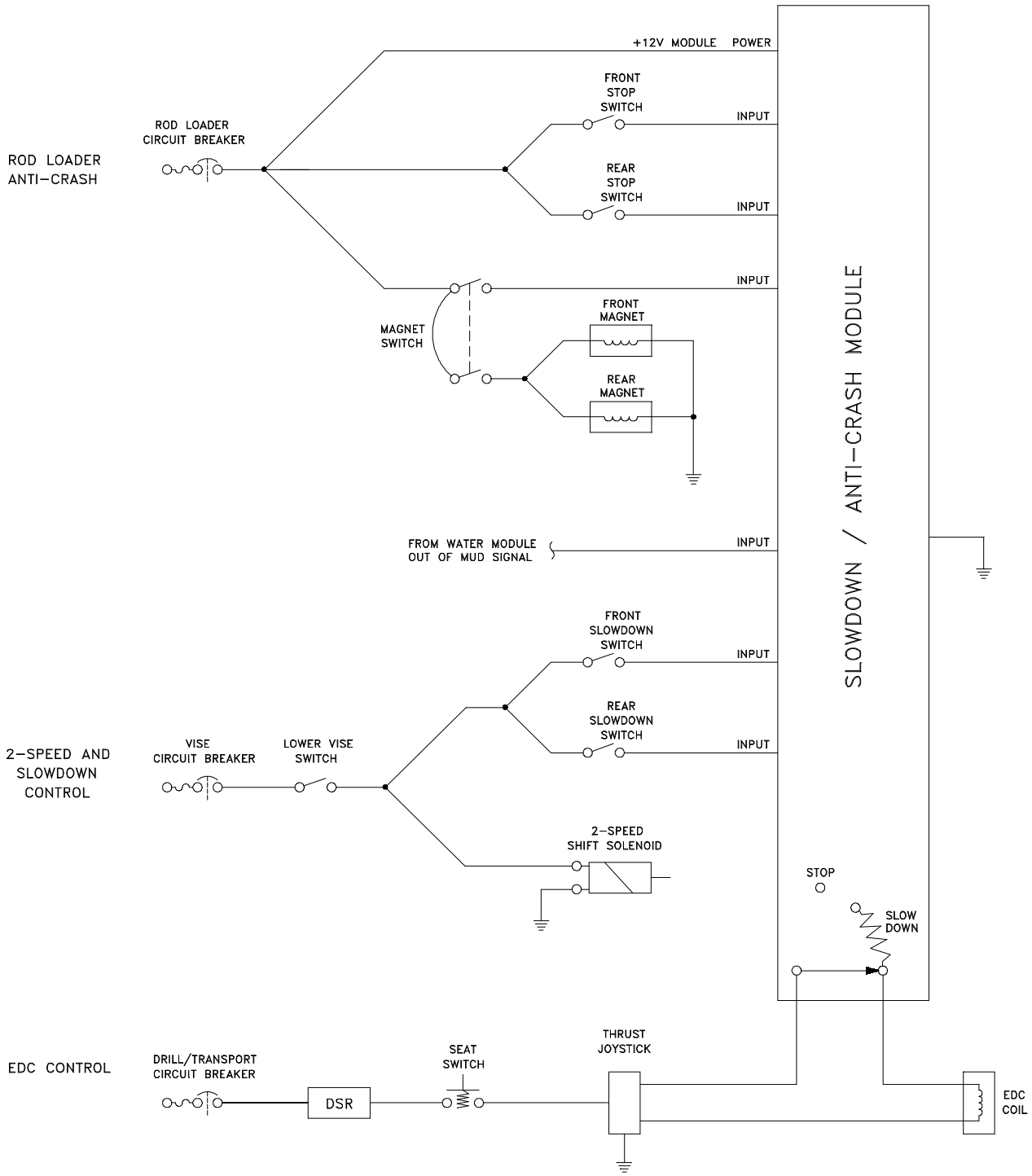
***NOTE:** under "standard operating conditions," the following pressures will normally be found in the circuits indicated:
"high side" pressures = 300–6000 psi (20–415 bar)
"low side" pressure = 300–500 psi (20–35 bar)
"nominal pressure" = 25–100 psi (1.7–6.9 bar)
"charge pressure" = 300–500 psi (20–35 bar) (same as "low side" pressure)

NOTE: In forward rotation, the pump 'B' port sends oil to the rotation motors 'A' ports; in reverse the rotation pump 'A' port sends oil to the rotation motors 'R' ports.

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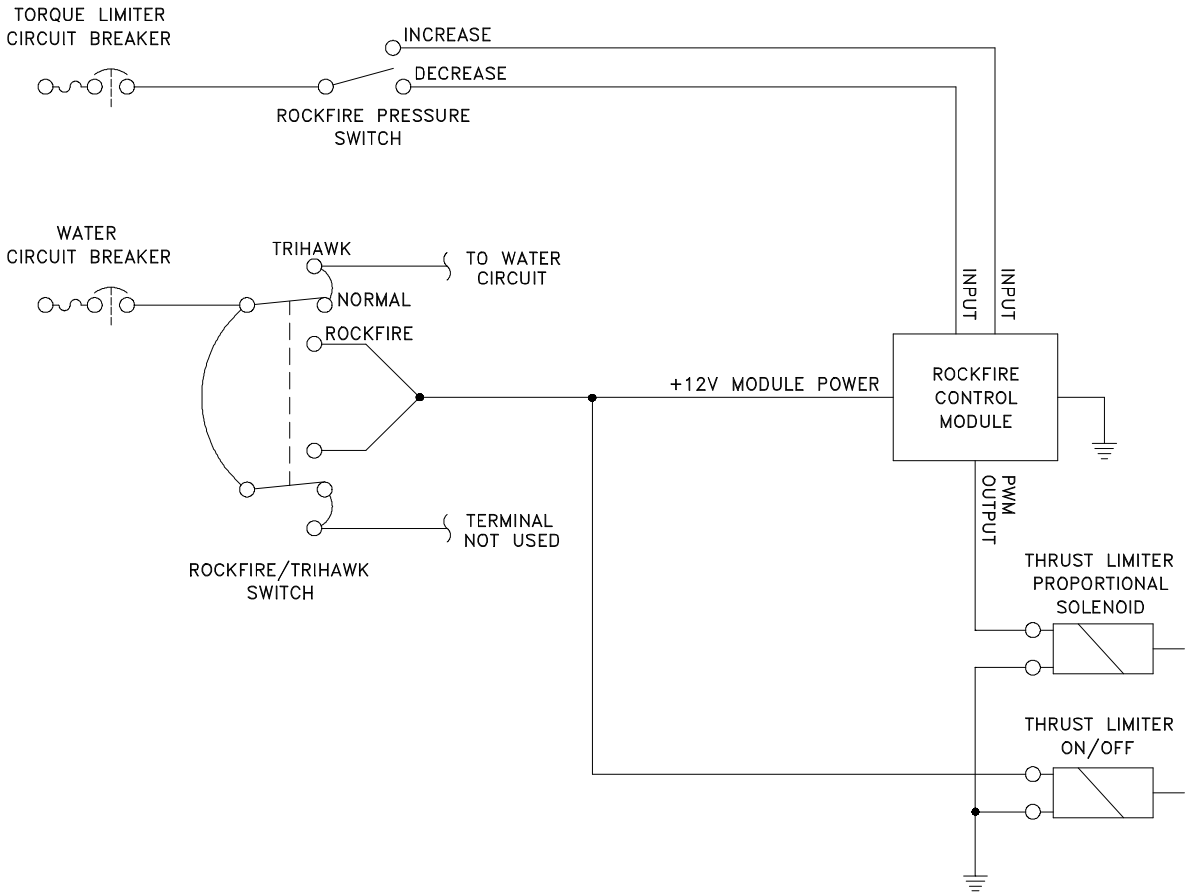
ELECTRICAL DIAGRAM - THRUST/PULLBACK



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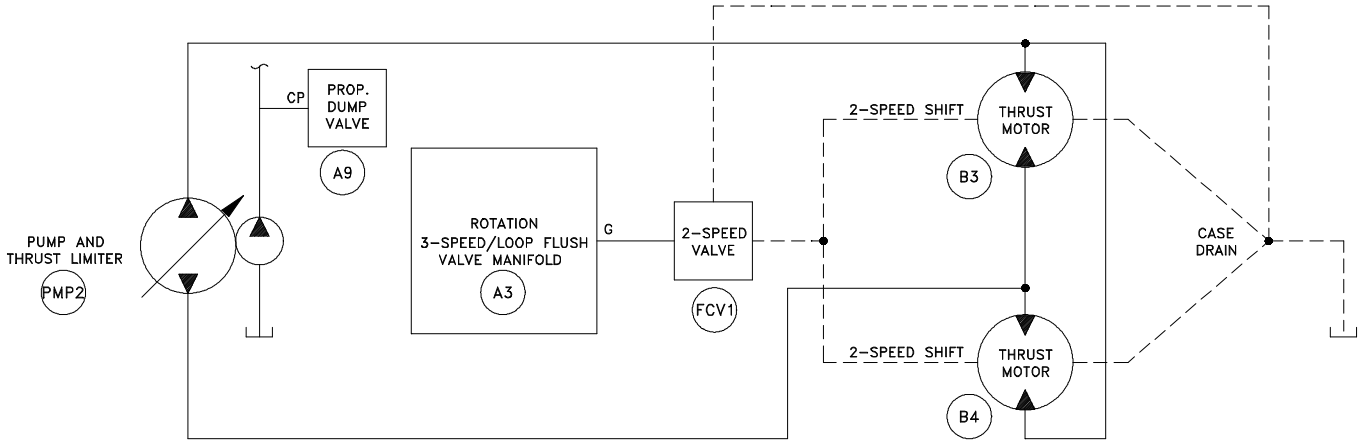
ELECTRICAL DIAGRAM - THRUST LIMITER (ROCKFIRE)



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HYDRAULIC DIAGRAM



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Section 80-2: Thrust / Pullback System Troubleshooting

HOW TO DO TROUBLESHOOTING

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***
5. ***Are the hydraulic components functioning correctly?***

Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking Out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, rod loader, vise, and drill/transport circuit breakers, and the DSR) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** front and rear slowdown switches and stop switches, the magnet switch, the drill mode (Rockfire/Normal/Tri-hawk) switch, the thrust limiter increase/decrease switch, and the seat switch must all work properly.
5. ***Are all variable resistances OK?*** Make sure the resistance is within tolerances.
6. ***Are all electrical actuators OK?*** Coils either in a the rod magnets or a solenoid can go bad; make sure the current path is complete and the resistance is within tolerance.
7. ***Is the mechanical output OK?*** Even if all electrical functions are OK, a valve may leak or fail to move, or relay contacts may stick or not conduct current.
8. ***Are all of the slowdown/anti-crash module circuits OK?*** Does it have correct voltage and ground, inputs, and complete current paths on all circuits? Most “module failures” are the result of a problem in the voltage source, current path, ground, switch or resistor function, or actuator failure. Check all those items before replacing a module.

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Checking Out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is a variable signal based on function demand being delivered to the compensator, either from a variable control such as the transport or water control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motors work ok unless the motors are worn, defective, incorrect replacements, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Some electrically controlled systems using variable current control of proportional solenoids might also change with temperature since current and temperature can be closely related.

Checking Out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

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SYMPTOM: ANY PROBLEM WITH THRUST/PULLBACK OPERATION

1. Are the machine common systems operating correctly? Check oil level, charge pressure, operating temperature, oil cooler operation, engine speed and power outside of specifications can cause or contribute to faulty operation. *Always check these basics before replacing any components or doing any other tests.*

Possible Problem	Possible Effect	What to do
hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
engine RPM too low	Low engine rpm will reduce rotation speed and limit the amount of power that can be delivered to the drill head.	**Check engine RPM** while operating under load.
machine electrical malfunction	If insufficient voltage is available, controller operation may not be correct.	**Check battery and alternator condition**.
operator error or miscommunication	If the operator does not understand the intended operation of the machine, machine performance may be considered to be a problem.	**Always interview the operator to verify the complaint.** Make sure that the machine is being operated correctly. **Check for poor operator technique**—particularly in unusual or difficult ground conditions

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2. Is the charge pressure low? Charge pressure and flow is needed to control the *pump servo*. Low charge pressure will lead to loss of pump control.

Possible Problem	Possible Effect	What to do
low hydraulic oil level	Oil level must be within sight glass. Low oil level can cause air to enter the charge pump if the inlet screen is not fully covered with oil.	**Check hydraulic oil level** and fill if necessary.
charge filter is plugged	A plugged filter will restrict charge flow.	**Check charge pressure** and replace the thrust/pullback charge filter if charge pressure is low.
inlet screen is blocked or air leak in inlet	A restriction (blocked screen or collapsed inlet hose) or suction leak (missing components, damage, or loose fittings) will restrict charge flow.	**Check inlet vacuum;** it should be between 8” and 2” Hg (75-100 kPa(a)) under standard conditions. If not, repair restriction or suction leak.
charge pressure relief is misadjusted or stuck	A misadjusted or defective relief can limit charge flow.	**Check charge pressure.** Adjust or replace charge relief if necessary (refer to page **70-3-7**).
charge pump worn or defective	If the charge pump is worn or damaged, charge flow will reduced.	**Check charge pump condition.** Refer to page **70-3-7**.
charge oil leaking to PFC pump system	The charge pump supplies pilot oil to the hydraulic proportional valve. A malfunction allowing uncontrolled charge pressure flow could reduce pressure enough to cause control problems.	**Verify that there is NOT constant flow to the proportional/dump valve system** by using a flowmeter or by blocking the line. Note: The pilot line to the proportional/ dump valve may be temporarily replaced with caps or plugs to block flow (do not operate water pump). If this restores charge pressure, investigate the cause of the leak in the PFC system.

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SYMPTOM: LOW THRUST OR PULLBACK FORCE OR PRESSURE

1. Is the thrust limiter applied or misadjusted? The *thrust limiter* sends oil to the *pump servo* to destroke the *pump*. Faulty operation, or operation when it is not desired, will limit *pump* pressure.

Possible Problem	Possible Effect	What to do
Rockfire switch malfunction	If an electrical signal is sent to the thrust limiter causing the thrust limiter to be applied, thrust pressure will be limited.	**Check for unintended thrust limiter "ON" signal** from the rockfire switch and replace switch if necessary (refer to page **80-4-1**).
thrust limiter solenoid valve is defective or dirty	If the solenoid valve leaks loop oil to the pressure relief, pump pressure will be limited to the pressure relief setting.	**Check solenoid valve for leaking.** Either cap off the thrust limiter and pump ports to see if the pump will operate normally without the limiter OR check the thrust limiter using a "pressure leak test" (refer to page **80-5-4**).
thrust limiter pressure relief valve defective or dirty	If the pressure relief setting is incorrect or the relief or an O-ring is leaking, pump pressure will be lower than desired whenever the torque limiter solenoid valve is energized.	**Check pressure relief for leaking:** O-rings, valve torque, valve cavity condition (refer to page **80-5-8**).

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2. Are the controls or EDC stroking the pump? Power must travel from the *power relay* through the '401' orange 8 ga *main power wire*, through the *DSR-Drill/Transport circuit breaker*, through the *DSR*, through the *seat switch* and to the *joystick control.* The *joystick control* then sends a varying current signal (milliamp or mA) to the *EDC AB coil*. The EDC uses the milliamp signal from the controls to direct oil to either of the PCP control ports. The control oil from the PCP is applied to one of the servo pistons to stroke the pump. Approximately 85 mA ±18 is required to fully stroke the pump in either direction. If the control is not powered, or if it does not send a correct signal to the EDC, or if the EDC receives a good signal but is defective, an incorrect pressure signal will be sent to the servo pistons, and the pump will not go on stroke correctly.

Possible Problem	Possible Effect	What to do
no power to controls	If any of the following occur, the controls will not be powered correctly —*circuit breaker* is tripped —*wiring* is damaged —*DSR* defective —*seat switch* defective or operator not seated .	**Check that power is available to pin '4' on the rotation joystick connector.** Refer to wiring schematic and the *Rotation Controls,* page **80-4-1**.
control circuit malfunction	There must be a complete current path Current starts from the joystick, travels to the EDC, and return to the joystick.	**First check wiring, connectors and pins in all control harnesses.** Check for milliamp (mA) signal to EDC. Full stroke current should be 85 mA ±18. Refer to EDC testing, page **40-5-7**.
EDC malfunction	If the EDC is receiving the correct signal but does not stroke the pump, it may be damaged internally or the flow of oil to the PCP may be blocked.	**Substitute a known good EDC** and/ or perform other steps found in Hydrostatic Service, page **40-5-1**, including checking the PCP screen condition.

3. Is the carriage operating in HIGH speed only? In LOW speed (lower vise off), no power is applied to the shift solenoid, so neither motor receives shift oil. In HIGH speed (lower vise on), the solenoid is energized and oil is applied to the shift ports of both motors. If the speed solenoid receives power when it should not, the motors will stay in HIGH.

Possible Problem	Possible Effect	What to do
Power always to solenoids	If the signal wire is shorted to +12V or if the rock drill switch is defective, solenoid could be ON at all times.	**Check power at the signal pins at the speed solenoid connector**. Check rock drill switch.

Continued on next page...

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4. Is the loop flush valve defective? Malfunctions in the loop flush valve components, including the pressure compensated *flow control,* the *pressure relief*, and the *speed solenoids*, can cause incorrect operation of the rotation motors along with the thrust-pullback motors. Shuttle oil after the flow control valve is used to shift the motor speeds. Low or no shift pressure will cause the motors to remain in low speed. Shift pressure that is always high will prevent the motors from returning to low speed. Oil pressure incorrectly applied to the shift port could also cause the shift valve to "bypass" so that loop oil flows directly from the 'B' side to the 'A' side, without turning the motor.

Possible Problem	Possible Effect	What to do
speed solenoid valve leaking	A leaking speed solenoid valve could allow unwanted charge oil to flow to the motor shift ports.	**Check for a stuck spool, damaged O-ring, or damaged valve cavity in the 2-speed solenoid valve.** Refer to page **80-5-12**
flow control defective	If the flow control is stuck closed or blocked, it would prevent shift oil from being applied to the speed solenoid.	**Check shift pressure, shuttle pressure, and shuttle flow**.
pressure relief defective	If the pressure relief is defective or set too low, shift pressure might be also be too low.	**Check shift pressure, shuttle pressure, and shuttle flow**.

Continued on next page...

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5. Are the pump or motors defective? The hydrostatic pump must deliver specified flow and pressure, and the motors must shift speeds correctly and function correctly internally for correct motor operation.The rotation motors use a spool valve to direct internal oil flow for low or high speed operation. If the spool valve does not move correctly, the motor can stay in low or high speed or may “bypass” causing no rotation operation at all.

Possible Problem	Possible Effect	What to do
motor shift operation incorrect	If the shift spool valve is stuck or operates erratically, the motor can either remain in high speed/low torque OR bypass, preventing shaft rotation	**Check motor shift spool operation.** Refer to page **80-5-16**.
pump malfunction or wear	If the pump is badly worn or damaged, it may not deliver sufficient flow or pressure.	After verifying correct operating conditions and controls, **perform a pressure and flow check on the pump**, bypassing the motor. If flow and pressure are low, replace the pump. If flow and pressure are sufficient, replace one or both motors.
motor malfunction or wear	If the pump is delivering adequate pressure and flow and the shift operation is correct, a worn or damaged motor will cause incorrect operation.	

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SYMPTOM: CARRIAGE TRAVELS TOO SLOWLY WHEN UNLOADED

1. Are the controls or EDC stroking the pump? Power must travel from the *power relay* through the '401' orange 8 guage *main power wire*, through the *DSR-Drill/Transport circuit breaker*, through the *DSR*, through the *seat switch* and to the *joystick control.* The *joystick control* then sends a varying current signal (milliamp or mA) to the *EDC AB coil*. The EDC uses the milliamp signal from the controls to direct oil to either of the control ports in the PCP. The control oil from the PCP is applied to one of the servo pistons to stroke the pump. Approximately 85 mA ±18 is required to fully stroke the pump in either direction. If the control is not powered, or if it does not send a correct signal to the EDC, or if the EDC receives a good signal but is defective, an incorrect pressure signal will be sent to the servo pistons, and the pump will not go on stroke correctly.

Possible Problem	Possible Effect	What to do
no power to controls	If any of the following occur, the controls will not be powered correctly —*circuit breaker* is tripped —*wiring* is damaged —*DSR* defective —*seat switch* defective or operator not seated .	**Check that power is available to pin '4' on the rotation joystick connector.** Refer to wiring schematic and the *Rotation Controls,* page **70-4-1**.
control circuit malfunction	There must be a complete current path for current to start from the joystick, travel to the EDC, and return to the joystick.	**First check wiring, connectors and pins in all control harnesses.** Check for milliamp (mA) signal to EDC. Full stroke current should be 85 mA ±18.
EDC malfunction	If the EDC is receiving the correct signal but does not stroke the pump, it may be damaged internally or the flow of oil to the PCP may be blocked.	**Substitute a known good EDC** Refer to page **40-5-7**.

Continued on next page...

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2. Is the 2-speed solenoid applying shift oil to the motors? In LOW speed, no power is applied to the shift solenoid, so neither motor receives shift oil. In HIGH, the solenoid is energized and oil is applied to the shift ports of both motors.

If the speed solenoid does not receive power when it should, the motors will not shift into HIGH. If the speed solenoid receives power when it should not, the motors will stay in HIGH.

Possible Problem	Possible Effect	What to do
no power to solenoid	The 2-speed solenoid receives power from the lower vise ON circuit. If it is no longer connected to that circuit or if the lower vise solenoid circut does not receive +12V, the carriage will remaing in LOW speed.	**Check for power at the signal pins at the speed solenoid connector.** Check coil continuity. Check for good ground. Check lower vise switch. Check power supply circuit.

3. Is the loop flush valve defective? (Refer to Low Thrust or Pullback Force or Pressure, page **80-2-6**

4. Are the pump or motors defective? The hydrostatic pump must deliver specified flow and pressure, and the motors must shift speeds correctly and function correctly internally for correct motor operation. The rotation motors use a spool valve to direct internal oil flow for low or high speed operation. If the spool valve does not move correctly, the motor can stay in LOW or HIGH speed or may “bypass” causing no rotation operation at all.

SYMPTOM: CARRIAGE WILL NOT SHIFT OUT OF HIGH

1. Is the 2-speed solenoid applying shift oil to the motors? (Refer to Low Thrust or Pullback Force or Pressure, page **80-2-6**.

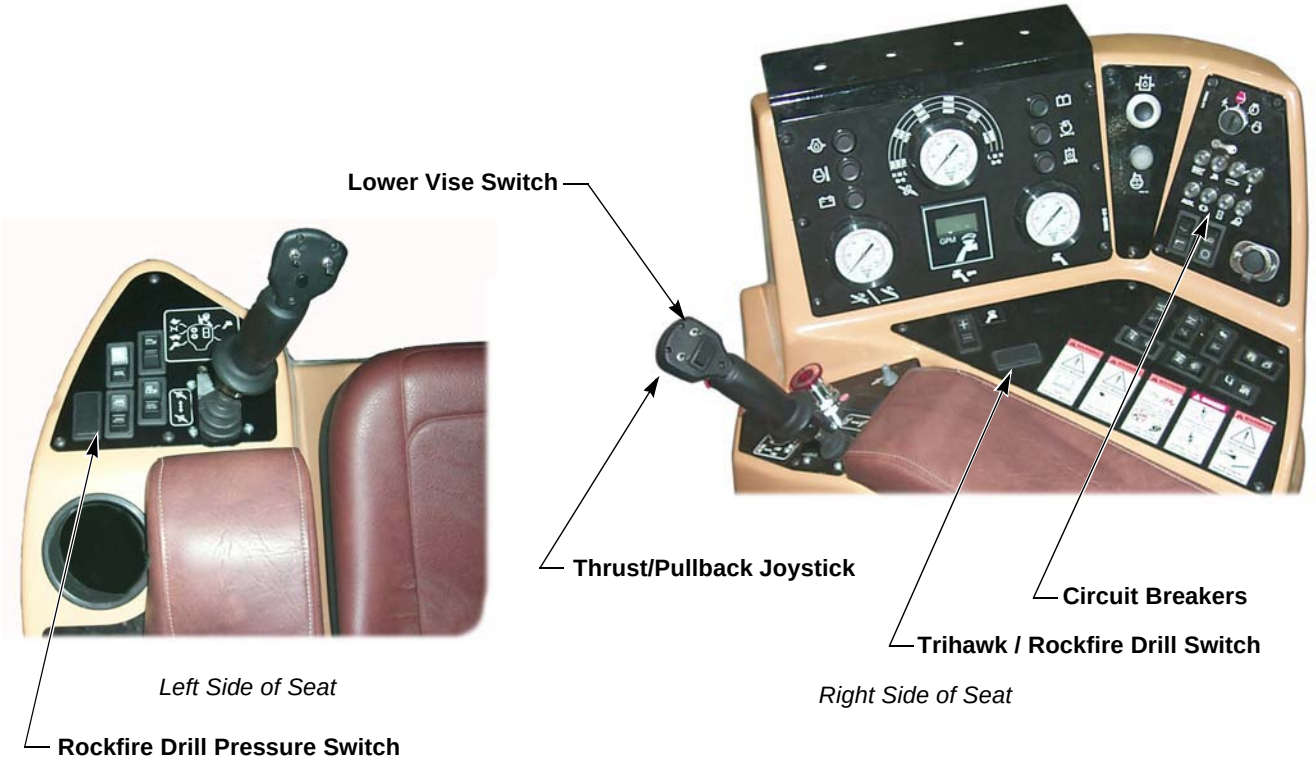
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Section 80-4: Thrust / Pullback System Controls

THRUST / PULLBACK CONTROLS LOCATION



Operation Overview

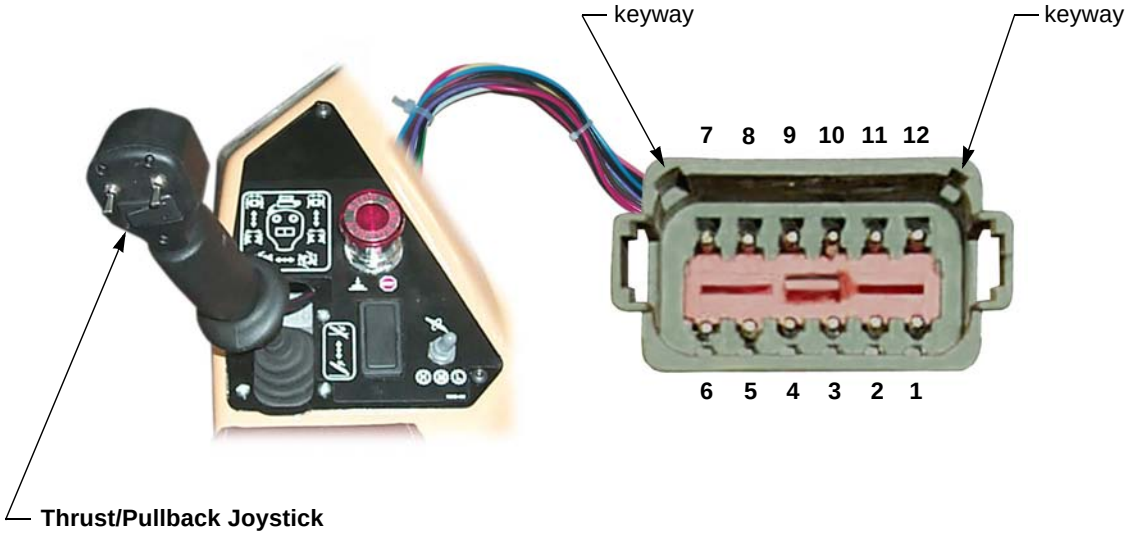
The thrust/pullback system controls includes four basic systems:

1. **The EDC controller circuit** (thrust joystick) controls speed and direction of the thrust/pullback motors.
2. **The slowdown/anti-crash circuit** varies the EDC control signal to slow or stop carriage travel to prevent overtravel and to prevent rod loader damage.
3. **The thrust limiter circuit** uses a hydraulic feedback loop to limit the amount of pressure available to the thrust motors during Rockfire drill or Trihawk drill operation.
4. **The two-speed motor circuit** shifts displacement of the rotation motors to provide two speed operation of the thrust/pullback carriage: low speed during thrust and pullback, high speed when changing rods.

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THRUST / PULLBACK JOYSTICK

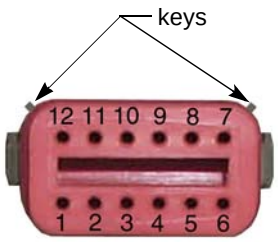


Controller Pin Identification

Pin	Wire I.D.	Type	Function
1	BK	GND	Supplies ground from console ground pin ‘7’ through circuit 330 to EDC controller terminal ‘1’.
2	GR	control	Carries EDC control current from/to EDC controller terminal ‘2’.
3	WH	control	Carries EDC control current from/to EDC controller terminal ‘3’.
4	RD	+12V	+12V (from seat switch) to EDC controller terminal ‘4’.
5	---	---	(not used)
6	BK	control	Trigger signal from joystick switch (not used in harness),
7	---	---	(not used)
8	---	---	(not used)
9	RD	+12V	+12V from EDC controller terminal ‘4’
10	VL	starter	Neutral start circuit (from ignition switch ‘S’ terminal) to joystick neutral switch. Receives current when ignition switch is in START.
11	BR	starter	Neutral start circuit (to rotation joystick pin ‘10’) from joystick neutral switch. Receives current when joystick is in NEUTRAL and current is supplied to pin ‘10’.
12	BK	GND	Ground from EDC controller terminal ‘1’ to rotation joystick pin ‘1’

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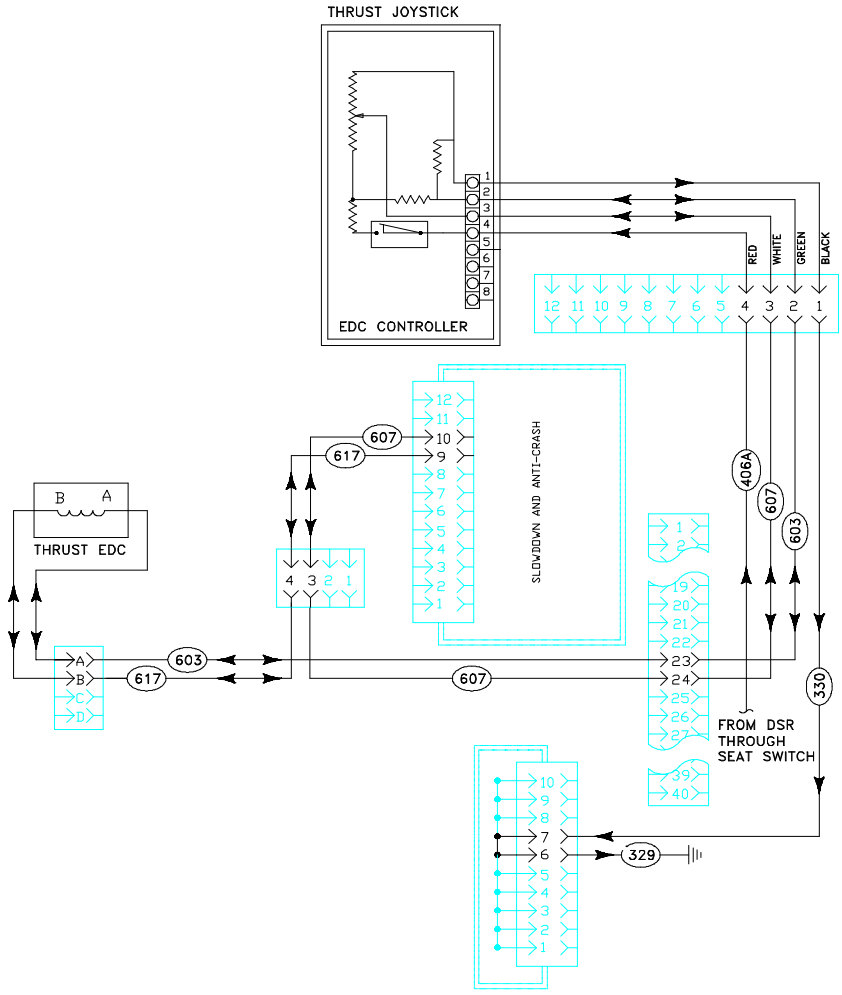
Harness Connector Pin Identification

Pin	Wire I.D.	Type	Function
1	330 BK	GND	Ground to terminal ‘7’ of console ground strip.
2	603 GR	control	Carries rotation pump EDC control current from/to EDC coil terminal ‘A’.
3	607 GR/WH	control	Carries thrust pump EDC control current from/to EDC coil terminal ‘B’ through slowdown/anticrash module pins ‘10” and ‘9’.
4	406A WH/ RD	+12V	+12V from seat switch through circuit 406
5	---	---	(not used)
6	---	---	(not used)
7	---	---	(not used)
8	---	---	(not used)
9	507 RD	+12V	+12V to pin 4 of rotation joystick
10	602 VL	starter	Neutral start circuit from ignition switch terminal ‘S’ when ignition switch is in START
11	007 WH/BK	starter	To rotation joystick pin ‘10’. Energized when ignition is in START and both thrust joystick control is in NEUTRAL.
12	331 BK	GND	ground to rotation joystick pin ‘1’

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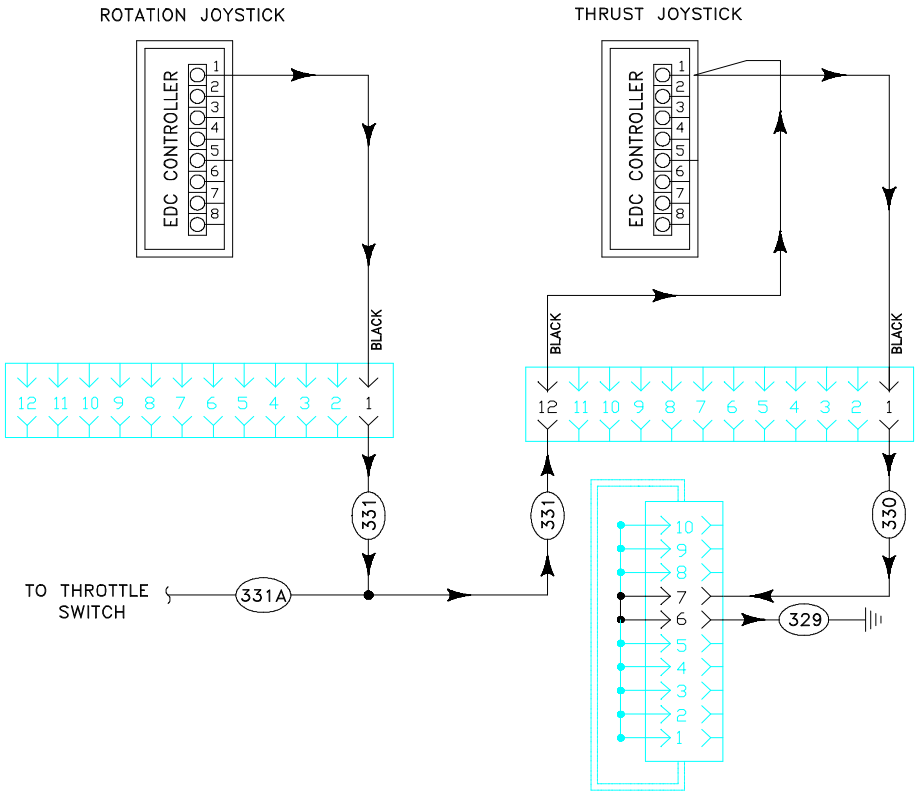
EDC Control Circuit



The EDC circuit controls uses the right (thrust/pullback) joystick to control oil flow and direction from the pump. Current from the DSR is sent through the seat switch to pin ‘4’ of the right joystick connector then to pin ‘4’ of the EDC controller in the joystick. The EDC controller sends a current signal on wires ‘603’ and ‘607’ through pins ‘2’ and ‘3’ of the joystick connector, through pins ‘23’ and ‘24’ of the 40 pin connector, and through pins ‘9’ and ‘10’ of the slowdown/anti-crash module, to the ‘AB’ coil of rotation pump EDC. This causes the pump to stroke in forward or reverse.

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EDC Ground Circuit

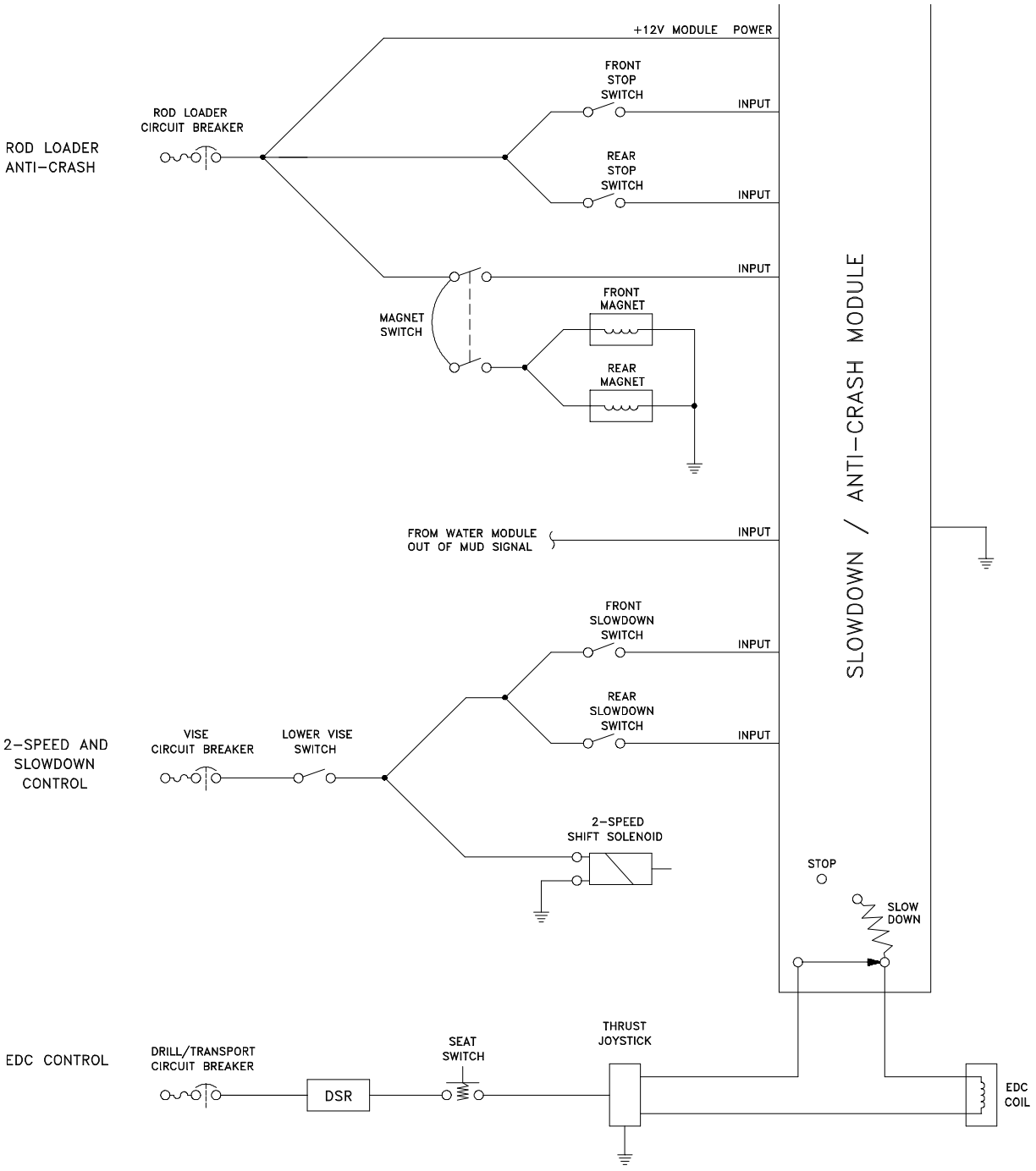


The EDC circuit ground path is from the EDC controller pin '1' to the console ground strip.

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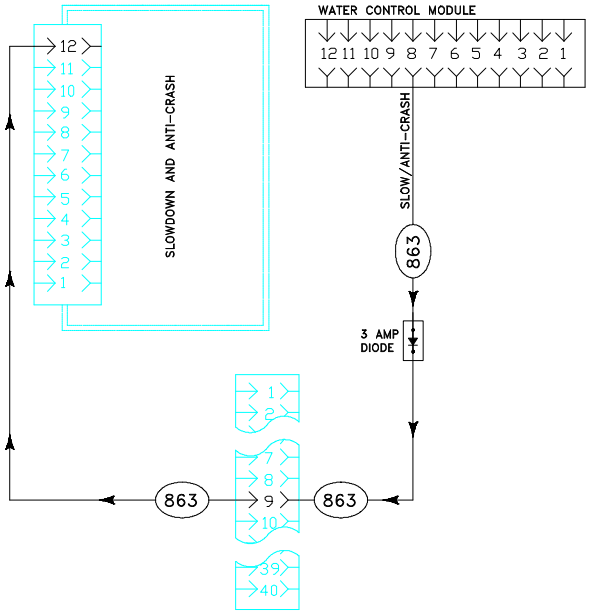
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SLOWDOWN / ANTI-CRASH CIRCUIT



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Slowdown/Anti-Crash Power Circuit



Operation

Slowdown

The slowdown/anti-crash module slows or stops carriage travel by varying EDC control current. The slowdown switches close whenever the carriage is close to either end. The closed switch sends a +12V signal to the slowdown/ anti-crash module which then limits the current being sent through the EDC circuit to the thrust/pullback EDC.

Stop

When either the front or rear stop switch is closed by the carriage reaching the end of its intended travel, the stop circuit prevents a signal from the EDC. This prevents any further travel in the wrong direction by cutting off current flow.

Anti-Crash

If the slowdown/anti-crash module receives +12V signal from the magnet switch indicating the rod loader arms are in the way of carriage travel, the anti-crash circuit of the slowdown/anti-crash module shuts off current to the thrust/pullback EDC.

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ROCKFIRE / TRIHAWK PRESSURE AND MODE SWITCHES

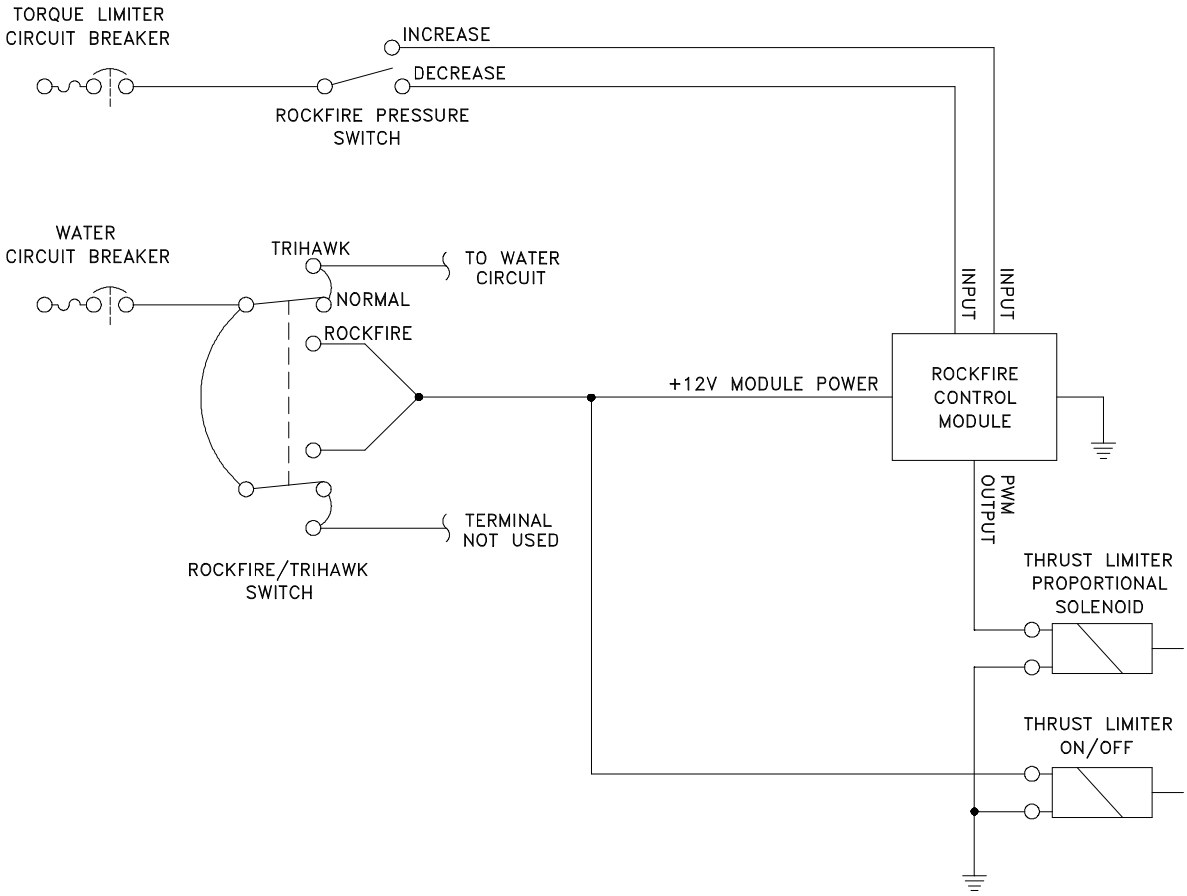




Rockfire Drill Pressure Switch
Push Top - increase maximum thrust limiter pressure
Push Bottom - decrease maximum thrust-limiter pressure

Trihawk / Rockfire Drill Switch
Push Top - Rockfire Drill
Centered - normal
Push Bottom - Trihawk Drill

Operation Overview



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THRUST LIMITER

Operation

The thrust limiter ON/OFF solenoid is energized by the drill mode switch in either the ROCKFIRE or TRIHAWK mode. This applies 'B' side loop pressure to the pump servo whenever the the pressure exceeds the pressure setting of the variable pressure relief. (Pressure is not limited when the drill mode switch is in NORMAL mode.)

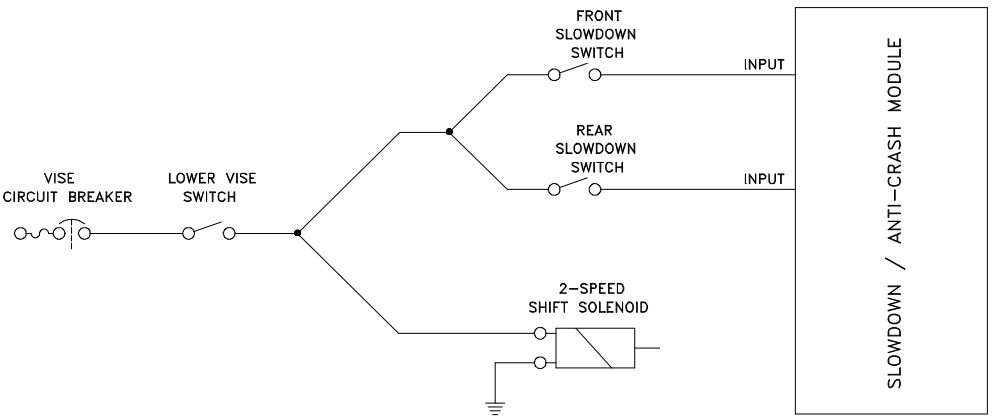
The variable pressure relief solenoid uses a pulse-width modulated (PWM) signal from the Rockfire module to increase the pressure relief setting. If no current is applied by the Rockfire module, the pressure relief remains at its basic setting, which limits the thrust pressure to a very low level. If the operator closes the INCREASE contact of the Rockfire drill pressure switch, the Rockfire drill module responds by sending a PWM signal to raise the pressure relief setting.

NOTE: See the following sections for circuit diagrams.

2-Speed Circuit

The thrust limiter is *normally non-passing* (closed). Under normal drilling conditions the circuit is *de-energized* and the limiter is not applied. When the drill mode switch is in ROCKFIRE or TRIHAWK mode, the circuit is *energized* and the thrust limiter is applied.

2-SPEED CARRIAGE CONTROL CIRCUIT

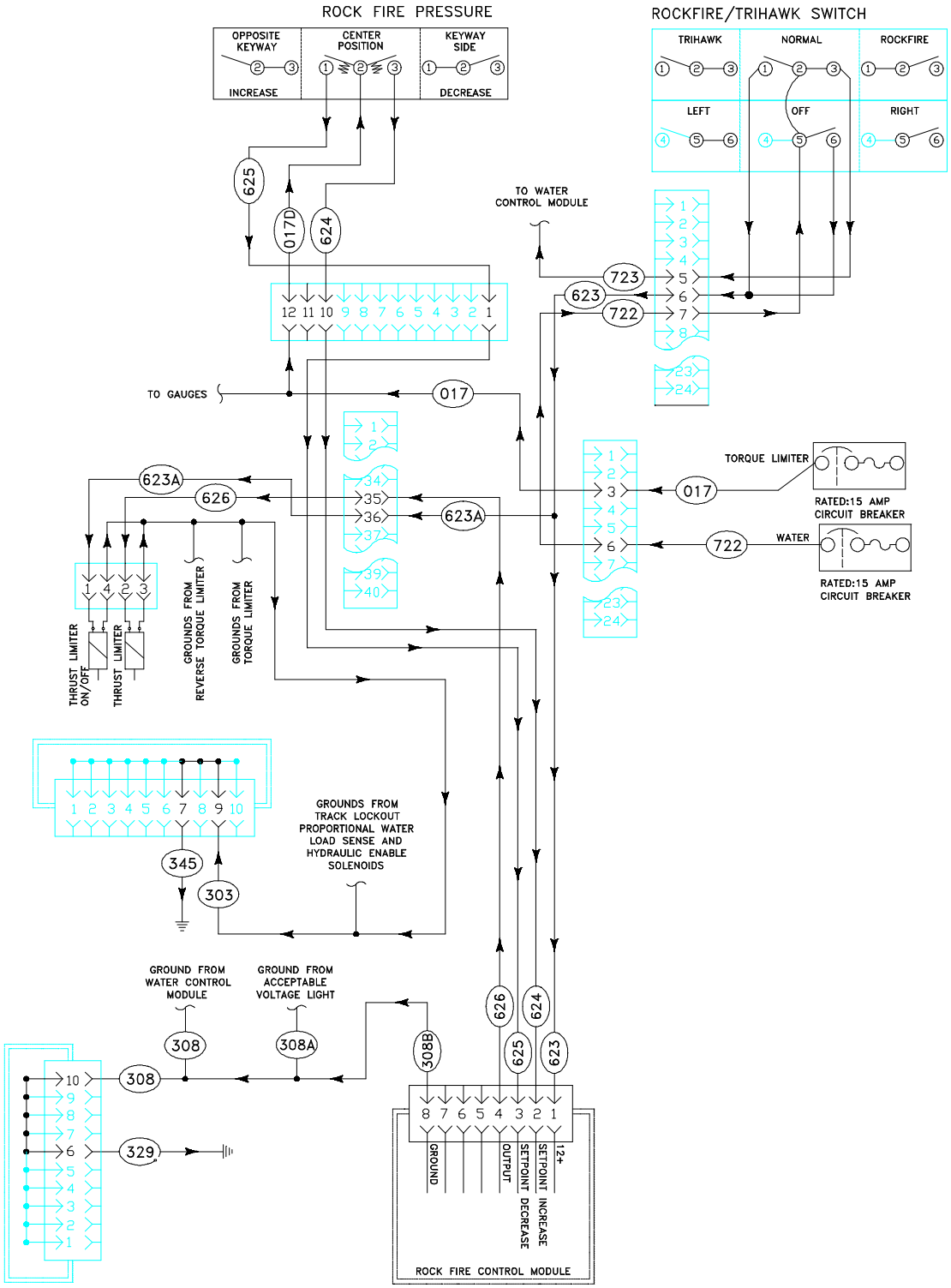


Power from the vise circuit breaker is provided to the 2-speed shift solenoid from the lower vise switch whenever the lower vise is on. The 2-speed shift solenoid applies shift oil (rotation hot oil shuttle pressure) to the 2-speed shift solenoid. (Power also travels to the module as a front or rear slowdown input from either slowdown switch.)

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ROCKFIRE DRILL CONTROL CIRCUIT

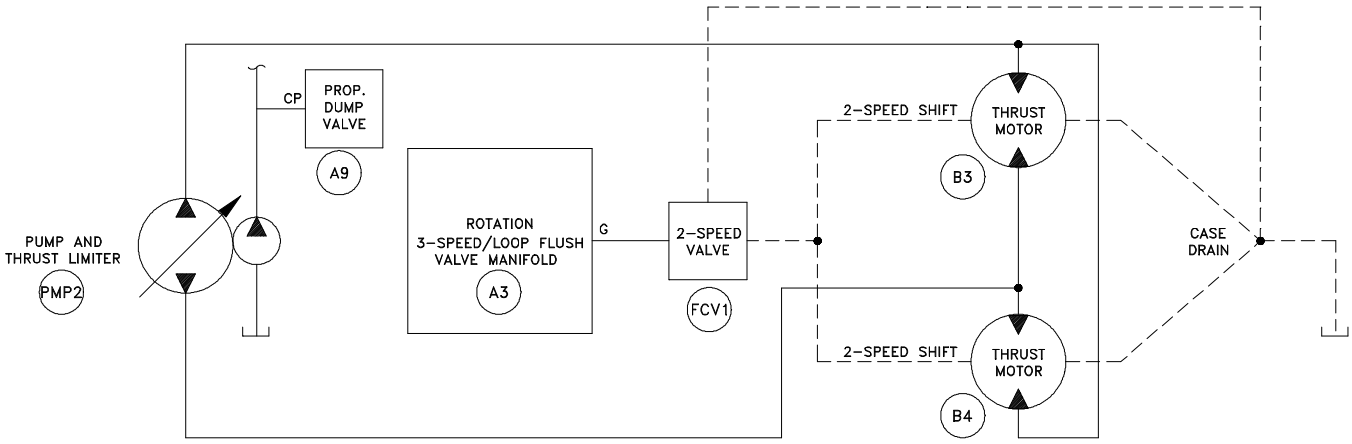


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Section 80-5: Thrust / Pullback System Hydraulic Circuit

THRUST / PULLBACK HYDRAULIC CIRCUIT DIAGRAM



Operation Overview

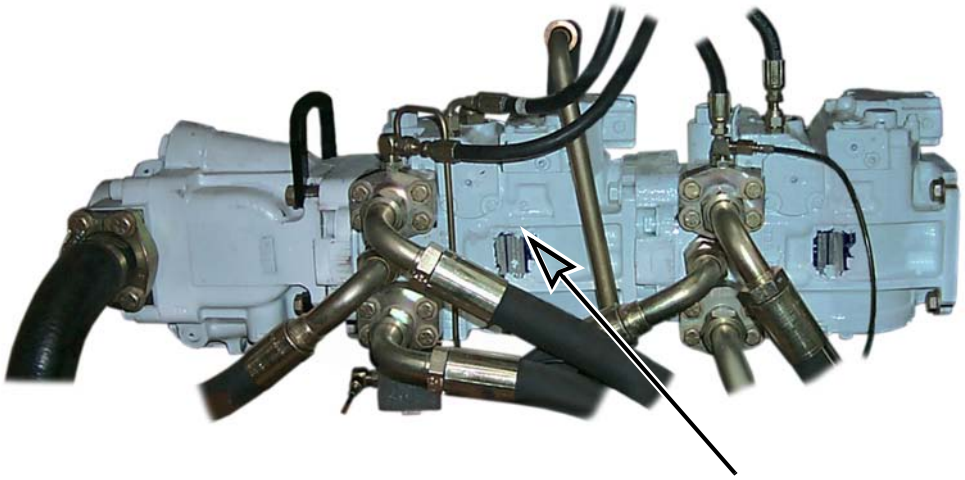
The thrust/pullback hydraulic system includes three basic circuits:

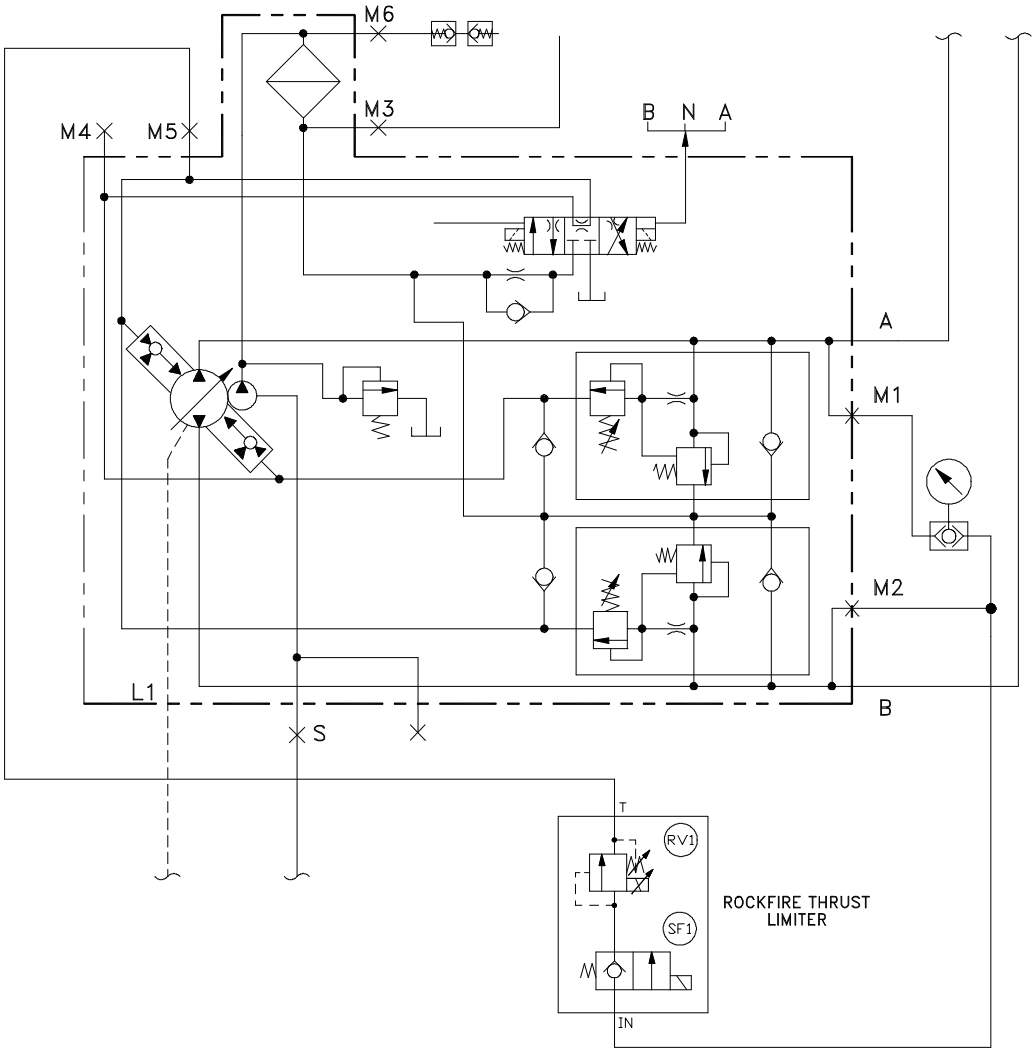
1. **The hydrostatic pump and thrust limiter** supply oil flow within a specified pressure range to the thrust/pullback motors.
2. **The 2-speed valve** directs the speed shift function of the motors.
3. **The thrust/pullback motors** receive hydraulic oil flow and drive the carriage (which holds the drive gearbox) forward or backwards on the drill rack.

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THRUST/PULLBACK PUMP





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Operation

IMPORTANT: When working on closed loop components, special procedures and extreme cleanliness standards are required (refer to *Hydrostatic Service Procedures,* page **40-6-1**).

The thrust/pullback hydrostatic pump provides oil flow from either the 'A' or the 'B' port to the thrust/pullback motors. The thrust/pullback joystick controls pump stroke and direction by an electrical signal to the EDC, using charge pressure to supply force to change the swashplate angle. A combined pressure limiter and pressure relief limits pump output by destroking the pump or relieving excess flow. A thrust limiter limits pump pressure when operating in ROCKFIRE or TRIHAWK mode.

NOTE: The function of the thrust/pullback pump is discussed here as it relates to the rest of the rotation system. For information on internal pump components, refer to page **40-5-1**

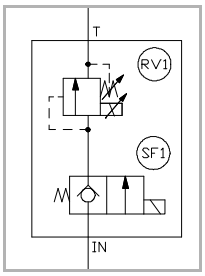
Multifunction Valve (System Pressure) Testing

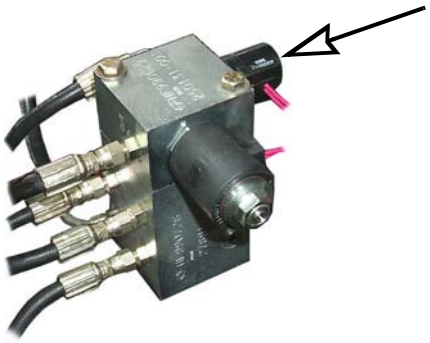
Testing the pump multifunction valves requires a detailed procedure which includes the thrust limiter valves, charge pressure adjustment, and multifunction valve testing. Refer to page **70-3-9**

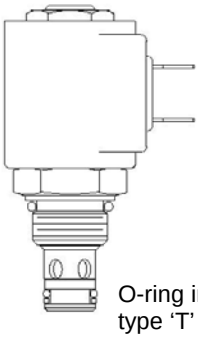
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THRUST LIMITER - ON / OFF SOLENOID VALVE







O-ring installation: type ‘T’

Operation

The thrust limiter limits thrust pressure whenever the drill mode switch is in ROCKFIRE or TRIHAWK mode and the loop pressure has reached the pressure relief setting.

Action

The thrust limiter applies loop oil to the pressure relief when the on/off solenoid is energized by the ROCKFIRE or TRIHAWK setting of the drill mode switch. If the loop oil is at a higher pressure than the thrust limiter pressure relief setting, the oil that passes over the relief is used to destroke the pump, limiting thrust applied to the drill rod.

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Specifications

Thrust Limiter On/Off Solenoid Coil Specifications	
type	'08' (P/N 251117-009)
minimum pull-in voltage	10.2 V
initial coil current draw at 70°F (20°C)	1.07 A at 10.5 VDC 1.2 A at 12 VDC 1.48 A at 14.5 VDC
resistance	9.8 ohms at 70°F (20°C)
nominal power rating	14.7 W
coil installation torque	5–7 ft-lb (6.75–9.5 Nm)
Diagnostic notes: *The coil contains a bipolar diode for spike suppression. Either lead may be connected to +12V since the diode only conducts at higher voltage. The coil may be checked in either direction with an ohmmeter. If the diode is bad, a voltage "spike" will occur everytime the coil is turned off, which could cause the Strike Alert to sound. The diode cannot be checked with an ohmmeter but a scope-meter or oscilloscope will display voltage spikes caused by a failed diode.*	

Thrust Limiter Solenoid Valve and Body Specifications	
Thrust limiter	
model	SF08-20-0-P-00
type	solenoid-operated, normally non-passing, piloted poppet-type
O-ring position	type 'T' (O-ring is above backup ring)
internal leakage	5 drops/min (0.25 cc/min)
valve body port size (all)	SAE 04
Diagnostic notes: *Since it is a poppet-type valve, the solenoid valve is a "non-leaker". When a pressure-leak test is performed it should exhibit virtually "zero" leakage. If it is not possible to perform a pressure-leak test, any indication that the valve internal components are not free to move means that the valve cannot perform properly. Verify that the inner poppet is free to move either by physical inspection or manipulation of the valve tip, or by energizing the solenoid and feeling the results of internal movement.*	

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THRUST LIMITER SOLENOID VALVE BENCH TEST

Test Objective

To determine if the thrust limiter solenoid valve is holding pressure (not leaking) until energized. If it is leaking, the maximum pressure that the thrust/pullback pump can reach may be limited by the pressure relief setting at all times. Leakage should be less than **5 drops⁄ min (0.25 cc/min).**

NOTE: The thrust limiter on/off solenoid is identical to the forward torque limiter solenoid. They may be interchanged for diagnostic purposes.

Special Tools and Materials

- hand-powered test pump capable of 3000 psi (210 bar)

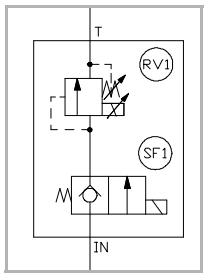
Conditions

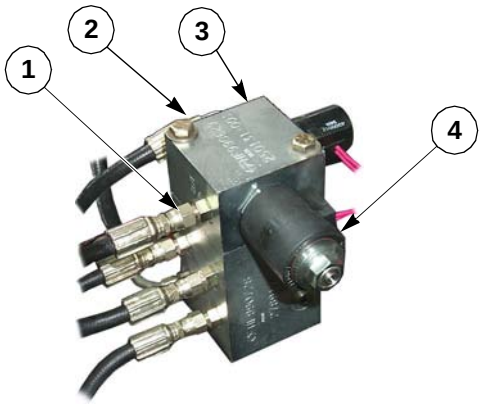
WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible, Relieve pressure before working on system. When searching for a leak, use an object like cardboard—not your hand. Fluid injected under the skin must be removed by a surgeon familiar with this type of injury.

WARNING: Before performing any maintenance on the machine, follow the Shutdown Procedure unless instructed differently by the manual.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Follow *Shutdown Procedure* (refer to page 10-2-1).
2. Remove hoses from port 'T' **(1)** and and port 'IN' **(2)** from thrust limiter **(3)**.
3. Remove the variable pressure relief **(4)** to ensure that any solenoid valve leakage can be noticed.
4. Connect a hand pump to inlet port 'IN' **(1)**. Pressurize with the hand pump to approximately 3000 psi (210 bar). Pressure should build up and hold steady with minimum pumping required to maintain pressure.
5. Using jumper leads, apply +12V and ground to the on/off solenoid leads. Oil should leak off and pressure should be reduced immediately.

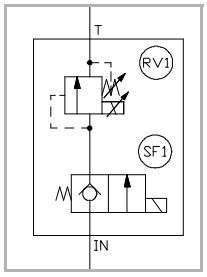
Results

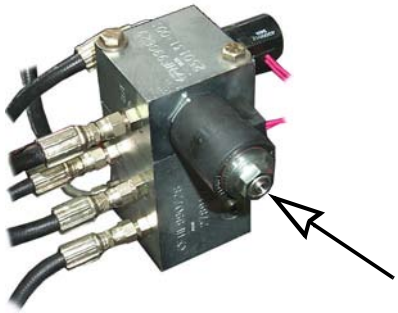
- ***If pressure builds up and stays steady,*** the solenoid valve is OK.
- ***If pressure leaks down rapidly or pressure cannot be built up,*** there is a problem with the solenoid valve, O-rings, or the valve cavity sealing surfaces. Leakage should be less than **5 drops/min (0.25 cc/min).**
- ***If energizing the solenoid does not relieve pressure*** there is a problem with the coil or the solenoid valve operation.

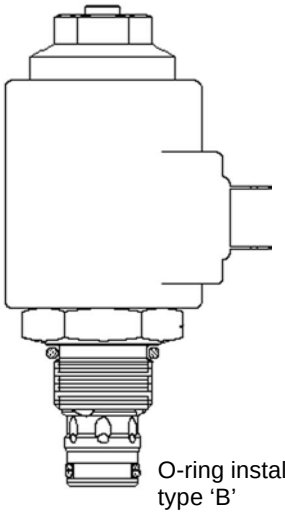
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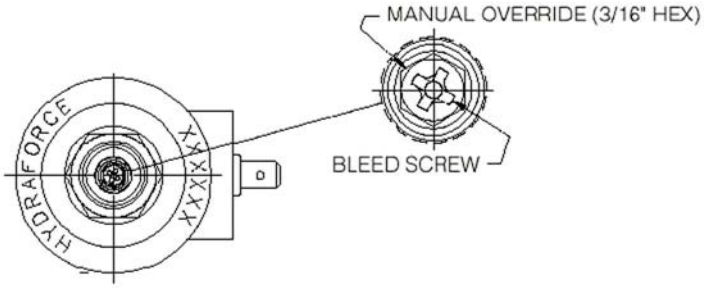
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THRUST LIMITER VARIABLE PRESSURE RELIEF









O-ring installation: type 'B'

Operation

The thrust limiter limits thrust pressure whenever the drill mode switch is in ROCKFIRE or TRIHAWK mode and the loop pressure has reached the pressure relief setting. The pressure relief setting is varied by a signal from the Rockfire module.

Action

The Rockfire module energizes the ON/OFF solenoid and applies a pulse-width modulated (PWM) signal to the variable solenoid. As the pulse width is increased (effectively increasing current to the solenoid), the pressure setting is also increased, which increases the thrust pressure that may be applied.

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Specifications

Thrust Limiter Relief Valve Solenoid Coil Specifications	
type	'10' (Vermeer P/N 251112-005)
minimum pull-in current	1.18 A
minimum pull-in voltage	10.2 V
initial coil current draw at 70°F (20°C)	1.46 A at 10.5 VDC 1.67 A at 12 VDC 2.01 A at 14.5 VDC
resistance	7.2 ohms at 70°F (20°C)
nominal power rating	20 W
coil installation torque	7–10 ft-lb (9.5–13.5 Nm)
Diagnostic notes: *The coil contains a bipolar diode for spike suppression. Either lead may be connected to +12V since the diode only conducts at higher voltage. The coil may be checked in either direction with an ohmmeter. If the diode is bad, a voltage "spike" will occur everytime the coil is turned off, which could cause the Strike Alert to sound. The diode cannot be checked with an ohmmeter but a scope-meter or oscilloscope will display voltage spikes caused by a failed diode.*	

Thrust Limiter Relief Valve Specifications	
thrust limiter pressure relief	
model	TS10-26AM-0-N-00
type	Screw-in, cartridge-style, pilot-operated, spool-type hydraulic relief valve. Infinitely adjustable across a prescribed range using a variable electric input. Pressure output is proportional to DC current input.
minimum relief setting	350 psi (24.1 bar)
control operating range	3000 psi (207 bar)
O-ring position (forward and reverse)	type 'B' (O-ring is beneath backup ring)
maximum pilot flow	0.2 gpm (0.76 L/min)
Adjustment: *To adjust, use the manual override to manually set pressure to at least 350 psi. If pressure is set lower than charge pressure, the carriage may creep since shuttle flow may be applied to the pump servo through the relief, causing the pump to stroke under some circumstances. When replacing the valve, back out bleed screw 2 to 4 rotations to allow all trapped air to escape. Screw in the bleed screw. Before operating electrically, back out manual override (CCW) until positive stop is reached. Start machine, select ROCK-DRILL mode, and leave controls in neutral. Carriage will creep slowly toward the rear of the rack. Screw in the manual override slowly until the carriage stops moving, then turn in approximately 1/4 to 1/2 turn more. (Lower pressure (fewer turns back in) will allow lower pressure rock drilling, but the setting must not allow any carriage creep.) Cycle the thrust/pullback controls and make sure that the carriage does not creep at any position on the rack.*	

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THRUST LIMITER PRESSURE RELIEF BENCH TEST

Test Objective

To determine if the pressure relief valve is holding pressure (not leaking) until the minimum pressure relief setting is reached and to determine if the pressure setting can be varied electrically. If it is leaking, the maximum pressure that the pump can reach will be limited whenever loop oil is applied to the relief. If the setting cannot be varied the maximum pressure that can be applied will probably be limited to the relief basic setting whenever loop oil is applied to the relief.

- Cracking pressure should be at least **300 psi (20 bar)**.
- Leakage should be less than **5 drops/min (0.25 cc/min)**.

Special Tools and Materials

- hand-powered test pump capable of 3000 psi (210 bar)

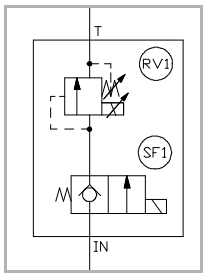
Conditions

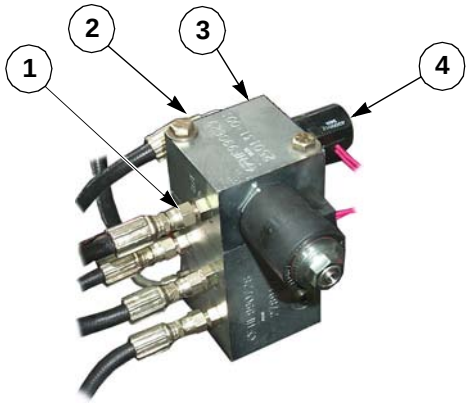
WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible, Relieve pressure before working on system. When searching for a leak, use an object like cardboard—not your hand. Fluid injected under the skin must be removed by a surgeon familiar with this type of injury.

WARNING: Before performing any maintenance on the machine, follow the Shutdown Procedure unless instructed differently by the manual.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Follow *Shutdown Procedure* (refer to page 10-2-1)
2. Remove hoses from port 'T' **(1)** and and port 'IN' **(2)** from thrust limiter **(3)**.
3. Remove the ON/OFF solenoid valve **(4)** and plug the port.
4. Connect a hand pump to port 'IN' **(2).** Pressurize with the hand pump. Pressure should build up and hold steady with minimum pumping required to maintain pressure, until you reach cracking pressure—approximately 300 psi (20 bar).

Results

- ***If pressure builds up and stays steady up to approximately 300 psi (20 bar),*** the pressure relief valve is okay.
- ***If pressure builds up and stays steady between approximately 100 - 290 psi (7–20 bar),*** the valve is functioning correctly but is adjusted incorrectly. Adjust the valve to crack open at 300–400 psi (20–28 bar).
- ***If pressure leaks down rapidly or pressure cannot be built up***, there is a problem with the solenoid valve, O-rings, or the valve cavity sealing surfaces.

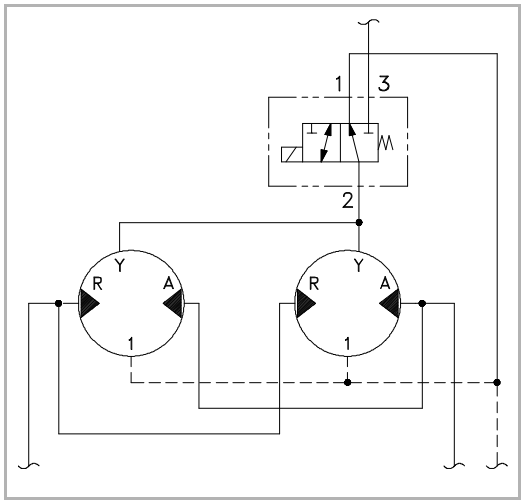
IMPORTANT: After restoring the machine, *verify* the pressure setting by operating the machine, and adjust as necessary.

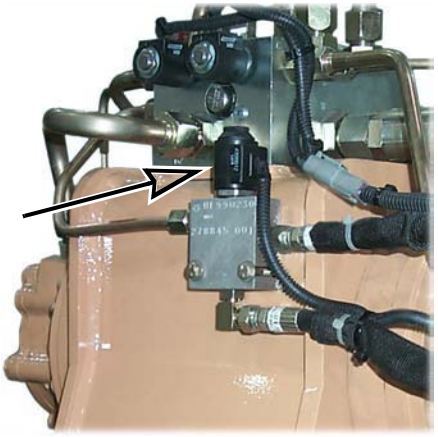
IMPORTANT: Do not use a hand pump to adjust a pressure relief unless specifically directed to do so. Cracking pressure with a hand pump does not indicate the pressure that can be obtained with a high flow hydraulic pump in the circuit.

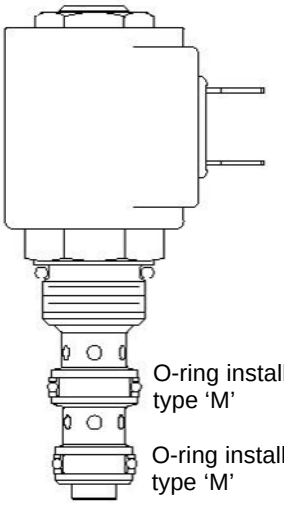
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2-SPEED SOLENOID







Operation

The 2-speed motor solenoid valve controls flow of oil to the 'Y' (shift) port of both thrust/pullbacks motors simultaneously. Energizing the solenoid shifts both motors into high speed, and de-energizing it shifts the motors into low speed.

Action

When the solenoid is energized the spool applies charge pressure from the shuttle valve to the motor 'Y' port and blocks flow to the case drain circuit. When a solenoid is de-energized, charge pressure is blocked from the motor Y' port, which is opened to the case drain circuit inside the shuttle block. This allows shift oil from the speed solenoid valve to drain off, allowing the motors to shift back to low-speed/high-displacement.

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Specifications

Motor Speed Solenoid Coil Specifications	
type	'08' (Vermeer P/N 251117-009)
initial coil current draw at 70°F (20°C)	1.07 A at 10.5 VDC 1.2 A at 12 VDC 1.48 A at 14.5 VDC
minimum pull-in voltage	10.2 V
resistance	9.8 ohms at 70°F (20°C)
nominal power rating	14.7 W
coil installation torque	5–7 ft-lb (6.75–9.5 Nm)
Diagnostic notes: *The coil contains a bipolar diode for spike suppression. Either lead may be connected to +12V since the diode only conducts at higher voltage. The coil may be checked in either direction with an ohmmeter. If the diode is bad, a voltage "spike" will occur everytime the coil is turned off, which could cause the Strike Alert to sound. The diode cannot be checked with an ohmmeter but a scope-meter or oscilloscope will display voltage spikes caused by a failed diode.*	

Motor Speed Solenoid Valve Specifications	
model	SV08-30-W-0-N-00
type	Solenoid operated, 3-way, direct acting, spool-type.
O-ring position	type 'M' (both O-rings) (O-ring is located between backup rings)
maximum leakage	3 fluid oz/min (82 cc/min) at 3000 psi (207 bar)
valve installation torque	20 ft-lb (27 Nm)
Diagnostic notes: *Since the hot oil shuttle valve is a spool type valve, it is a "leaker" that will exhibit controlled leakdown during a pressure-leak test.*	

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2-Speed Solenoid Valve Bench Test

Test Objective

To determine if the motor speed solenoid valve is holding pressure (not leaking) until energized. If it is leaking, the motors may shift erratically or may be shifted into high speed/low torque at all times. Leakage should be less than **3 fl-oz/min (82 cc/min) at 3000 psi (207 bar).**

Special Tools and Materials

- handpowered test pump capable of 500 psi (35 bar)

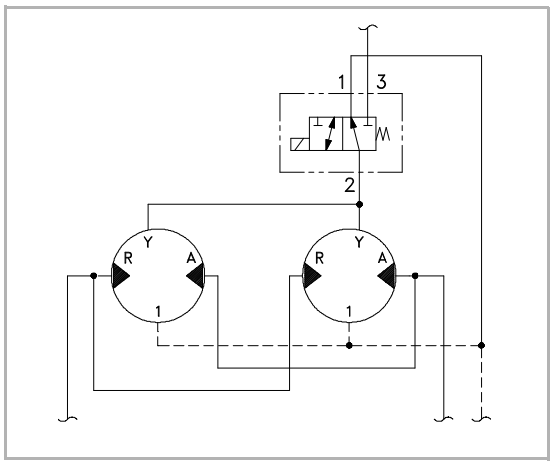
Conditions

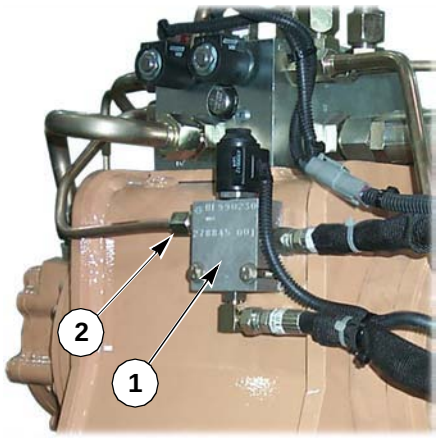
WARNING: Pressurized fluid can penetrate body tissue and result in serious injury or death. Leaks can be invisible, Relieve pressure before working on system. When searching for a leak, use an object like cardboard—not your hand. Fluid injected under the skin must be removed by a surgeon familiar with this type of injury.

WARNING: Before performing any maintenance on the machine, follow the Shutdown Procedure unless instructed differently by the manual.

IMPORTANT: For accurate testing, the test pump and components must be 70°F (20°C) or warmer.

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Procedure

1. Follow *Shutdown Procedure* (refer to page 10-2-1).
2. Remove all three hoses from the 2-speed valve **(1)**.
3. Connect a hand pump to port '3' **(2)**. Pressurize with the hand pump to approximately 500 psi (35 bar). Pressure should build up and hold steady with minimum pumping required to maintain pressure.

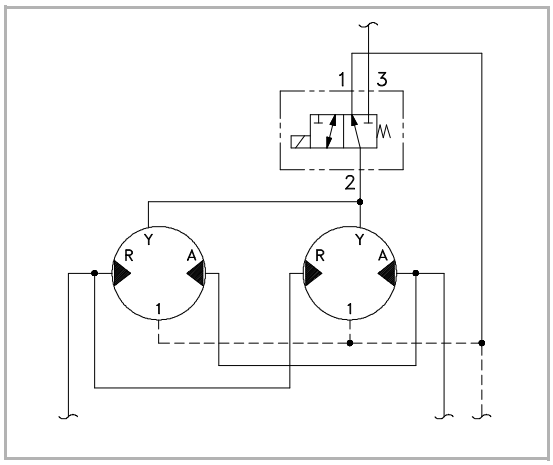
Results

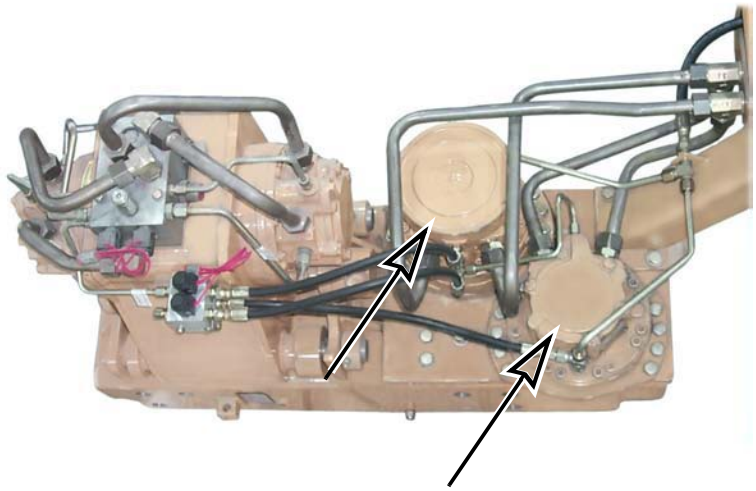
- ***If pressure builds up and stays steady,*** the solenoid valve is okay.
- ***If pressure leaks down rapidly or pressure cannot be built up,*** there is a problem with the solenoid valve, O-rings, or the valve cavity sealing surfaces. Leakage should be considerably less than **3 fluid oz/min (82 cc/min).**

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THRUST/PULLBACK MOTORS





Operation

The thrust/pullback motors are bolted to the carriage. Each motor has a pinon gear which mates with the pinion rack . The motors receive oil from the thrust/pullback pump to turn the gears. The thrust/pullback pump provides a variable output to drive the motors. The thrust/pullback motors are automatically shifted to half-displacement high-speed mode whenever the lower vise is ON.

Action

Forward: Oil from the thrust/pullback pump (PMP2) 'B' port flows to the 'A' ports of the thrust/pullback motors. Exhaust (low side) oil from the 'R' ports of the motors travels to the 'A' port of the pump.

Reverse: Oil from the thrust/pullback pump (PMP2) 'A' port flows to 'R' ports of the thrust/pullback motors. Exhaust (low side) oil from the 'A' ports of the motors travels to the 'A' port of the pump.

NOTE: The motor 'A' port is the primary inlet port and receives pressure oil from the pump 'B' port. This requires different internal valving inside the left and right motors to allow opposite rotation to result from pressurizing the 'A' port.

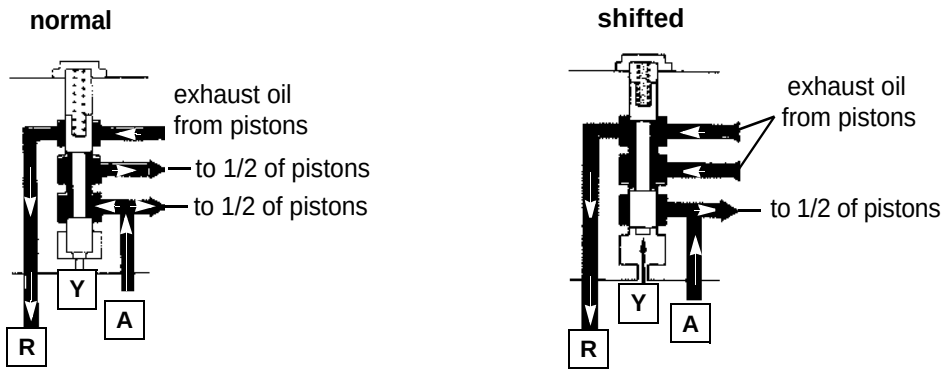
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Displacement Shift: During normal operation, out of *ten* pistons in each motor, *four* are receiving pressurized oil from the 'A' port and applying torque to the drive shaft, *four* are exhausting to the 'R' port, and *two* are in transition between exhaust and pressure.

Applying shuttle oil pressure to the 'Y' port of either motor shifts a spool valve. This exhausts half of the motor pistons directly to the 'R' port, which prevents them from applying torque to the drive shaft. Now only two out of the ten pistons are receiving pressurized oil and the rest are either connected to exhaust oil at the 'R' port or are in transition between pressure and exhaust. This reduces motor displacement by 1/2 and increases motor speed.

The motor is shifted back to normal by removing shuttle oil pressure through the case drain circuit, which allows the spool valve to return to normal and allows use of all the motor pistons.



Dual Motor Operation

Shift Operation: Both motors shift displacement at the same time so that both are either in low speed or in high speed at the same time.

Rotation Direction: Left and right motors are identical except that the internal distribution block is indexed for clockwise or counterclockwise rotation when oil is applied to the 'A' port, which is intended to be the primary inlet or feed port. If necessary, motors can be changed for opposite rotation.

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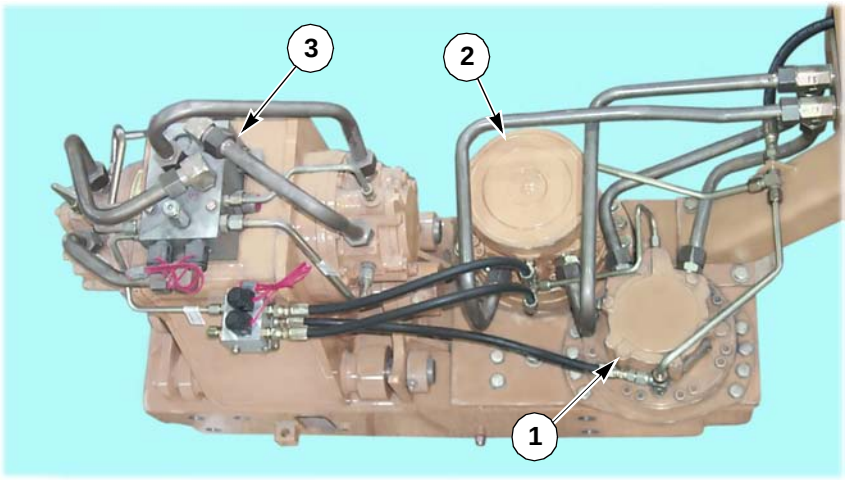
Section 80-6: Thrust / Pullback System Repair

MOTOR REMOVAL / INSTALLATION

Special Tools and Materials

- torque wrenches capable of producing 30 ft-lb (40 Nm) and 100 ft-lb (135 Nm)

Remove Motors

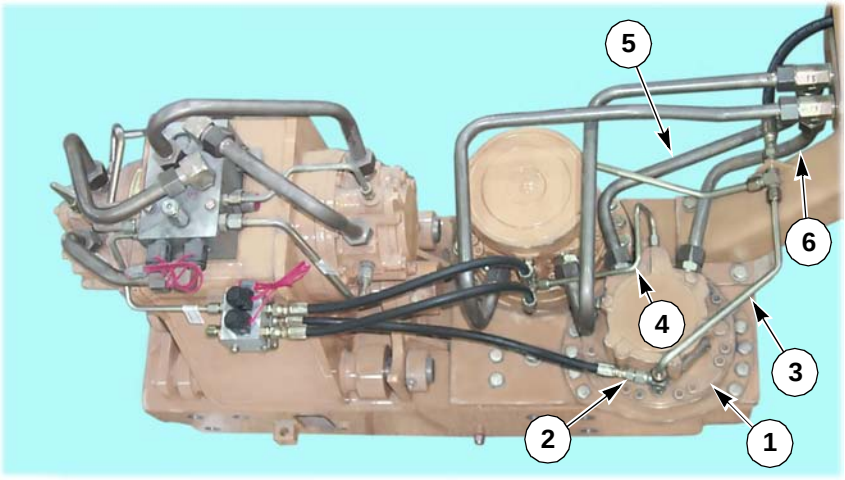


1. Level the rack and move the thrust/pullback carriage to the back of the rack.
2. Follow the *Shutdown Procedure* (refer to page 10-2-1).
3. Since you will be opening the hydrostatic closed-loop system, thoroughly clean motors **(1)** and **(2)**, as well as the three speed/loop flush valve assembly **(3)**.

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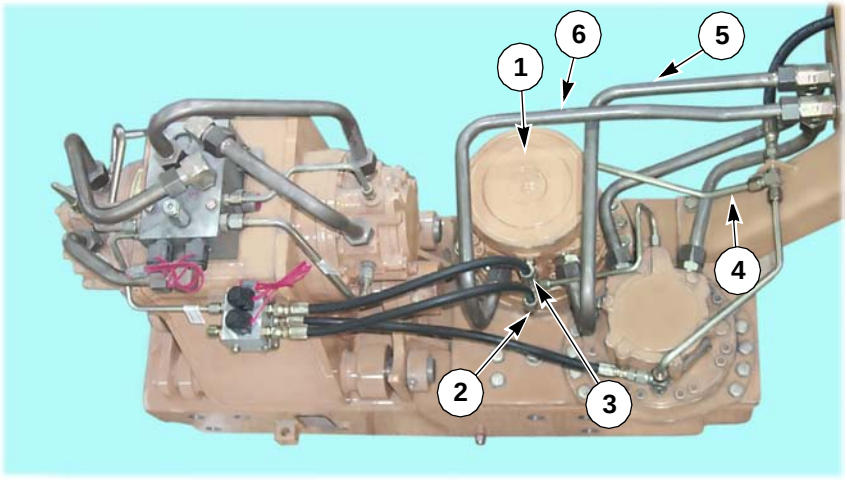
Because cleanliness is extremely important, cap or plug all of the hoses, tubes and fittings during disassembly.

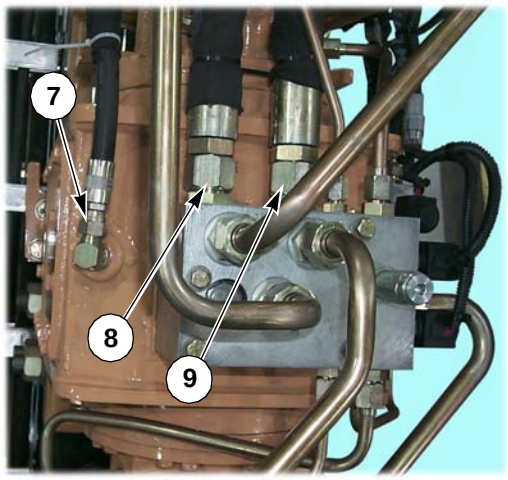
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4. Label and remove the hose and tubes in the suggested order for motor **(1)** as follows:

- hose **(2)**
- tubes **(3)**, **(4)**, **(5)** and **(6)**

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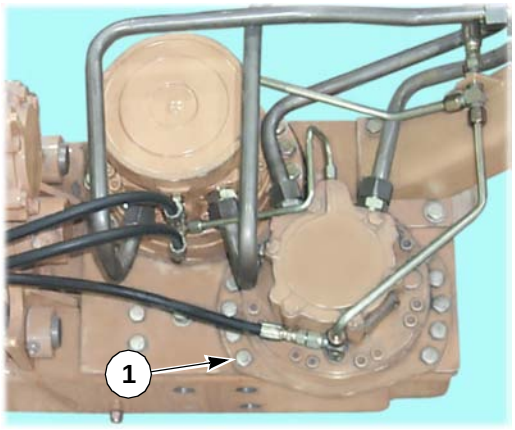
Because cleanliness is extremely important, cap or plug all of the hoses, tubes and fittings during disassembly.

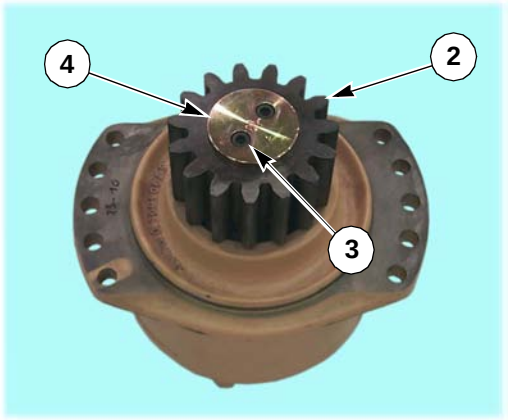
5. Label and remove the hoses and tubes in the suggested order for motor and brake assembly **(1)** as follows:
   - hoses **(2)** and **(3)**
   - tubes **(4)**, **(5)**, and **(6)**
6. Label and remove:
   - case drain hose **(7)** (if necessary for clearance)
   - 'A' port hose **(8)** and 'B' port hose **(9)** (if necessary for clearance)

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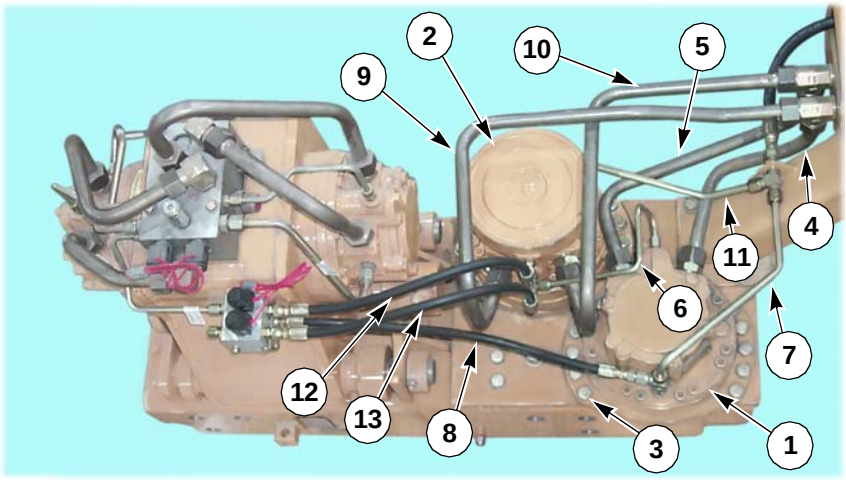
WARNING: Clamp or block the thrust/pullback carriage to lock it in place, preventing the carriage from moving if the rack is inclined. Serious crushing injuries may occur if struck by moving carriage.

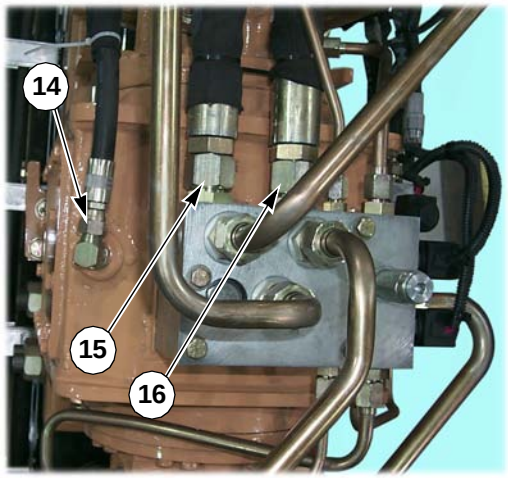
7. Remove ten bolts **(1)** for the motor being serviced. Lift the motor from the carriage.

8. Remove gear **(2)** by removing two screws **(3)**, washers (not shown), and plate **(4)**.

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Install Motors





1. Lift motors **(1)** and **(2)** onto the carriage. Gradually tighten ten bolts **(3)** on each motor, using a cross-pattern tightening sequence to evenly seat the motors. Final torque the bolts to 180 ft-lb (244 Nm).

When connecting hoses and tubes to fittings, carefully oil the threads and seats so that correct torque values can be achieved as the nuts are tightened. Always use lightly lubricated new O-rings during re-assembly.

2. Install the tubes and hoses in the following suggested order for the particular motor being serviced:

Hose and Tube Connections		
Sequence	**Ports**	**Torque**
(4)	'A' (motor 1) to fitting	92 ft-lb (124.7 Nm)
(5)	'R' (motor 1) to fitting	92 ft-lb (124.7 Nm)
(6)	'Y' (motor 1) to 'Y' (motor 2)	19 ft-lb (25.8 Nm)
(7)	'1' (motor 1) to fitting	28.5 ft-lb (38.6 Nm)
(8)	'T2' (valve) to '1' (motor 1)	19 ft-lb (25.8 Nm)
(9)	'A' (motor 2) to fitting	92 ft-lb (124.7 Nm)
(10)	'R' (motor 2) to fitting	92 ft-lb (124.7 Nm)
(11)	'1' (motor 2) to fitting	28.5 ft-lb (38.6 Nm)
(12)	'B' (valve) to 'B' (motor 2)	19 ft-lb (25.8 Nm)
(13)	'Y' (valve) to 'Y' (motor 2)	19 ft-lb (25.8 Nm)
(14)	case drain (rotation gearbox)	28.5 ft-lb (38.6 Nm)
(15)	'A' (three speed/loop flush valve)	87.5 ft-lb (118.7 Nm)
(16)	'B' (three speed/loop flush valve)	87.5 ft-lb (118.7 Nm)

3. Remove the clamps and blocks, securing the thrust/pullback carriage.

4. Refer to the *System Startup* procedures (refer to page **40-6-1**) for the proper filling of the hydrostatic oil lines.

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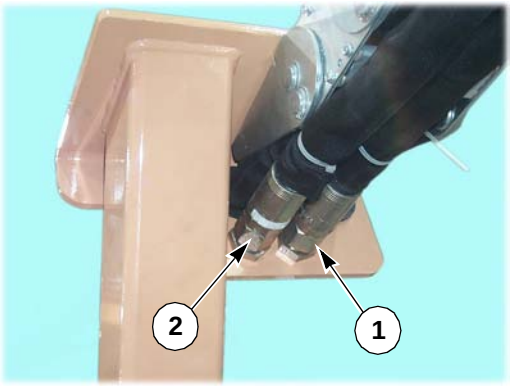
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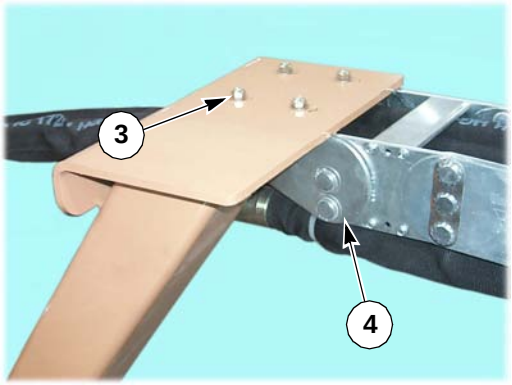
CARRIAGE REMOVAL / INSTALLATION

Special Tools and Materials

- torque wrenches capable of producing range of 30 ft-lb (40 Nm) and 300 ft-lb (407 Nm)
- four 1/2" x 10" NC bolts

Remove Carriage



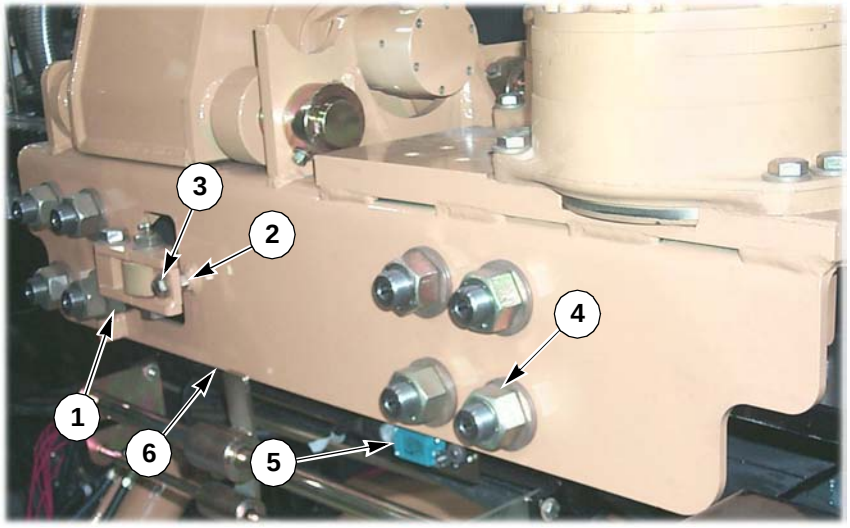


1. Remove the thrust/pullback motors. Refer to *Motor Removal Installation*, page 80-6-1
2. Remove the rotation gearbox. Refer to *Carriage Removal/Installation*, page 80-6-6
3. Remove hoses **(1)** and **(2)**. Remove four nuts **(3)**, washers and bolts, releasing hose carrier **(4)**.

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4. Loosen lock nut **(1)**. Loosen lock nut **(2)** and back out bolt **(3)** to relieve guide roller pressure on each side of the rack. Loosen four nuts **(4)** (bottom rollers only) on each side of the rack.

5. Remove limit switch **(5)** by removing two mounting screws, four washers (not shown) and two nuts (not shown).

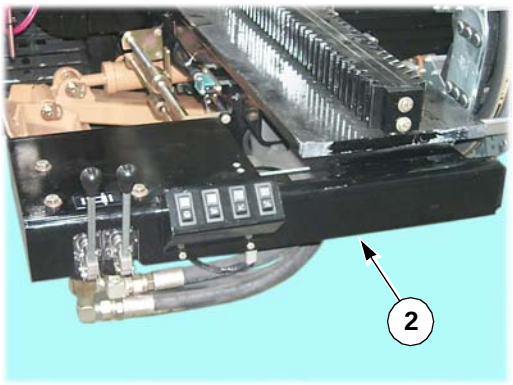
6. Install a suitable lifting sling onto carriage **(6)** so it will be balanced when slid off the rack. Attach an adequate lifting device to the sling, and lift enough to remove the weight of the carriage from the rack.

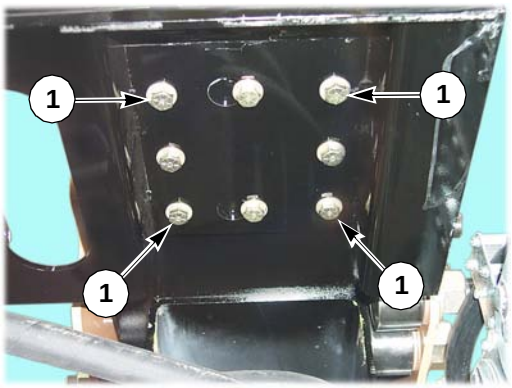
WARNING: Clamp or block the thrust/pullback carriage to lock it in place, preventing the carriage from moving if the rack is inclined. Serious crushing injuries may occur if struck by moving carriage.

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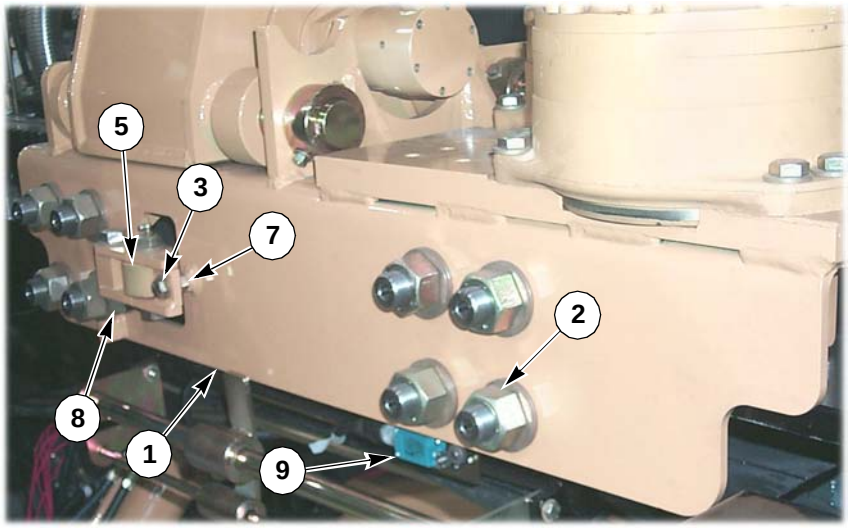


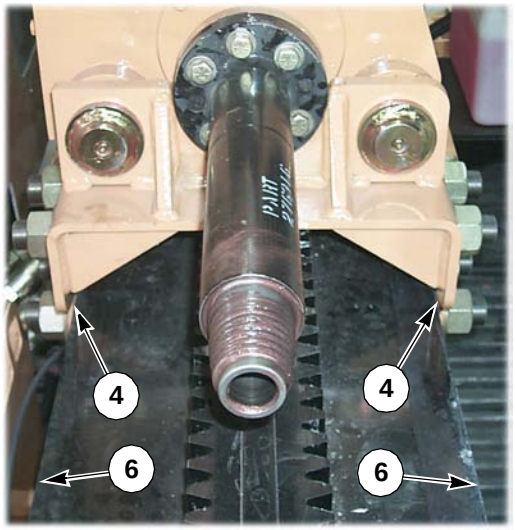
7. Remove four bolts **(1)** and washers on the underside of mount **(2)**, replacing them with four 1/2 x 10” NC bolts (not shown) and washers. Remove the rem"ining bolts and washers, allowing the mount to rest on the four 1/2 x 10” NC bolts.

8. Remove the clamps and blocks, and slide the carriage from the rack.

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Install Carriage





1. Install a suitable lifting sling onto carriage **(1)** so it will be balanced. Attach an adequate lifting device to the sling, and slide the carriage onto the rack.

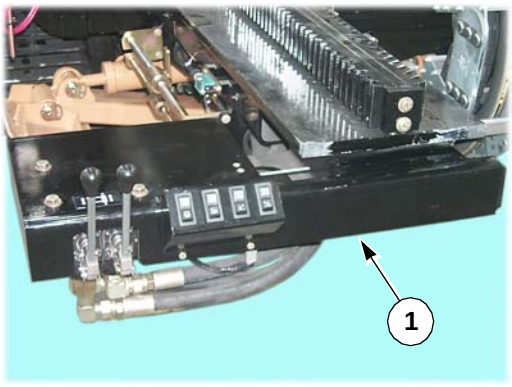
WARNING: Clamp or block the thrust/pullback carriage to lock it in place, preventing the carriage from moving if the rack is inclined. Serious crushing injuries may occur if struck by moving carriage.

2. Torque four nuts **(2)** (bottom rollers only) on each side of the rack to 125 ft-lb (170 Nm).
3. Use bolt **(3)** on each side of the rack to adjust equal gaps **(4)** between the carriage and rack plate. Then, set a clearance of 1/16" (2 mm) between guide rollers **(5)** and rack edges **(6)**. Tighten nut **(7)** and torque nut **(8)** to 300 ft-lb (407 Nm) on each side.
4. Install limit switch **(9)**, using two mounting screws, four washers (not shown) and two nuts (not shown). Tighten the switch at the exteme top end of the slot on the mounting bracket.

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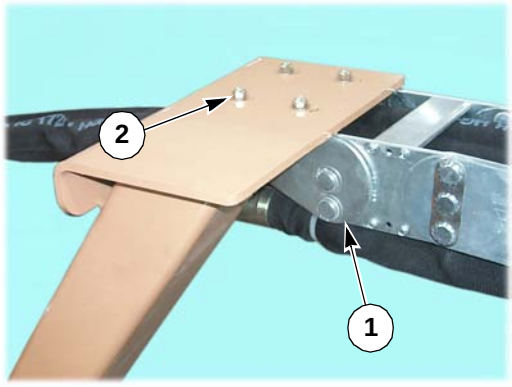
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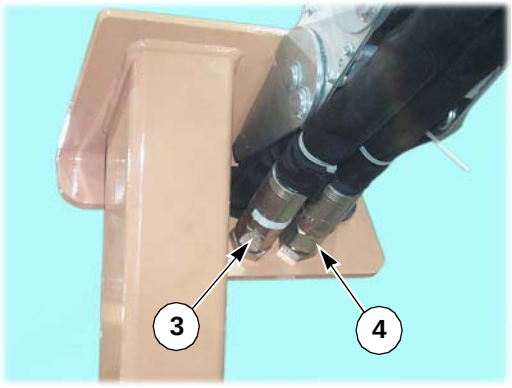
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5. Lift mount **(1)** up against the underside of the rack and install eight bolts **(2)** and washers. Remove the clamps and blocks used to prevent the carriage from falling off of the rack.

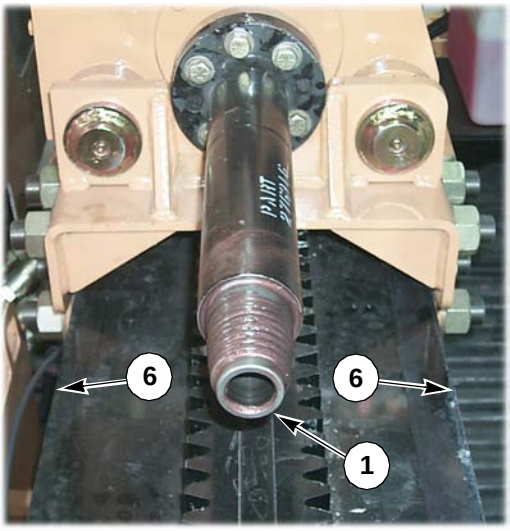


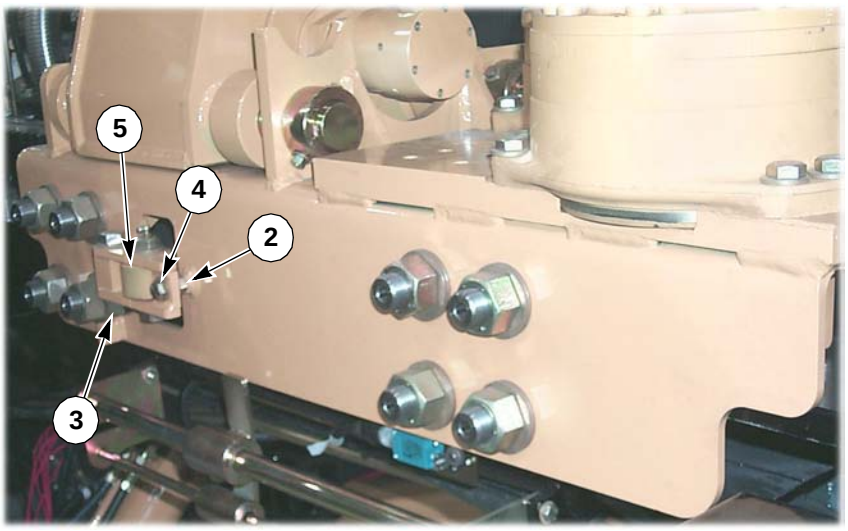


6. Lift hose carrier **(1)** into place and install the four bolts, washers and nuts **(2)**. Torque the nuts to 25 ft-lb (34 Nm).
7. Install the hoses **(3)** and **(4)**, torquing them to 87.5 ft-lb (118.7 Nm).
8. Install the rotation gearbox. Refer to *Gearbox Installation*, page **80-6-9**
9. Install the thrust/pullback motors. Refer to *Install Motors*, page **80-6-5**

Continued on next page...

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10. Clamp a rod in the upper vise. Verify that drive chuck **(1)** correctly engages the rod end. If adjustment is required, loosen nuts **(2)** and **(3)** on each side of the rack. Use adjustment bolts **(4)** to shift the carriage side-to-side, centering the drive chuck to the rod end.

11. Once the drive chuck is centered, set a clearance of 1/16" (2 mm) between guide roller **(5)** and rack plate edge **(6)** on each side. Tighten nuts **(2)** and torque nuts **(3)** to 300 ft-lb (407 Nm).

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Section 90-0: Rod Loader and Vise

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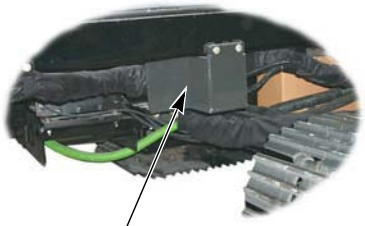
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Rod Alignment to Drive Chuck	90-6-3
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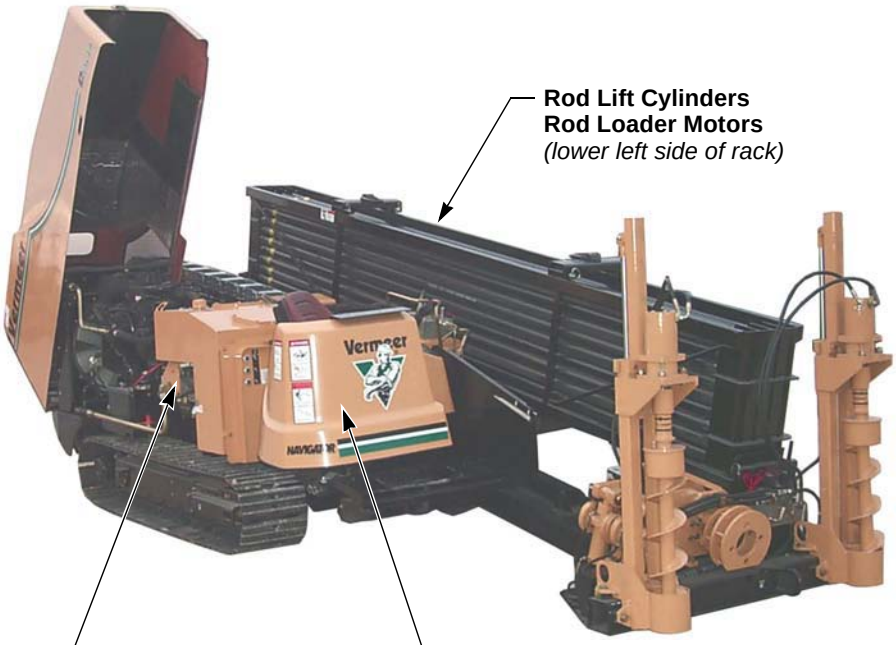
Section 90-1: Rod Loader and Vise Overview

System and Component Locations

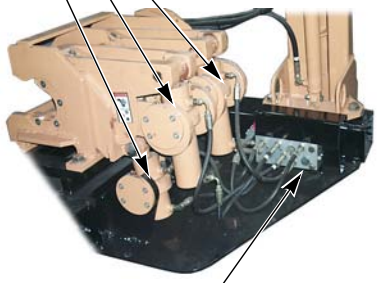


Rod Loader Manifold
(under rack)

Rod Lift Cylinders
Rod Loader Motors
(lower left side of rack)



Upper Vise Rotation Cylinder
Upper Vise Cylinder
Lower Vise Cylinder



PFC Pump
Proportional Dump Valve
Return Filter Manifold

Controls
Ignition Switch
Emergency Stop
Rod Transfer Switch
Rod Lift Switch
Upper Vise Switch
Upper Vise Rotate Switch
Lower Vise Switch

Vise Manifold

Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Rod Loader & Vise table of contents (will direct you to system and component information)	90-0-1
Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Engine	30-0-1
Common Hydraulic System	40-0-1
Common Electrical System	50-0-1

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OPERATION OVERVIEW

PFC Pump

The PFC pump supplies hydraulic flow at pressure according to demand.

Load Sense Solenoid Valve

The load sense solenoid valve is energized any time a hydraulic function is operated with an electric switch. This opens the valve to allow oil flow to the load sense line. There are no load sensing lines connected with the rod loader and vise valves; all load sense oil to the PFC pump is supplied by the load sense solenoid, the proportional valve, or the transport valve.

Rod Loader Electromagnets

The rod loader electromagnets are triggered by the magnet switch when the rod loader arms begin to extend toward the rack. The magnet switch also provides the “magnets on” signal to the slow-down/anti-crash module.

Rod Loader Motors

Two motors operate rack and pinion gearing to move the rods. The motors are connected in series with pressure reliefs.

Vise Manifold

The vise manifold (MFL6) uses four solenoid valves to control vise operation. There is no load sense line from the vise manifold to the PFC pump. Instead, the load sense function is triggered electrically.

Rod Loader Manifold

The rod loader manifold (MFL5) uses two bi-directional solenoid valves to control all rod loader operation.

Operation

Correct operation of the system requires that the load sensing system is functioning correctly and the barrier switches are closed.

SYSTEM SPECIFICATIONS

The following specifications are for the rotation system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
governed engine RPM	2200 rpm
Rod Loader Motors	
motor make/ Model	Eaton 2000
displacement per revolution	9.6 cid (157 cc)

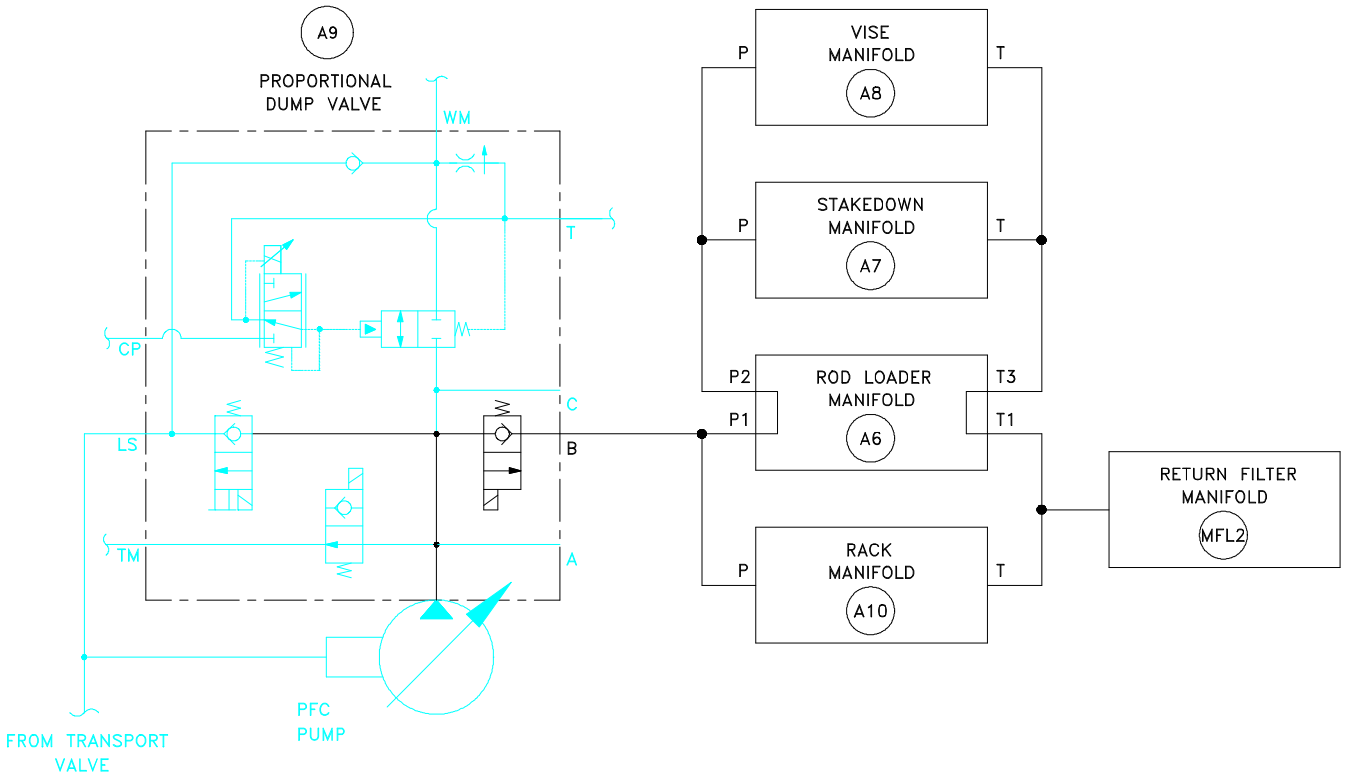
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HOSES

Hose ID/ Pressure	Circuit Type	Function
PFC 'B' implement pressure	pressure	Provides PFC pump pressure to the pressure ports on the rod loader manifold and the rack manifold and indirectly to the stakedown manifold and the vise manifold.
Tank Return nominal pressure	return	Returns oil from the vise manifold, the stakedown manifold, the rod loader manifold, and the rack manifold to the return filter manifold.

***NOTE:** under "standard operating conditions," the following pressures will normally be found in the circuits indicated:
"nominal pressure" = 25–100 psi (1.7–6.9 bar)
"implement pressure" = 300–3000 psi

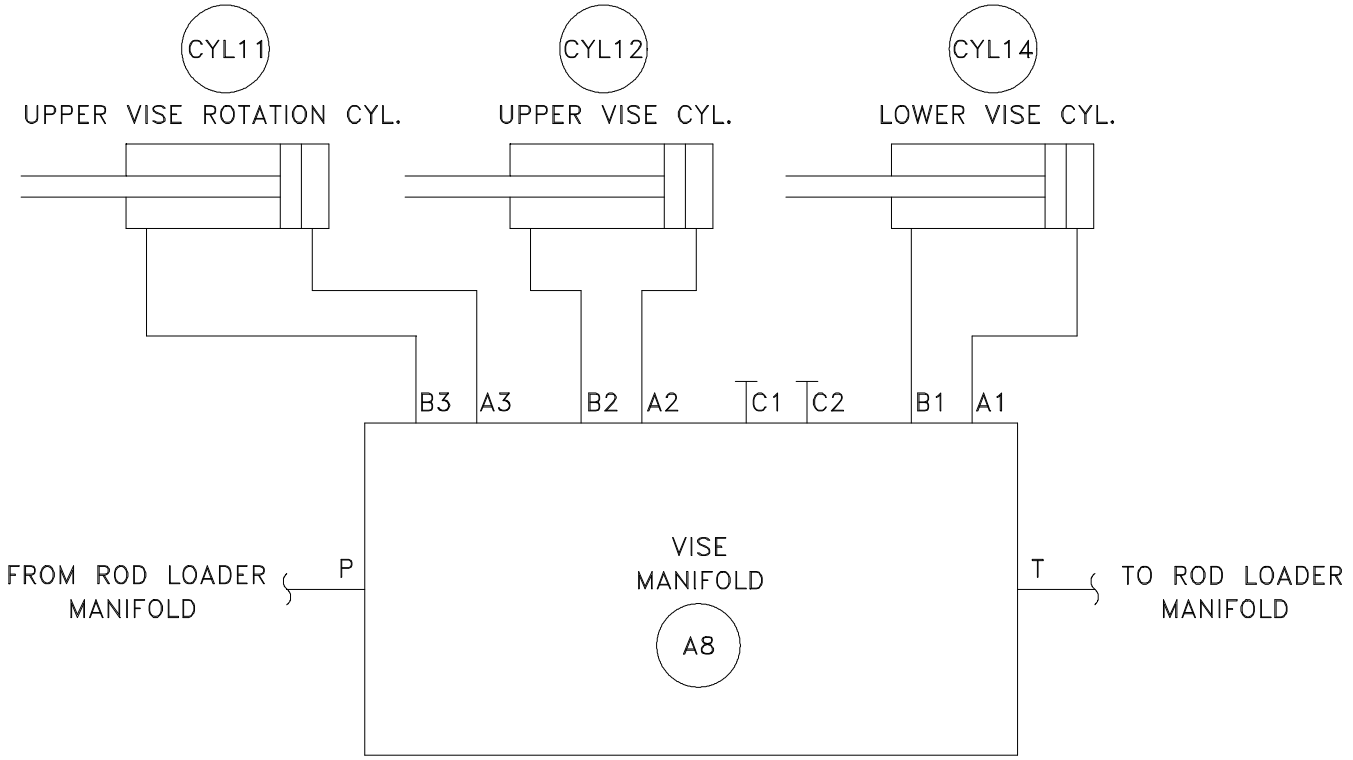
Hose Diagram - Rod Loader and Vise



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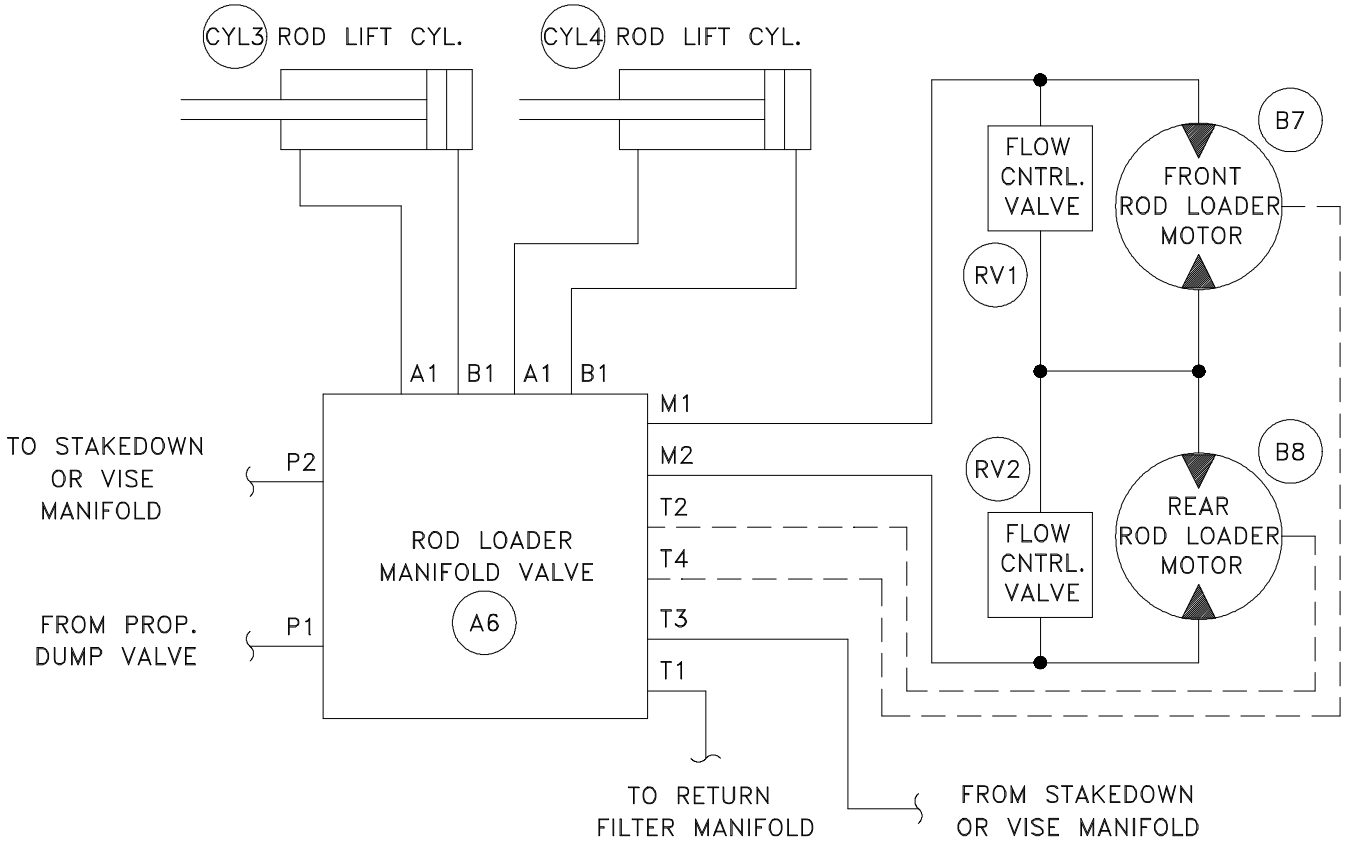
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Hose Diagram - Vise Manifold Valve



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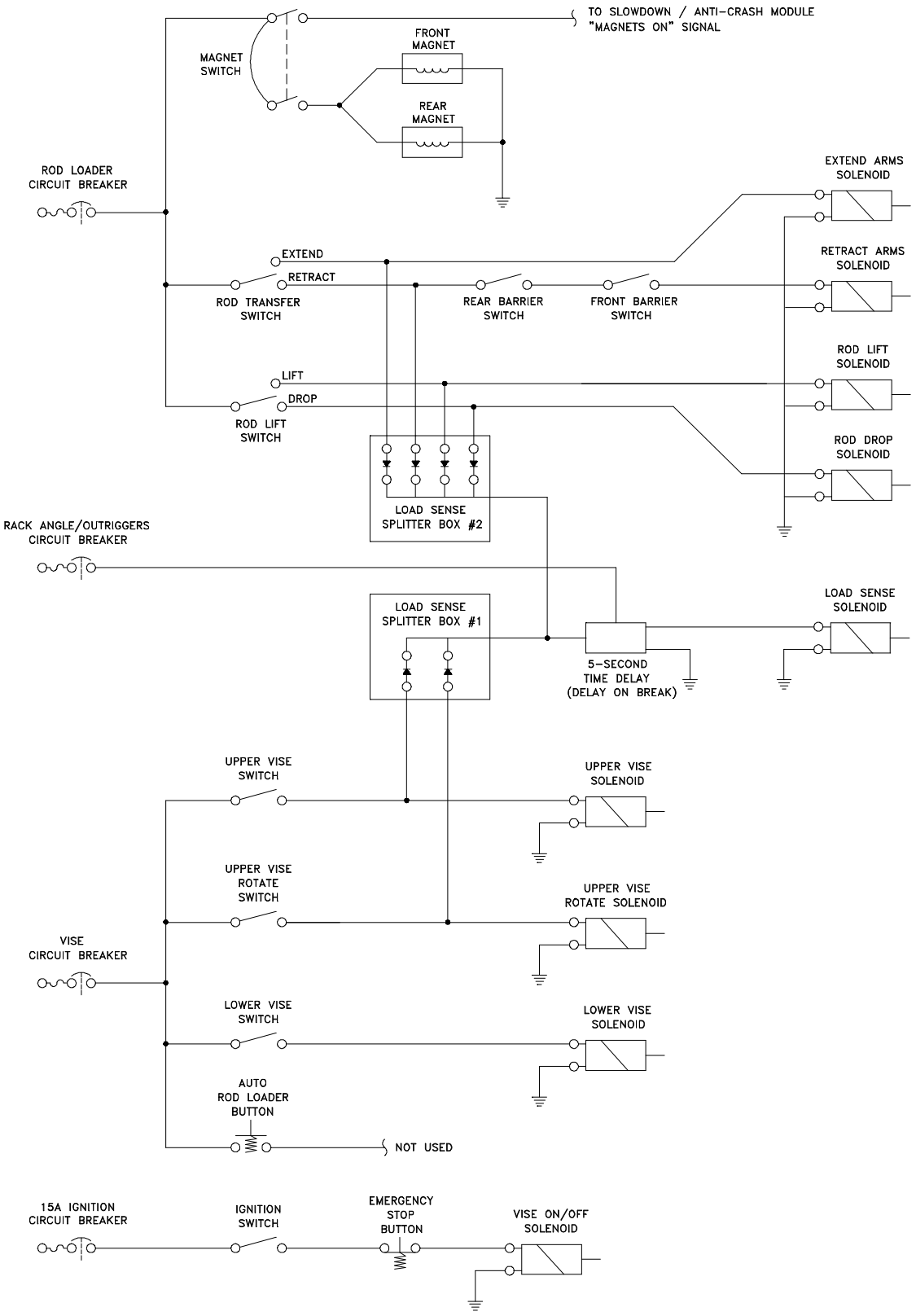
Hose Diagram - Rod Loader Manifold Valve



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ELECTRICAL DIAGRAM



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Section 90-2: Rod Loader and Vise Troubleshooting

HOW TO DO TROUBLESHOOTING

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***
5. ***Are the hydraulic components functioning correctly?***

Check out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

6. **Is there a mechanical problem?** Check for bent, broken, or misadjusted components.
7. **Are the machine common systems operating correctly?** The load sense splitters include diodes which energize the load sense solenoid while isolating individual circuits. A shorted or open diode for another system could cause problems with vise or rod loader operation.
8. **Are the related systems working correctly?** The PFC pump flow is shared with all implement functions and and the water pump drive circuit. A malfunction in one circuit could affect the other.
9. **Are the controls working correctly?** The **rod loader circuits** are powered by the rod loader circuit breaker and include the three limit switches (magnet switch, rear barrier switch, and front barrier switch) and two operator control control switches (rod transfer and rod lift). The **vise circuits** are powered by the vise circuit breaker and include three operator control switches (lower vise switch, upper vise switch, upper vise rotate switch.) The **5-second load sense delay** is powered by the rack angle/outrigger circuit breaker.
10. **Are the hydraulic components functioning correctly?** The four main solenoid valve manifolds are supplied PFC pump pressure from the hydraulic enable valve. The PFC pump and load sense functions must be working correctly, and the hydraulic enable solenoid valve must allow flow from the 'B' port of the proportional/dump valve. The flow control valves must be functioning properly and not misadjusted or loader arms might not synchronize at the end of their cycle. The rod loader and vise manifolds use orifices to control flow. If either orifice is blocked or not installed, operation will be affected.

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Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

Checking Out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, ignition switch, rod loader, rack, and vise circuit breakers) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** Refer to the overall system schematics to determine what switches are contained within a system or circuit.
5. ***Are all electrical actuators OK?*** Almost always a coil—either in a relay or a solenoid; make sure the current path is complete and the resistance is within tolerance.
6. ***Is the mechanical output OK?*** Even if all electrical functions are OK, a valve may leak or fail to move, or relay contacts may stick or not conduct current.
7. ***If a control module is used, are all of its circuits OK?*** Does a control module system have correct voltage and ground, inputs, and complete current paths on all circuits? Most “module failures” are the result of a problem in the voltage source, current path, ground, switch or resistor function, or actuator failure. Check all those items before replacing a module.

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Checking Out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is a variable signal based on function demand being delivered to the compensator, either from a variable control such as the transport or water control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motors work ok unless the motors are worn, defective, incorrect replacements, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Some electrically controlled systems using variable current control of proportional solenoids might also change with temperature since current and temperature can be closely related.

Checking Out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

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SYMPTOM: ROD LOADER OR VISE WILL NOT OPERATE

1. Is the hydraulic enable system OK? Each time the engine is started, the hydraulic enable system must be activated.

Possible Problem	Possible Effect	What to do
hydraulic enable system not activated	Each time the engine is started, the hydraulic enable system must be activated in order to operate any implement hydraulic functions.	**Refer to Common Hydraulic System Troubleshooting,** page **40-2-1**.

2. Is the rod loader circuit live? The rod loader circuit receives power from the rod loader circuit breaker.

Possible Problem	Possible Effect	What to do
rod loader circuit breaker tripped	Rod loader power is provided from the rod loader circuit breaker. If it is tripped or defective, no current will be provided to the rod loader control circuit.	**Check that power is available from the rod loader circuit breaker.**

3. Is the vise circuit live? The vise circuit receives power from the vise circuit breaker.

Possible Problem	Possible Effect	What to do
vise circuit breaker tripped	The vise circuit receives power from the vise circuit breaker. If it is tripped or defective, no current will be provided to thevise control circuit.	Check that power is available from the vise circuit breaker.

SYMPTOM: ROD LOADER OR VISE LACKS POWER OR FORCE

1. Are the machine common systems operating correctly? Operating the machine outside of intended parameters (i.e. in HIGH when it should be in MEDIUM or LOW) can lead to customer complaints. Also, oil level, temperature, and condition, oil cooler problems, or engine speed and power outside of specifications can cause or contribute to faulty operation.

Possible Problem	Possible Effect	What to do
hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
plugged suction screen	A plugged suction screen will cause machine operation problems and eventually will cause extensive equipment damage.	**Clean suction screen**

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SYMPTOM: ROD LOADER WILL NOT RETRACT ARMS

1. Are the barriers in position and the barrier switches operating correctly? The rod loader arm barriers must be in the DOWN position to close the front and rear barrier switches. The rod loader arms will not retract if the barrier switches are not closed.

Possible Problem	Possible Effect	What to do
barriers not DOWN or barrier switches are misadjusted or defective	The rod loader arm barriers must be in the DOWN position to close the front and rear barrier switches. The rod loader arms will not retract if the barrier switches are not closed.	**Check the barrier position and switch adjustment and operation.**

SYMPTOM: MAGNETS ARE NOT ENERGIZED

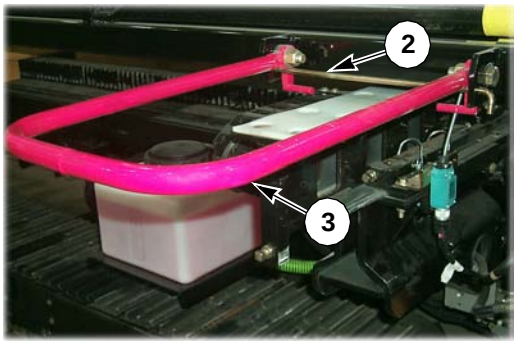
1. Is the magnet switch working? The magnet switch should close when the loader arms move towards the drill head, away from the first rod column.

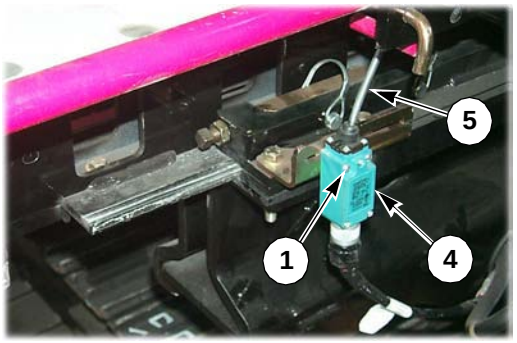
Possible Problem	Possible Effect	What to do
magnet switch misadjusted	The magnet switch should close when the loader arms move towards the drill head, away from the first rod column. This energizes both magnets.	**Check magnet switch adjustment** (refer to page **90-6-1**).

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Section 90-6: Rod Loader Adjustments

Safety Guard Arm Limit Switch

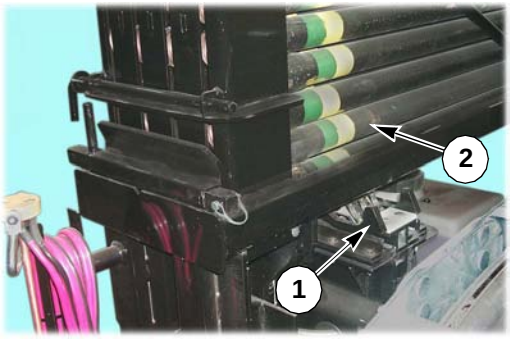


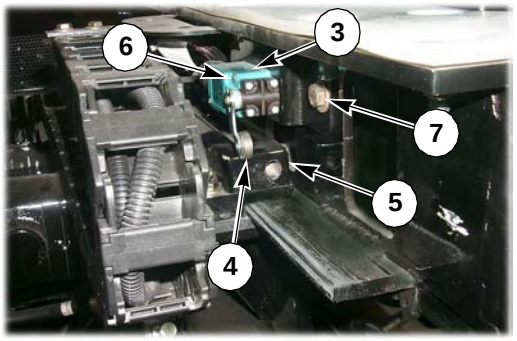


Limit switches are located on the front and rear rod loaders.

1. Loosen two screws **(1)**. With bar **(2)** locking the safety guard arm **(3)** in the position shown, slide limit switch **(4)** on the mounting bracket slightly past the point where an audible click is heard as switch actuator **(5)** is deflected. Tighten two screws **(1)**.
2. Verify correct switch operation by raising and lowering safety guard arm **(3)**, locking the arm in place with bar **(2)**.

Anti-Crash / Magnet Switch





This anti-crash/magnet switch is only on the rear rod loader.

1. Fully retract rod loader arms **(1)** so they are under first rod column **(2)**.

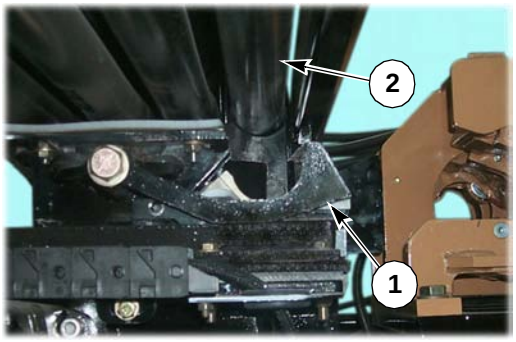
Two screws **(6)** and two bolts **(7)** allow the switch to be positioned vertically and horizontally.

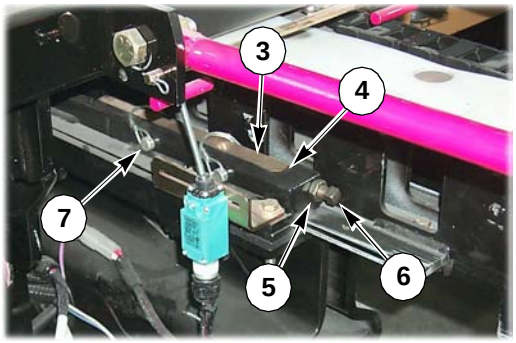
2. Position switch **(3)** so the following conditions exist:
   - Roller **(4)** makes firm contact with plate cover **(5)**.
   - Manually pulling back on the roller results in an audible click.
   - Roller ramps smoothly (without binding switch) onto the top surface of the plate cover as the rod loader arms move forward.

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ALIGNMENT OF ROD LOADER ARMS TO ROD COLUMN





1. Arms **(1)** on front and rear rod loaders are designed to be correctly centered to rod column **(2)** when the following conditions exist:
   - Rod loaders are fully retracted.
   - Bars **(3)** are fully back against plate cover stop surfaces **(4)**.
2. To reposition arms **(1)** forward relative to the rod column, adjustments are as follows:
   - Fully extend front and rear rod loaders to relieve pressure on bars **(3)**.
   - Loosen lock nuts **(5)**.
   - Advance screws **(6)** from being fully flush with plate cover stop surfaces **(4)** to reposition arms forward.
   - Tighten lock nuts **(5)**.

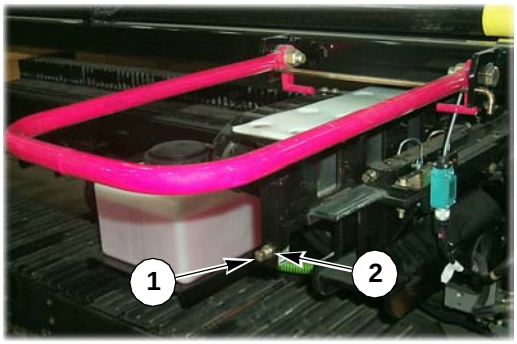
The holes for pins **(7)** are oversized to permit a small amount of adjustment using screws **(6)**.

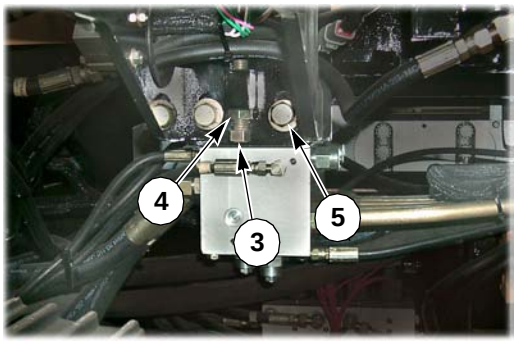
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ROD ALIGNMENT TO DRIVE CHUCK

Special Tools

- torque wrench capable of producing 180 ft-lb (244 Nm)





Procedure

1. Load a rod on the rod loader arms and fully extend the arms. Visually check rod alignment to the upper vise and drive chuck. Then, verify alignment further by clamping the rod in the upper vise and slowly engaging the drive chuck with the rod.
2. Adjustments are as follows:
   - The front and rear rod loaders are centered horizontally using screws **(1)**. Loosen lock nuts (2) and advance the screws to decrease the extension of the arms. Tighten the lock nuts.
   - The front and rear rod loaders are centered vertically using screws **(3)**. Loosen lock nuts **(4)**, as well as bolts **(5)** and nuts (not shown). Advance screws **(3)** to raise the arms. Torque bolts **(5)** and nuts to 180 ft-lb (244 Nm). Tighten lock nuts **(4)**.

Two of four bolts **(5)** on each rod loader are located behind hoses.

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Section 100-0:Water System

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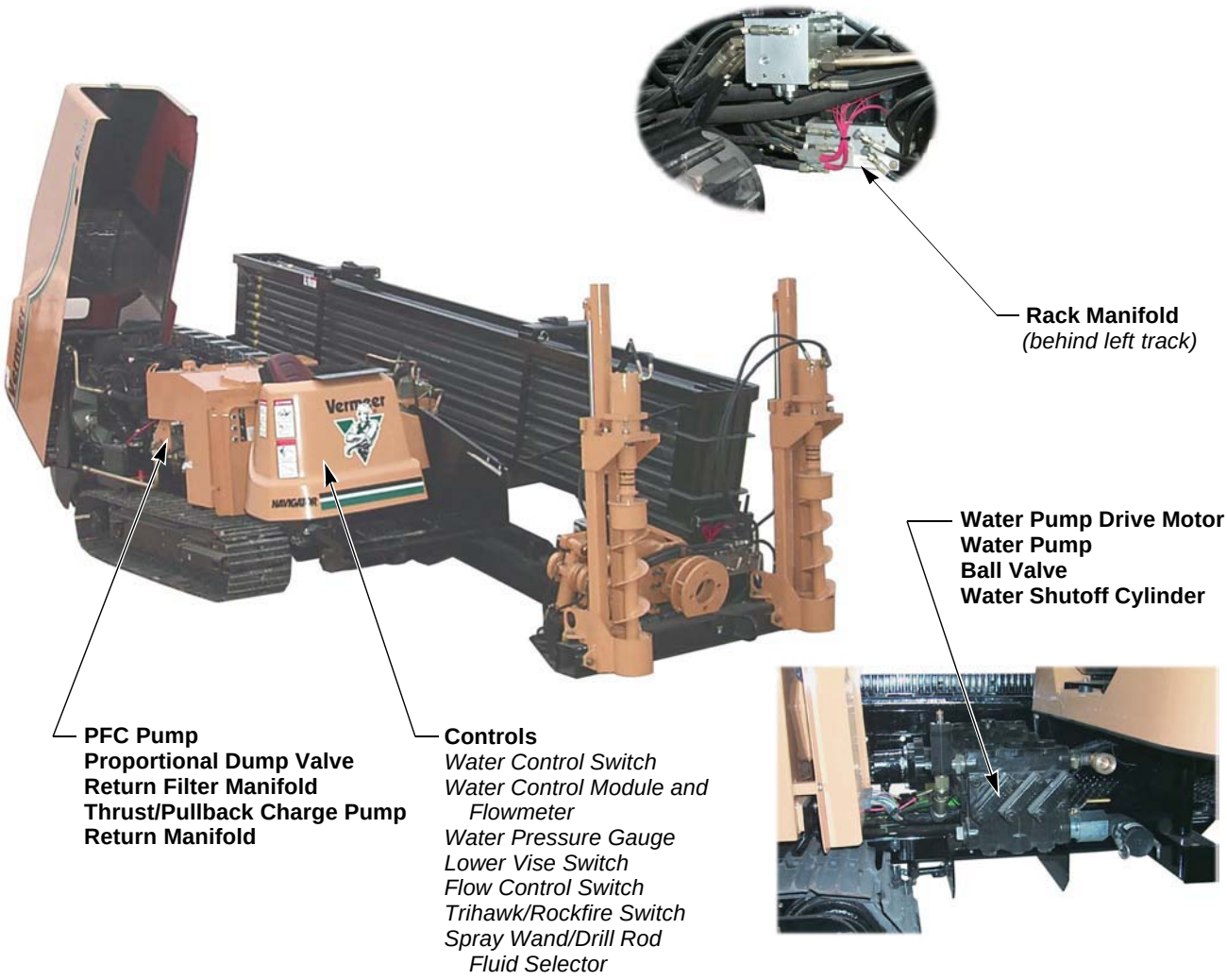
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Section 100-1: Water System Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
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Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Engine	30-0-1
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OPERATION OVERVIEW

Engine — The engine drives the PFC pump.

PFC Pump — The PFC pump supplies all hydraulic power for the water pump system.

Load Sense Circuit — The Load Sense circuit sends a load sense signal from the proportional valve to the PFC pump. An internal checkball prevents any other load sense signal from bleeding off into the water control circuit.

Proportional Valve — The proportional valve is an electrically controlled valve that modulates a pilot signal from the thrust/pullback charge pump to the **piloted** proportional valve.

Piloted Proportional — The piloted proportional valve provide variable control of water pump drive motor rotation speed based on the pressure input from the proportional valve.

Water Pump — The water pump is a three cylinder heavy duty pump with special long-life piston seal cups. It is important to note the special service procedures required. The water pump requires a positive inlet charge and is not designed for suction operation.

Ball Valve — The ball valve is a two position on-off valve operated by a hydraulic cylinder, which is controlled by a solenoid valve in the rack angle/outrigger manifold.

Water Control Module — The water control module sends an electrical signal to control the proportional valve based on signals from the water control switches.

Flowmeter — The flowmeter uses a pulse-pickup unit (PPU) to send a water pump drive motor signal to the water control module. The module calculates theoretical flow based on optimum conditions and displays “calculated gpm”. It is important to note that it is a **calculated value** and not a direct reading of flow since it is impractical to install a flowmeter in a mud pumping system.

Operation — Correct operation of the system requires that the engine is turning at rated rpm, the PFC pump has an adequate supply of oil, and that a positive charge of water or mud mix is provided to the pump.

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SYSTEM SPECIFICATIONS

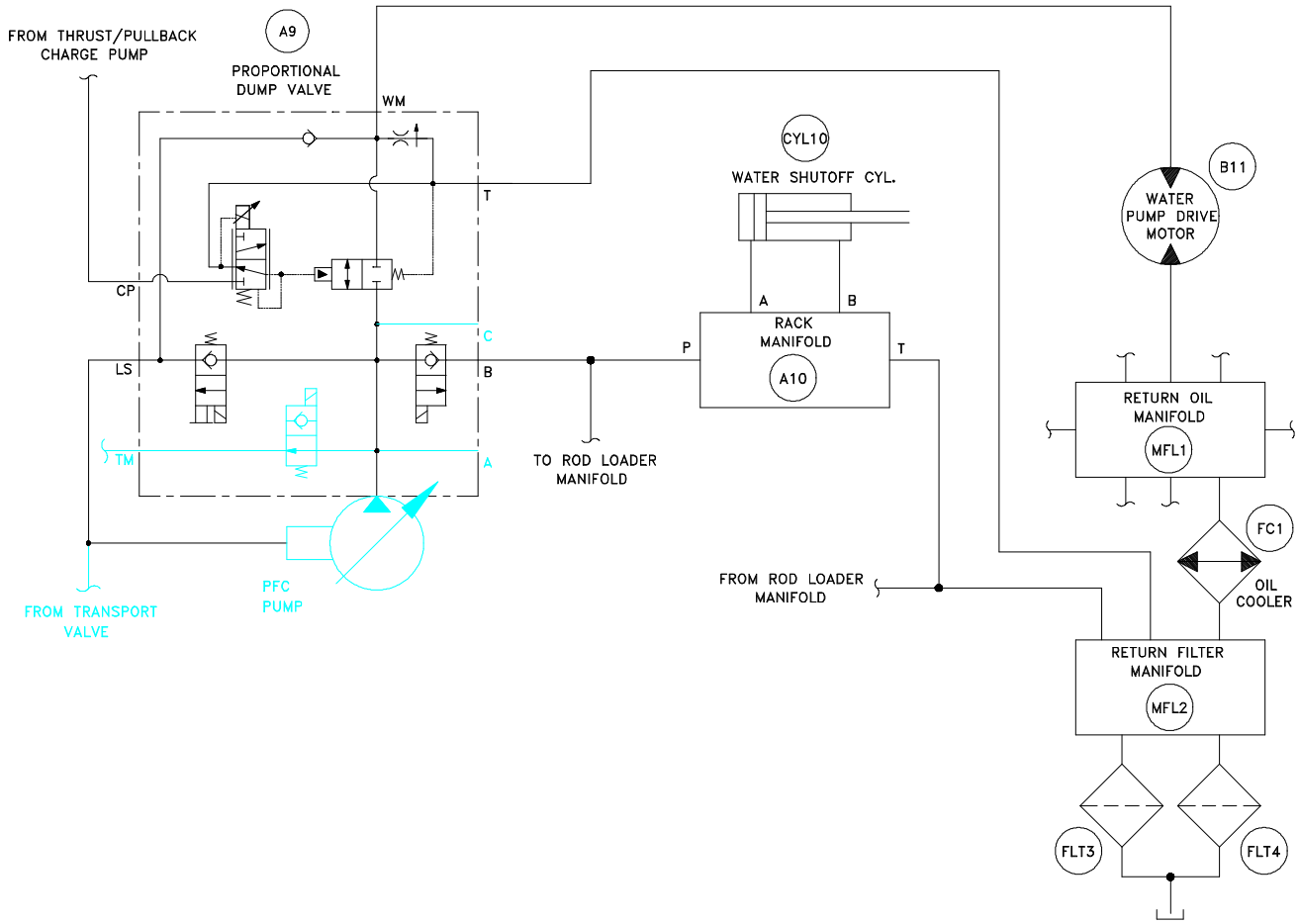
The following specifications are for the water system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
governed engine RPM	2200 rpm
Water Pump	
make / model	FMC L09018HD
maximum nominal flow	50 gpm (189 L/min)
maximum rated pressure	1300 psig (90 bar) maximum discharge
displacement per revolution	26.84 cid = .1162 gal/rev (440 cc)
Water Pump Drive Motor	
motor make / model	Eaton 4000
displacement per revolution	12.5 cid (205 cc)

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HYDRAULIC DIAGRAM



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Hoses

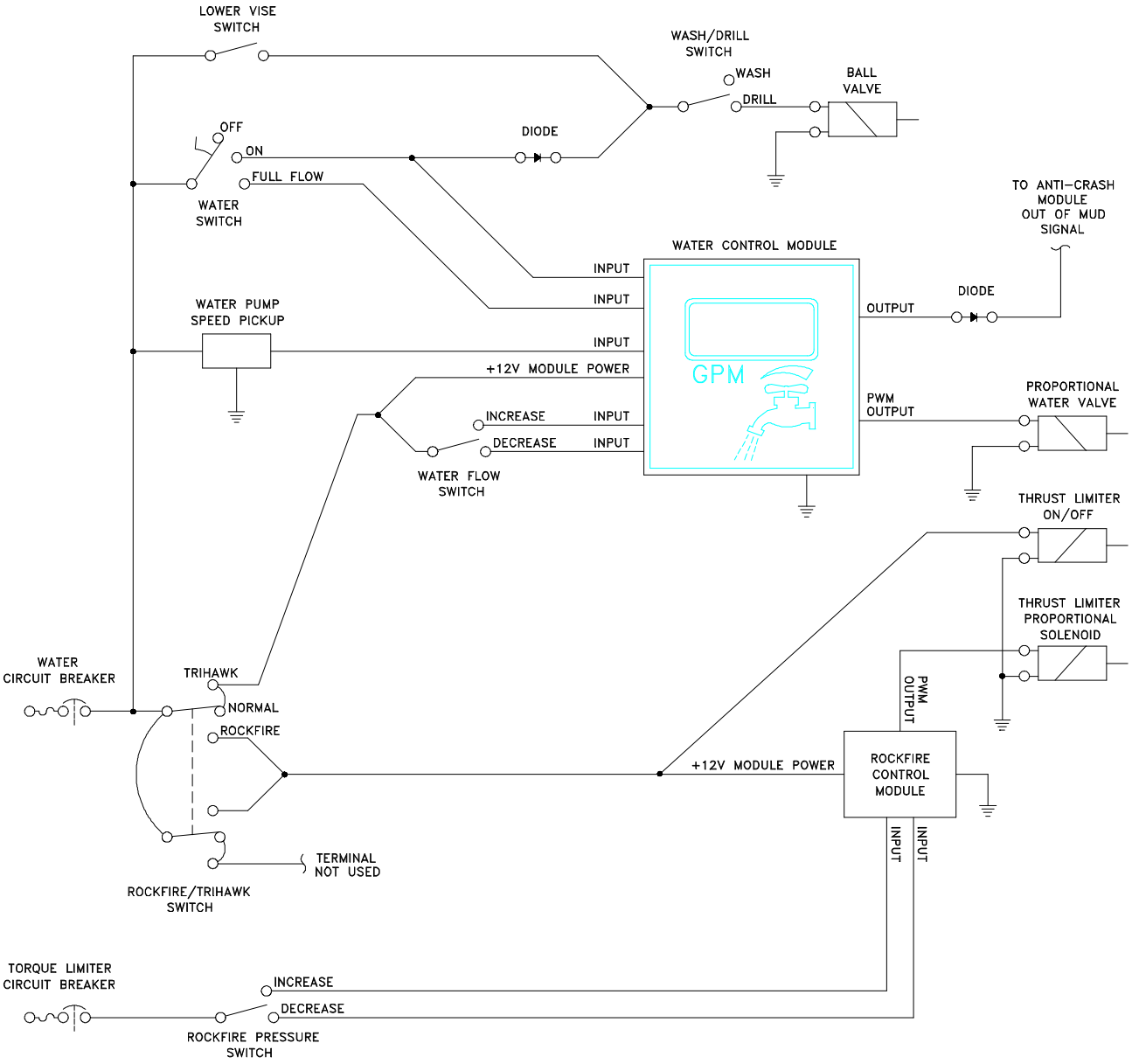
Hose ID/ Pressure	Circuit Type	Function
Rack Manifold Pressure implement pressure	pressure	Provides PFC pump (PMP3) pressure to the rack manifold ‘P’ port
Rack Manifold Return nominal pressure	return	Returns oil from rack manifold (A10) “T” port to return filter manifold (MFL2)
Water Pump Drive Motor implement pressure (modulated)	pressure	Provides modulated pressure from the water proportional solenoid to operate the water pump drive motor.
Proportional Valve Return nominal pressure	return	Vents the proportional valve, piloted proportional valve, and water pump pressure lines.
Water Pump Drive Motor Return nominal pressure	return	Returns oil from water pump drive motor to return manifold (MFL1) ‘A’ port
Ball Valve Extend **Ball Valve Retract** implement pressure	pressure	Operates the ball valve cylinder on or off - from ball valve solenoid valve

***NOTE**: under “standard operating conditions,” the following pressures will normally be found in the circuits indicated:
“implement” pressures = 300 - 3000 psi (20–200 bar)
“nominal pressure” = 25–100 psi (1.7–6.9 bar)

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ELECTRICAL DIAGRAM



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Section 100-2:Water System Troubleshooting

HOW TO DO TROUBLESHOOTING

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there correct flow and pressure to the water pump drive motor?*** Are the control system, PFC pump, and proportional/dump valve working correctly ?
2. ***Is the water pump drive motor worn-out or defective?*** Pressure and flow at the drive motor ports will make the motor work OK unless it is worn or defective.
3. ***Is the water pump defective?*** If the piston cups are worn, leakage will be excessive. If valves or seats are worn or damaged, flow will be reduced and the inlet or outlets will be jerky.
4. ***Are the machine common systems operating correctly?***
5. ***Are the related systems working correctly?*** Is thrust/pullback charge pressure available to control the proportional output?

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Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking Out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, ignition switch, torque limiter and water circuit breakers) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug. It may be necessary to physically push and pull on each wire in a harness at the connectors to make sure they are fully seated and making contact.
4. ***Are all the switches OK?*** The rockfire pressure switch, lower vise switch, water switch, wash wand switch, full flow button switch, water flow switch, and drill mode switch all influence operation of the water system.
5. ***Is the water pump speed pickup OK?*** The water control module uses the water pump speed pickup to control the proportional solenoid and to display the calculated flow.
6. ***Is the proportional control circuit (electric and hydraulic proportional valve) OK?*** Make sure the current path is complete and the resistance is within tolerance. If proportional coil operation is suspect, check resistance at operating temperature.
7. ***Is the ball valve solenoid and cylinder OK?*** Check ball valve solenoid resistance or current draw at operating temperature.
8. ***Is the mechanical output OK?*** Even if all electrical functions are OK, a valve may leak or fail to move, or relay contacts may stick or not conduct current.
9. ***Are the water control module and rockfire control module circuits OK?*** Does they have correct voltage and ground, correct inputs, and complete current paths on all circuits? Most “module failures” are the result of a problem in the voltage source, current path, ground, switch or resistor function, or actuator failure. Check all those items before replacing a module.

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Checking Out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is the load sense signal from the proportional/dump valvewater control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motor work ok unless the motor is worn, defective, incorrectly replaced, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal such as a pinched line, restricted hose, or incorrectly machined fitting will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Since the proportional water control uses variable current control, any abnormal tempreture-related changes will affect circuit operation since current and temperature can be closely related.

Checking Out Mechanical Systems

Always check for mechanical malfunctions—such as binding linkages, bent or broken components, and loose fasteners.

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SYMPTOM: NO WATER OUTPUT

1. Is the water pump drive motor running? The water pump drive motor receives a variable hydraulic oil flow. To obtain this hydraulic flow, a varying electrical signal from the water control module which controls a proportional solenoid valve. The proportional solenoid valve modulates a thrust/pullback pump charge pressure signal. This modulated oil pressure controls a proportional hydraulic valve which varies flow from the PFC pump

Possible Problem	Possible Effect	What to do
water circuit breaker tripped or defective	Water system power is provided from the water circuit breaker. If it is tripped or defective, no current will be provided to the water control circuit.	**Check that power is available from the water circuit breaker.**
ROCKFIRE selected	The rockfire switch shuts off power to the water control module whenever the ROCKFIRE position is selected.	**Select correct switch position**
no flow output selected	The water control module controls water pump drive motor speed based on commands from the water flow switch. If a low enough setting is selected there may be no flow at all.	**Make sure a high enough setting is selected.**
PFC pump	The PFC pump drives the water pump drive motor. If the PFC pump does not supply flow, the motor will not turn and the pump will not operate.	Check that the water pump is turning. If not, check PFC pump and controls.
drill head or drill pipe is blocked	Water output pressure is limited by the 3000 psi (210 bar) pressure compensator setting on the PFC pump. If the maximum pressure is obtained on the PFC pump, flow to all hydraulic functions including the water pump will be stopped. This protects the water pump from excess pressure.	**Make sure that the drill head or drill pipe is not plugged.**
no charge pressure available	If for any reason charge pressure is not available from the thrust/pullback pump, there will be no hydraulic flow to the water pump.	**Verify that charge pressure is available at the 'CP' port on the proportional/dump valve.**
drain line from the proportional/dump valve is blocked	Oil leakage from the proportional valves must be drained to tank. If the drain line is blocked, eventually the leakage will prevent the valves from opening.	**Verify that the 'T' drain line from the proportional/dump valve is not blocked.**

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2. Is the ball valve opening? Opening the ball valve requires that the wash wand switch must be closed AND that either the lower vise switch is OFF (i.e., the ball valve part of the switch must be closed) or the full flow button switch AND the water switch are both closed.

Possible Problem	Possible Effect	What to do
ball valve solenoid valve is not opening	A minimum of two switches must be closed to open the ball valve solenoid valve which uses a hydraulic cylinder to open the ball valve.	**Check lower vise switch**, full flow button, water switch, diode condition, and wash wand switch.
ball valve solenoid coil or valve defective	The ball valve solenoid valve is located in the rack manifold. If PFC pump pressure is not available or if the solenoid valve is defective, the ball valve will not open.	**Check PFC pump system**, ball valve solenoid valve, and ball valve hydraulic cylinder.

3. Is the control circuit working correctly? Power, grounds, and current path must be correct in order for the water control circuit to function correctly.

Possible Problem	Possible Effect	What to do
grounds	If the ground path is missing, is too resistive, or the voltage drop more than 0.5V, all electrical operation can be effected.	**Check all grounding locations.** Check ground voltage between ground buss and battery negative terminal at rest and while operating an electrical load. Repair any condition causing high ground voltage either at rest or under load.
current path	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path.** Inspect visually or use an ohmmeter or voltmeter.
control module	The control module must receive 12V from the drill mode (rock drill) switch.	**Check power input to the water control module.**

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SYMPTOM: PUMP PERFORMANCE

1. Does the pump fail to deliver any flow? Check that the pump is turning and that water is available to the inlet. Also check that the ball valve is actually open in case there is a problem with the ball valve lever arm function.

Possible Problem	What to do
Pump shaft not turning	**Verify function of hydraulic motor.**
Supply tank empty	**Fill tank to correct level.**
Inlet line blocked or restricted	**Trace inlet line.**

2. Does the pump deliver a low flow rate? Pump flow rate is affected by these things: input shaft speed (i.e. is the control and hydraulic system working), water supply (is there sufficient flow of water at a positive pressure—under almost all circumstances the water pump requires a remote water charging pump; the pump is not intended to operate under a vacuum), and water pump efficiency (if the pump is worn out or has defective components it will reduce water flow, particularly under pressure).

Possible Problem	Possible Effect	What to do
pump shaft speed too slow	If the hydraulic system is worn or there is a control problem so that the hydraulic motor slows down under load, the output of the water pump under pressure will be limited.	**Verify correct hydraulic motor speed.**
excessive amount of air entrained in fluid or mud viscosity too thick	The charge pump may be delivering a certain volume of fluid that contains a high volume of air. When the fluid is pressurized, the air is compressed causing a loss of available flow. Leaky inlet fittings can also cause air entrainment.	**Check water/mud quality; check inlet lines and fitting.**
restriction in inlet line; remote water charge pump system inadequate for pump demand	The water pump is intended to be run with a positive inlet pressure. Do not rely on the water pump to draw fluid from a tank or other source without using a charge pump system that delivers a positive pressure **as measured at the high pressure pump inlet.**	**Correct the inlet condition.**
valves stuck open, worn or seats washed out	Any mechanical condition that allows recirculation of fluid will reduce flow rate, especially under load.	**Repair pump.**

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3. Does the pump run rough and/or knock? Rough running or knocking can indicate either cavitation or air entrainment, or a mechanical failure.

Possible Problem	Possible Effect	What to do
pump cavitating	Cavitation is caused by inlet restriction and other conditions that cause very low pressure in the pumping chamber. Also, if the hydraulic hoses to the water pump drive motor are reversed, similar symptoms may result.	**Verify that mud mixture not too heavy and mixed properly**; verify that inlet line correct length and diameter; verify that any inlet strainer not plugged with debris. **Verify that the hydraulic motor is hosed correctly.**
excessive amount of air entrained in fluid	The charge pump may be delivering a certain volume of fluid that contains a high volume of air. When the fluid is pressurized, the air is compressed causing a loss of available flow. Leaky inlet fittings can also cause air entrainment.	**Check water/mud quality.**
valve problem or piston problem		**Repair pump.**

4. Does the pump leak mud during operation? Leakage should be very limited during operation so significant mud leakage indicates a wear problem or mechanical failure. Pump should be serviced as soon as possible.

Possible Problem	What to do
piston cups are wearing and about to fail	**Rebuild pump.**
fluid cylinder bolts are not properly tightened	**Check bolt torque.**
fluid O-rings or gaskets damaged	**Repair pump**
piston holder O-ring failed	**Repair pump.**

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5. Are there excessive piston cup failures? Refer to the chart below for possible causes of piston cup failures.

Possible Problem		What to do
pump allowed to run dry for extended periods of time		**Never run pump dry.**
cylinder liner is damaged (scored or cracked)		**Replace cylinder liner.**
piston holder O-ring damaged		**Repair pump.**
pump cavitating (cups often run hot)		**Correct inlet or mud conditon.**
mud poorly mixed or contains lots of sand		**Use high quality, thoroughly mixed mud.**
using incorrect piston cup part number		**Check part number and use only type 'B' piston cups.**

6. Does the pump develop proper pressure? Pump flow may be normal under light load conditions but be severely limited when the rod is down-hole. Look for any condtion that would contribute to leakage or ineffeciency under load.

Possible Problem	Possible Effect	What to do
valve problem	If an inlet or exhaust valve is not sealing, pump efficiency will be sharply reduced.	**Repair pump.**
pump not turning at proper speed	If the hydraulic system is worn or there is a control problem so that the hydraulic motor slows down under load, the output of the water pump under pressure will be limited.	**Verify motor/pump shaft speed.**
pump cavitating (cups often run hot)	Cavitation is caused by inlet restriction and other conditions that cause very low pressure in the pumping chamber.	**Correct inlet or mud conditon.**

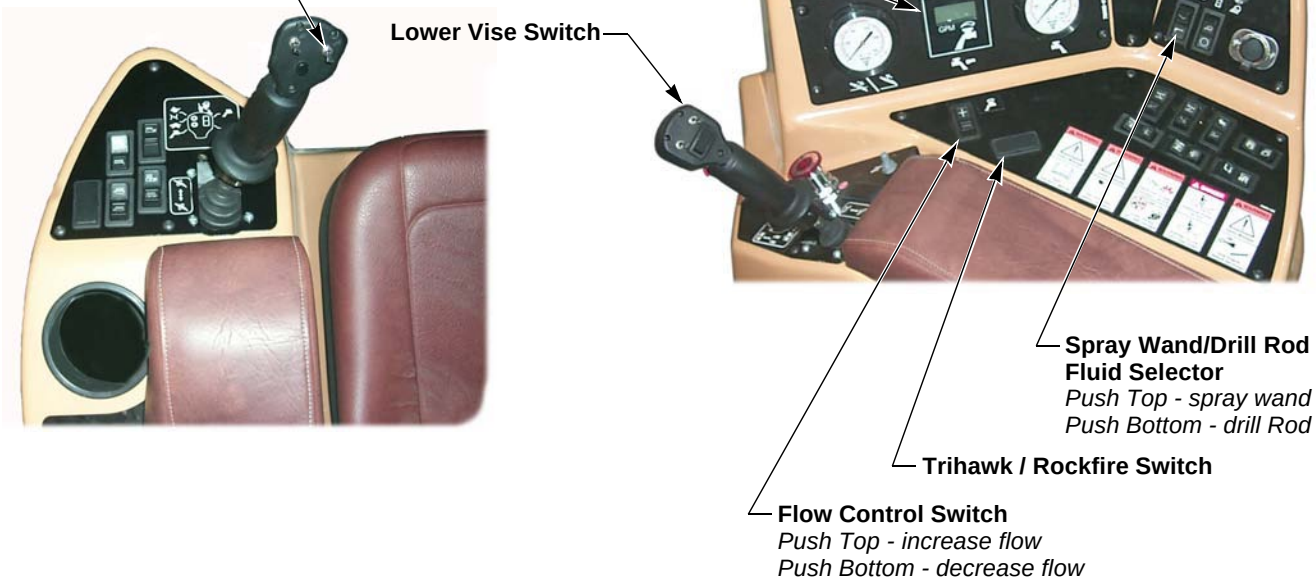
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Section 100-4: Water System Controls

WATER SYSTEM CONTROLS LOCATION



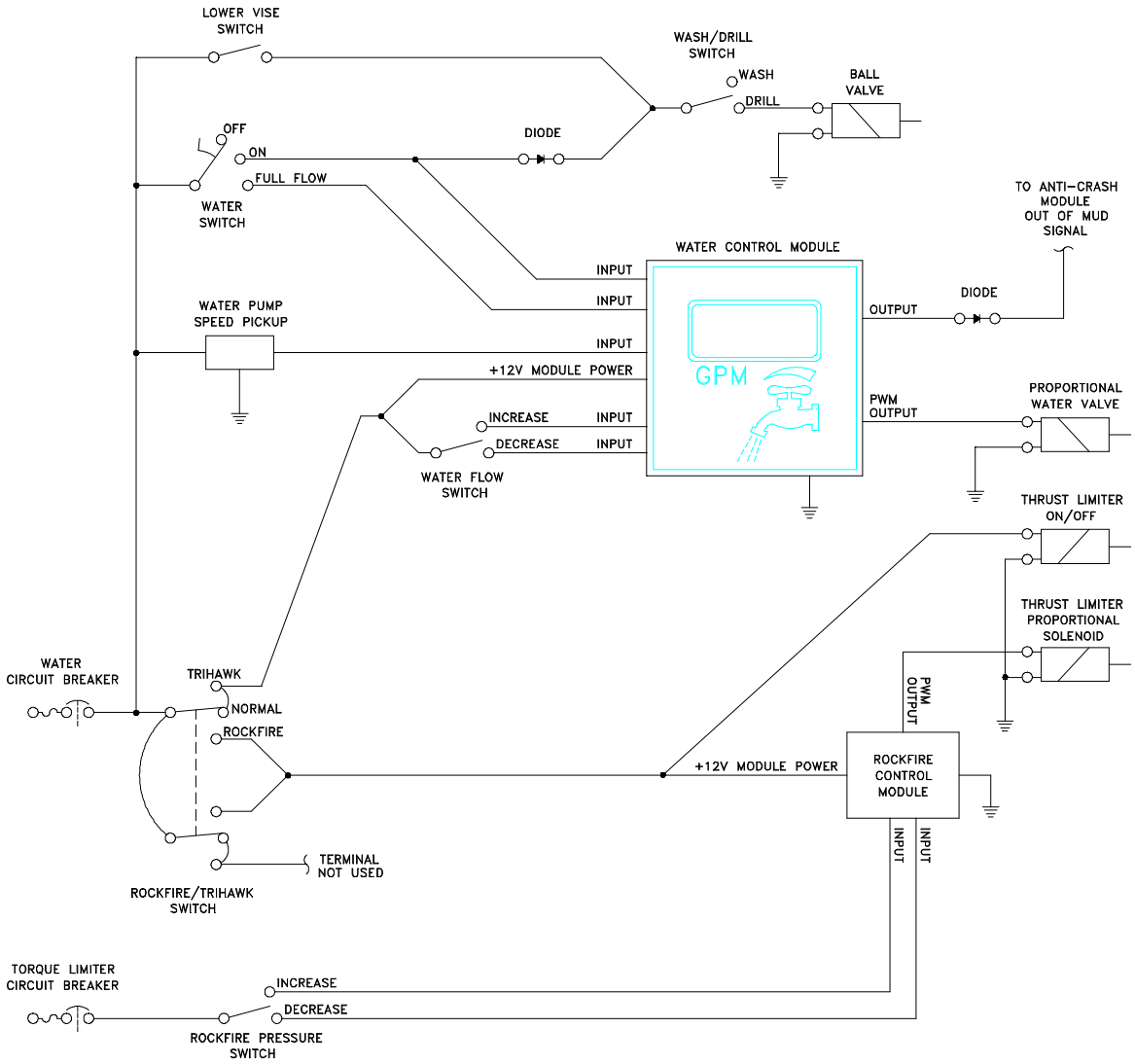
Water system controls include:

1. **Ball valve (water on/off valve) controls:** water control switch, lower vise switch, drill /wash(wash wand) switch.
2. **Water module inputs:** the water control module is controlled by the Trihawk/Rockfire switch, water control switch, and the flow control switch.
3. **Water pump drive motor speed controls:** the water pump drive motor is controlled hydraulically by the water control module output.

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WATER PUMP CONTROLLER CIRCUIT



Overview

The water system includes a module control system to provide variable speed drive of the water pump and a switch system that opens or closes the water ball valve. A speed pickup at the water pump drive motor informs the water control module of water pump speed and provides a display of calculated water flow.

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Circuit Action - Ball Valve

The ball valve is closed by the hydraulic cylinder any time the solenoid is NOT energized. To energize the ball valve solenoid, the wash wand switch must be in the DRILL position and either the lower vise OFF (i.e. the water contacts of the lower vise switch closed) or the water switch and the full flow switch contacts closed.

Circuit Action - Water Pump

The water pump drive motor is driven by a variable hydraulic flow from the proportional valve in the proportional/dump valve assembly on the PFC pump. When the drill mode switch is in NORMAL or TRIHAWK, power is supplied to the water control module. The water control module sends a variable pulse-width modulated (PWM) signal to the proportional valve based on inputs from the water increase/decrease switch, the full flow and water switches, and the water pump speed pickup.

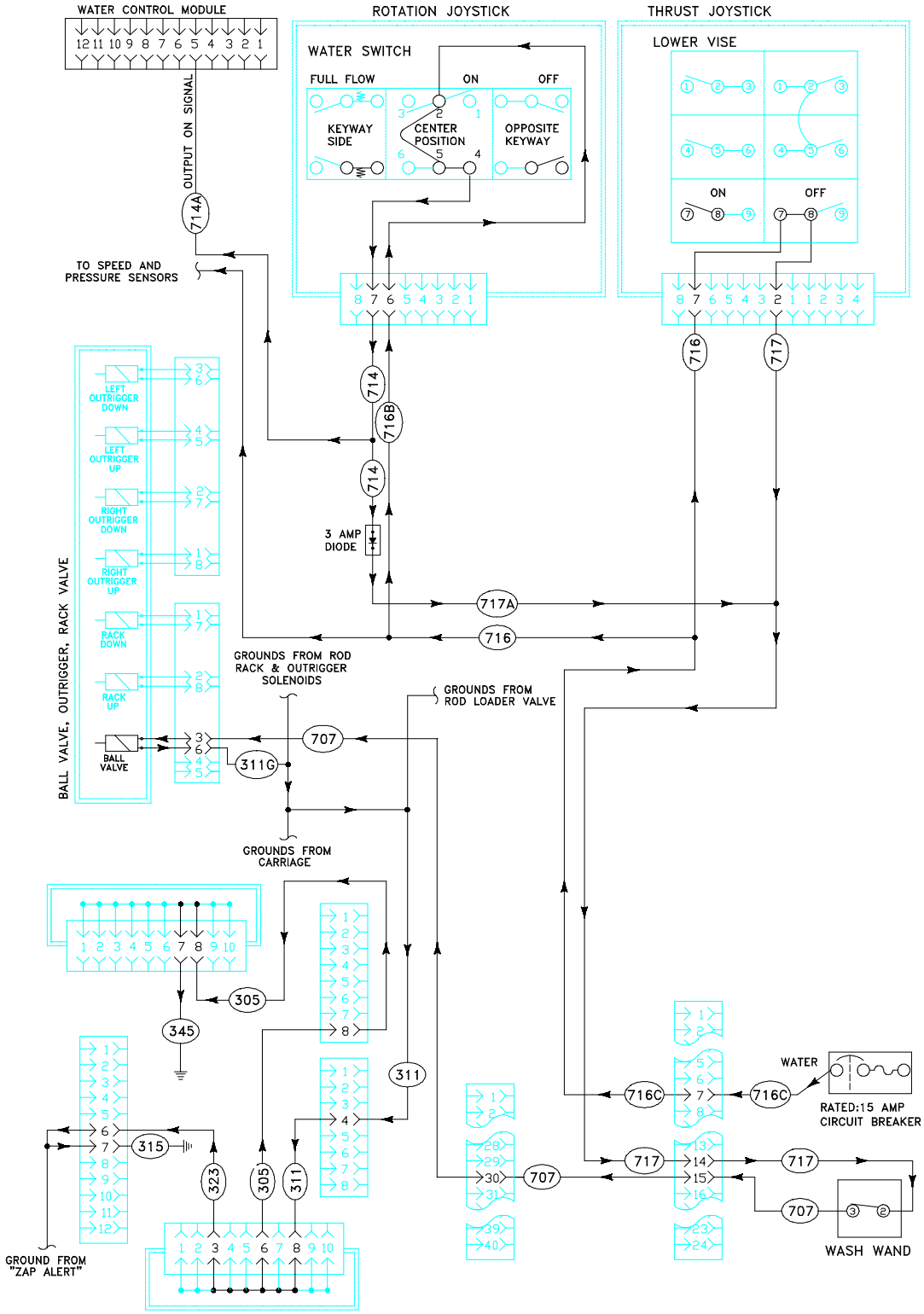
Circuit Action - Flowmeter

The water pump speed pickup sends a pump RPM signal to the flowmeter display which calculates flow based on water pump displacement. Since it is a calculated figure, it cannot compensate for water pump mechanical problems or restrictions in the hose inlet. It will, however, indicate if the hydraulic system is not supplying sufficient flow, or if the hydraulic system efficiency is reduced.

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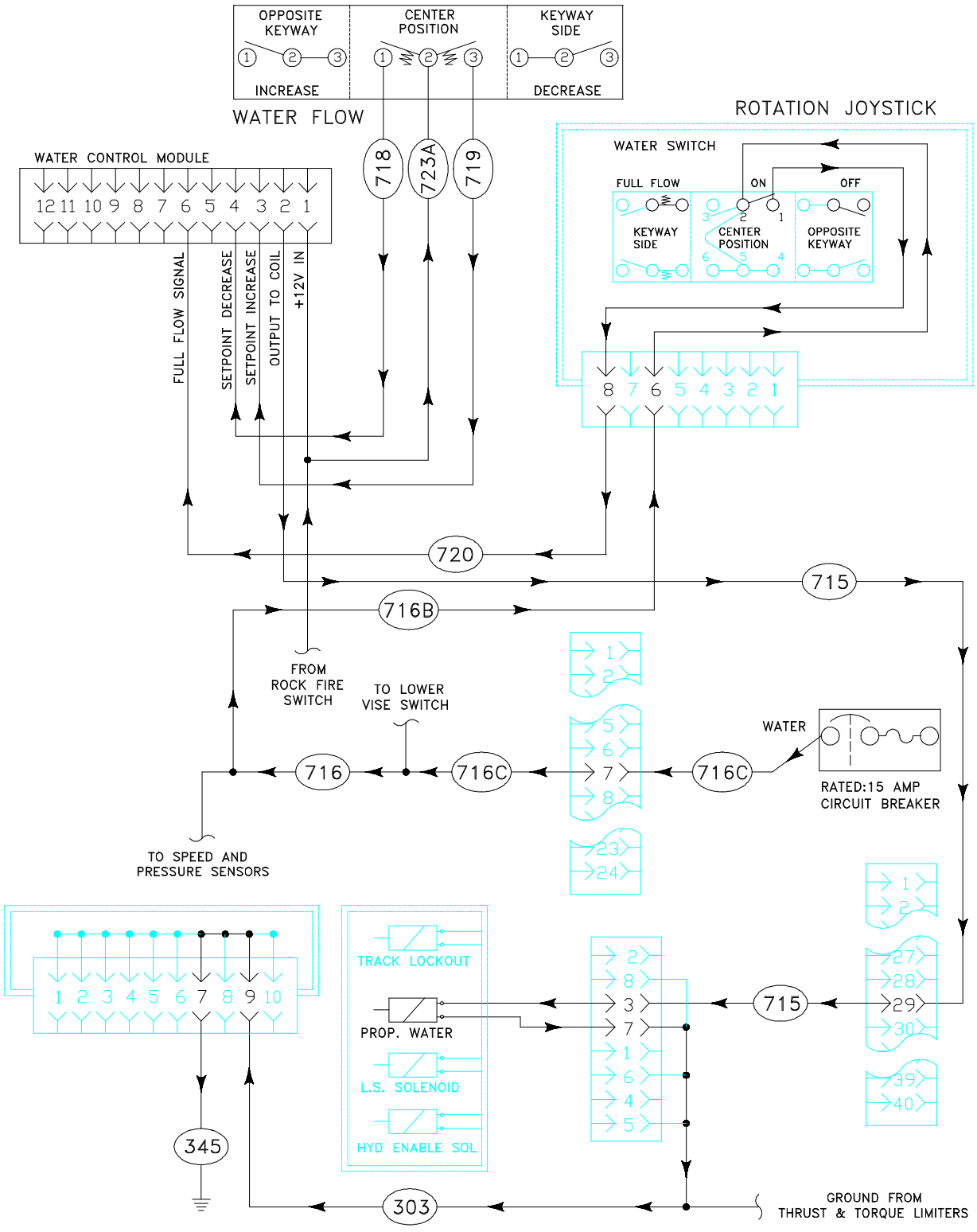
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BALL VALVE CONTROL CIRCUIT



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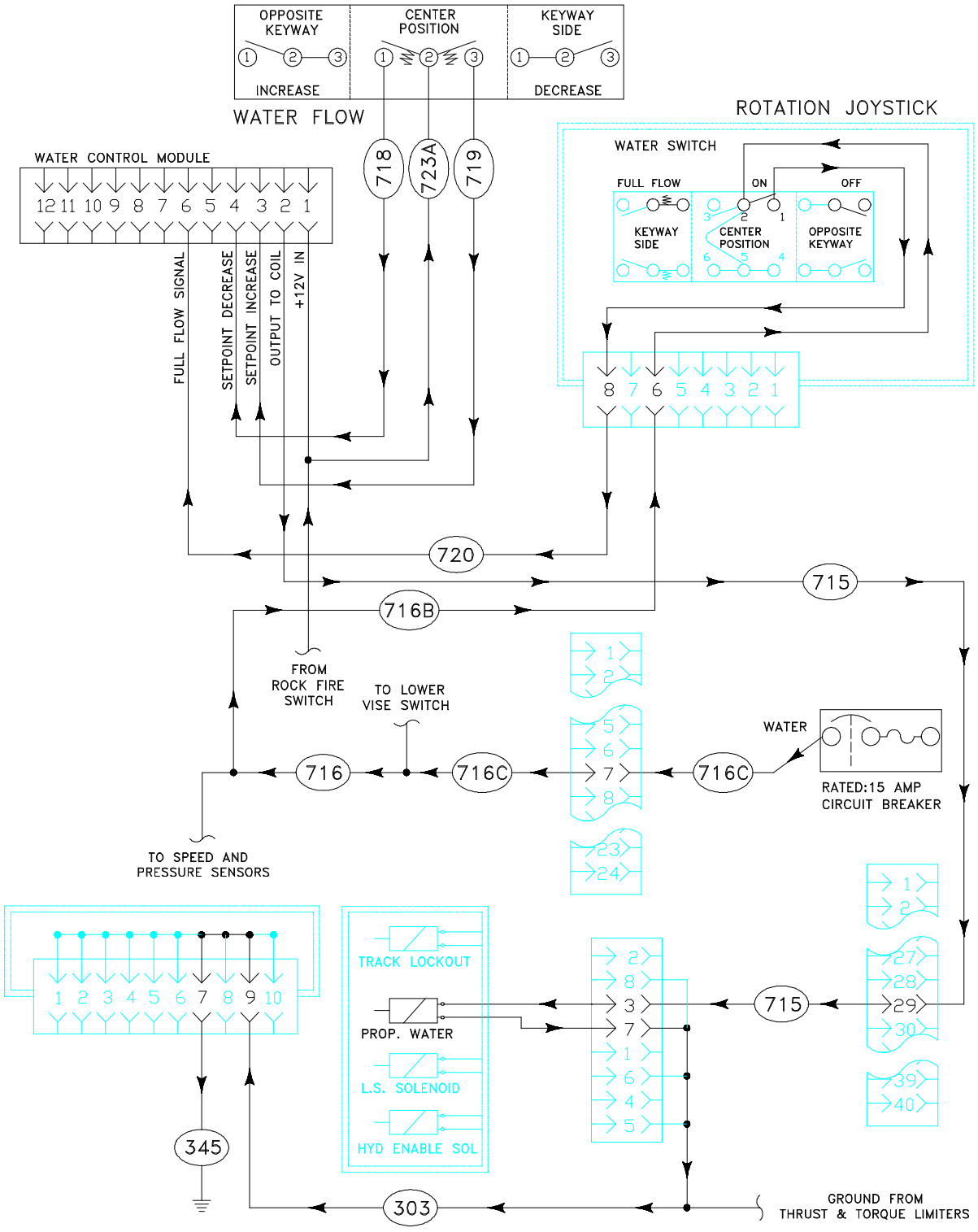
WATER FLOW CONTROL CIRCUIT



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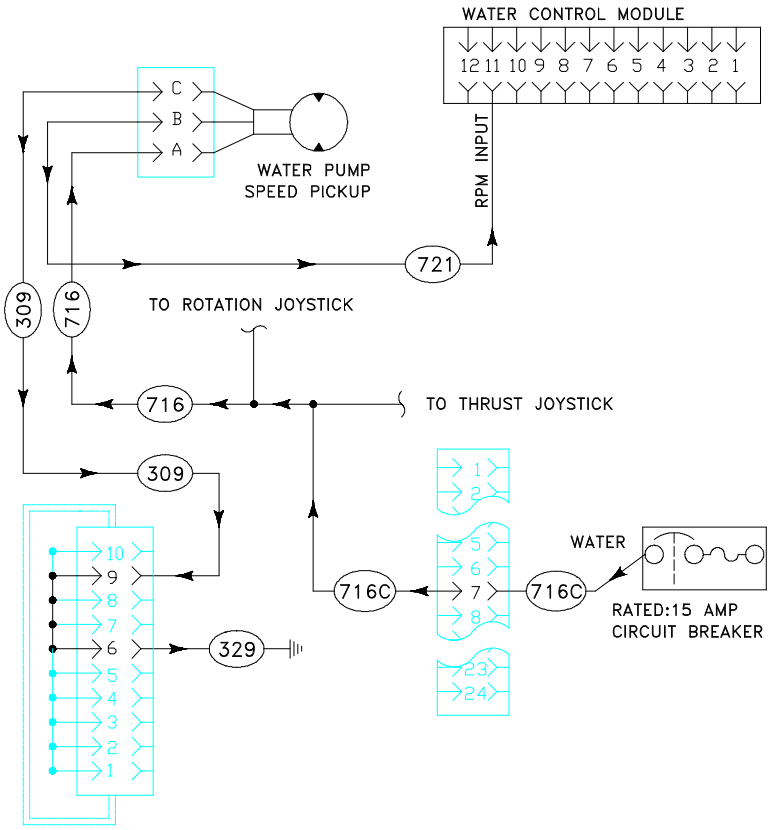
WATER CONTROL MODULE POWER CIRCUIT



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PUMP SPEED SENSOR CIRCUIT



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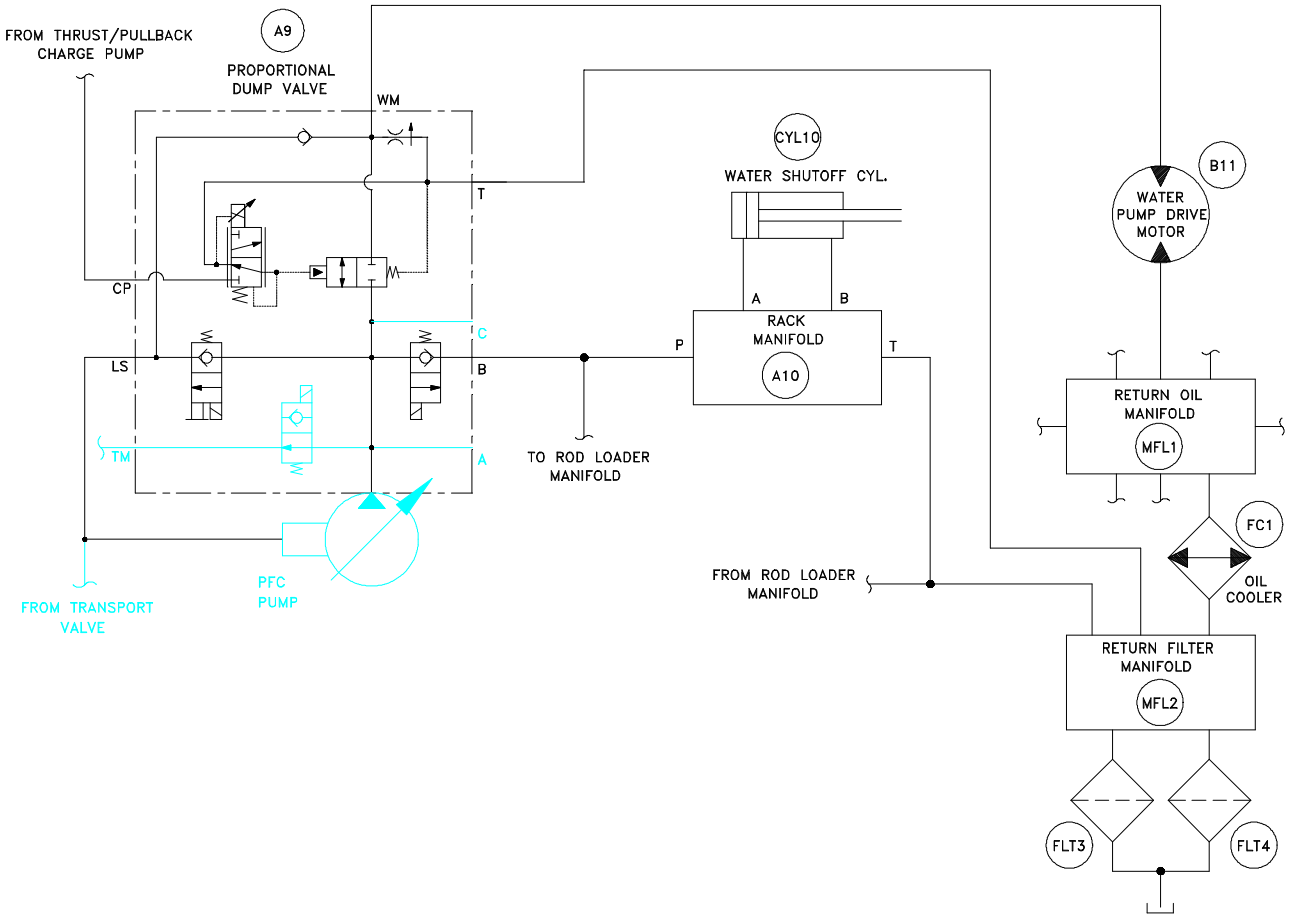
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Section 100-5:Water System Hydraulic Circuit

WATER SYSTEM HYDRAULIC CIRCUIT DIAGRAM



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Operation Overview

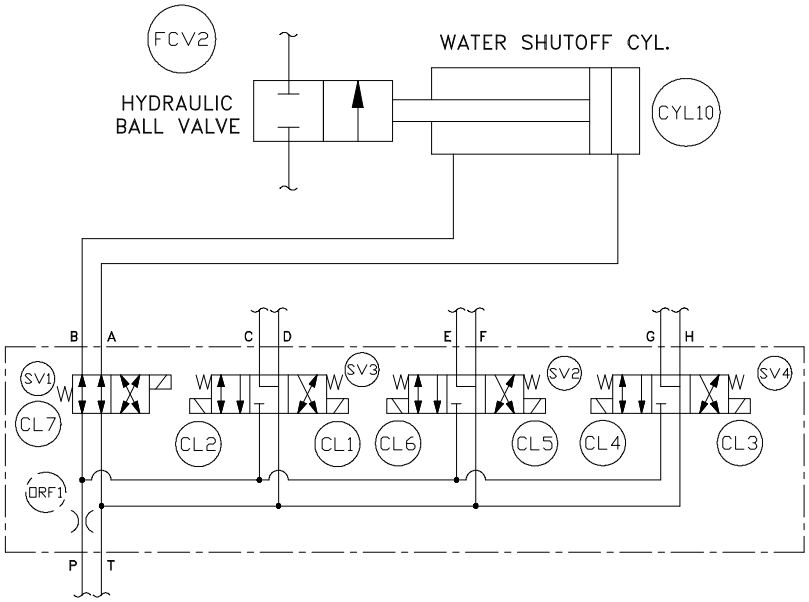
The water hydraulic system includes the following:

1. **The PFC pump** supplies all hydraulic power for the water pump system.
2. **The Load Sense circuit** sends a load sense signal from the proportional valve to the PFC pump. An internal checkball prevents any other load sense signal from bleeding off into the water control circuit.
3. **The proportional valve** is an electrically controlled valve that modulates a pilot signal from the thrust/pullback charge pump to the **piloted** proportional valve.
4. **The piloted proportional valve** provide variable control of water pump drive motor rotation speed based on the pressure input from the proportional valve.
5. **The ball valve** is a two position on-off valve operated by a hydraulic cylinder, which is controlled by a solenoid valve in the rack angle/ outrigger manifold.

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RACK MANIFOLD



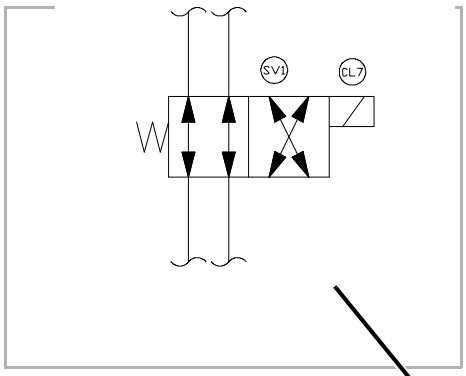
Operation

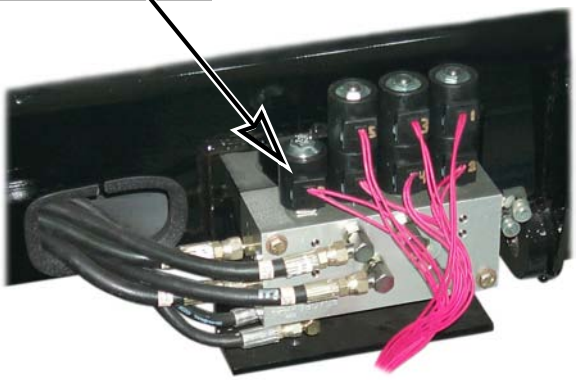
When the solenoid is de-energized, the ball valve is held closed. When the solenoid is energized, the ball valve is opened by the ball valve hydraulic cylinder.

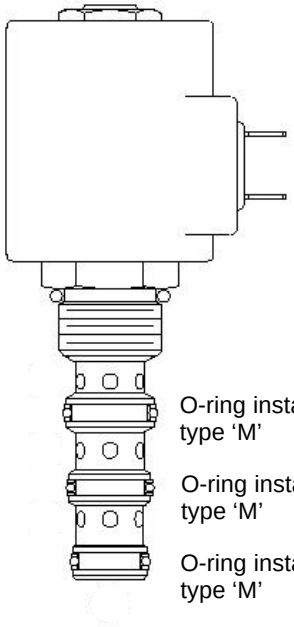
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BALL VALVE SOLENOID VALVE







Operation

The ball valve solenoid valve retracts the ball valve cylinder to shut off water flow or extends the ball valve cylinder to allow water flow.

Action

The ball valve solenoid valve is a two position, four way valve that sends a “full retract” signal (shut off water) when de-energized or a “full-extend” signal (allow water flow) when energized. There is no center or neutral position

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Specifications

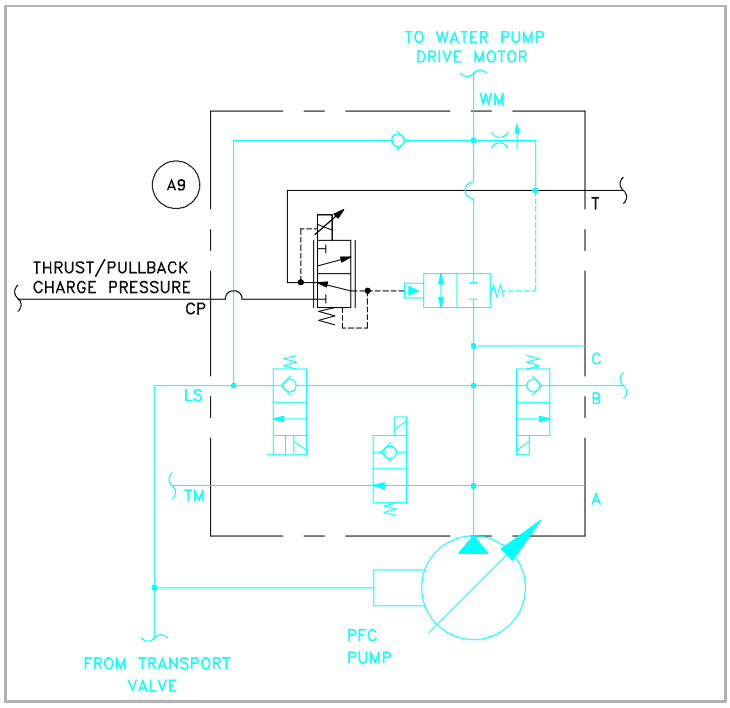
Ball Valve Solenoid Coil Specifications	
type	'10' (Vermeer P/N 251112-005)
minimum pull-in current	1.18 A
minimum pull-in voltage	10.2 V
initial coil current draw at 70°F (20°C)	1.46 A at 10.5 VDC 1.67 A at 12 VDC 2.01 A at 14.5 VDC
resistance	7.2 ohms at 70°F (20°C)
nominal power rating	20 W
coil installation torque	7–10 ft-lb (9.5–13.5 Nm)
Diagnostic notes: *The coil contains a bipolar diode for spike suppression. Either lead may be connected to +12V since the diode only conducts at higher voltage. The coil may be checked in either direction with an ohmmeter. If the diode is bad, a voltage "spike" will occur everytime the coil is turned off, which could cause the strike alert to sound. The diode cannot be checked with an ohmeter but a scope-meter or oscilloscope will display voltage spikes caused by a failed diode.*	

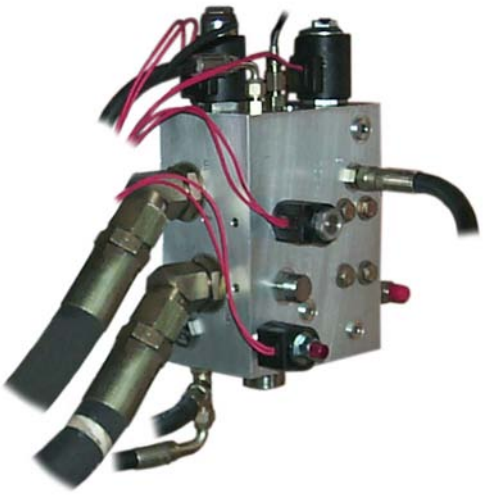
Ball Valve Solenoid Valve and Body Specifications	
Solenoid Valve	
model	SV10-4009W-0-N-D0
type	two position four-way spool type valve
O-ring position (all positions)	type 'M'
maximum leakage	3 fluid oz/min (82 cc/min)
Diagnostic notes: *Since the solenoid valve is a spool type valve, it is a "leaker" that will exibit controlled leakdown during a pressure-leak test.*	

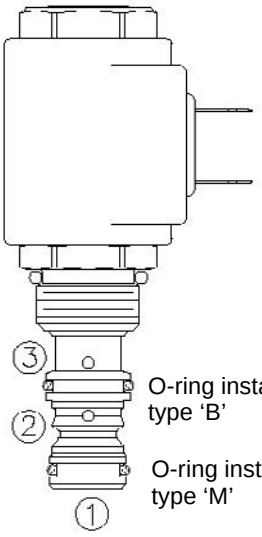
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PROPORTIONAL VALVE (ELECTRICAL)







O-ring installation: type ‘B’

O-ring installation: type ‘M’

Operation

The **electrical** proportional valve is controlled by an electrical signal from the water control module. It controls the hydraulic proportional valve by varying a charge pressure signal from the thrust/pullback pump.

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Specifications

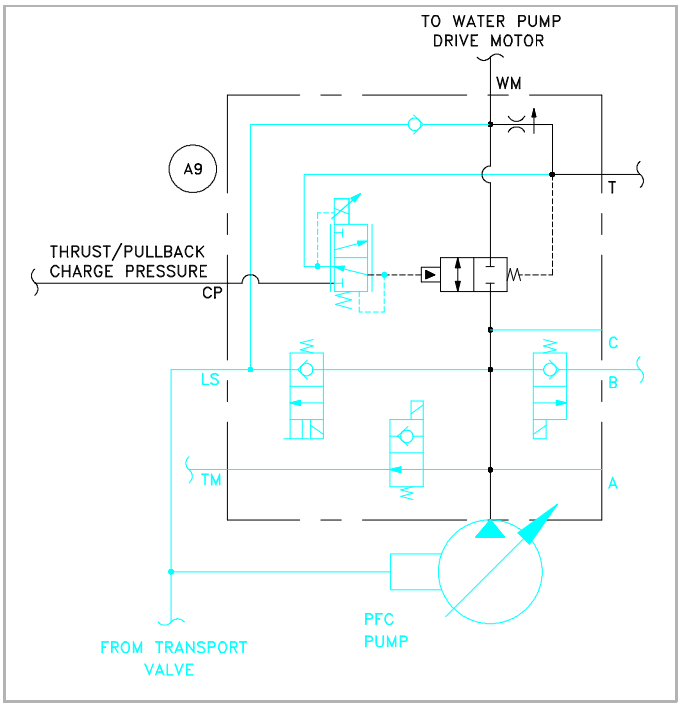
Electrical Proportional Valve Solenoid Coil Specifications	
type	proportional coil (Vermeer P/N 251108-003)
maximum control current	1.2 A
resistance	9.8 ohms at 70°F (20°C)
coil installation torque	5 ft-lb (6.8 Nm) maximum
Diagnostic notes: *The coil does NOT contain a diode for spike suppression.*	

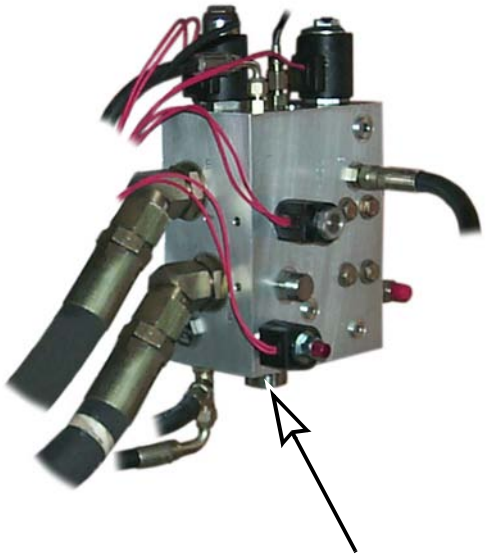
Electrical Proportional Solenoid Valve Specifications	
solenoid valve	
model	EHPR08 3303-0-N-00
type	solenoid-operated, normally non-passing, piloted poppet-type
valve installation torque	20 ft-lb (27.1 Nm)
O-ring position	type ‘B’ (top O-ring); type ‘M’ (bottom O-ring)
Diagnostic notes: *Since the solenoid valve is a spool type valve, it is a “leaker” that will exibit controlled leakdown during a pressure-leak test. If it is not possible to perform a pressure-leak test, any indication that the valve internal components are not free to move means that the valve cannot perform properly. Make sure that the inner spool is free to move either by physical inspection or manipulation of the valve tip, or by energizing the solenoid and feeling the results of internal movement.* *The EHPR08-33 allows free flow from port 3 to 1 when no current is applied to the coil. When the coil is energized, port 2 is connected to 1. Increasing current applied to the coil will increase the control (reduced) pressure proportionally. If pressure at port 1 exceeds the setting induced by the coil, pressure from port 1 is relieved to 3. Note: Any back pressure in the on port 3 becomes additive to the pressure setting at a 1:1 ratio.*	

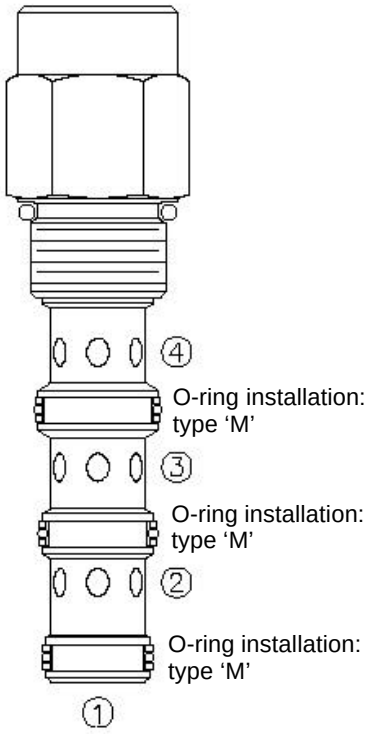
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PROPORTIONAL VALVE (HYDRAULIC)







Operation

The hydraulic proportional valve is controlled by a pilot oil signal from the electric proportional valve. It controls the flow to the water pump drive motor.

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Specifications

Hydraulic Proportional Valve Specifications	
solenoid valve	
model	PD12-4403-0-N
type	pilot-operated, spool-type, hydraulic directional valve for two-way circuits requiring remote pilot actuation
valve installation torque	35 ft-lb (47 Nm)
O-ring position (all)	type ‘M’
Diagnostic notes: *Since the hydraulic proportional valve is a spool type valve, it is a “leaker” that will exibit controlled leakdown during a pressure-leak test. If it is not possible to perform a pressure-leak test, any indication that the valve internal components are not free to move means that the valve cannot perform properly. Make sure that the inner spool is free to move either by physical inspection or manipulation of the valve tip, or by energizing the solenoid and feeling the results of internal movement.* *In neutral (unpiloted), the PD12-44 blocks flow from port 3 to 2 bidirectionally. The spring chamber is directed to port 1, which is internally O-ring sealed from the cartridge flow paths. On remote pilot signal at port 2, the valve shifts to open from port 3 to 4, bidirectionally. Any pressure on port 4 is added to the spring value.*	

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Section 100-6:Water Pump Repair

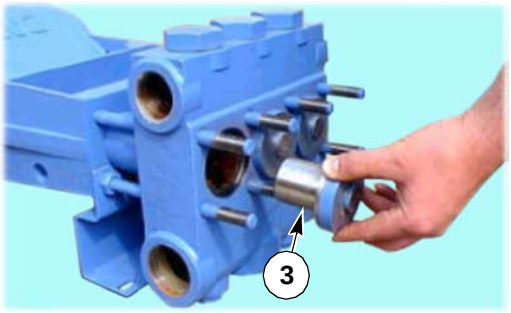
PISTON CUP SEAL REMOVAL / INSTALLATION

Special Tools and Materials

- torque wrenches capable of producing 30 ft-lb (40 Nm) and 90 ft-lb (122 Nm)
- rubber mallet
- FMC piston tool (Vermeer P/N 240141-019)
- FMC torque wrench adapter (Vermeer P/N 278825-003) for FMC piston tool
- glycerin for assembly lubricant

Remove Piston Cup Seals





Approximately 24" (610 mm) of clearance is required between the front of the pump and any obstructions to service the piston cups.

1. Remove the six nuts retaining three diagonal cylinder cover clamps **(1)**, and pull the clamps from the fluid cylinder.

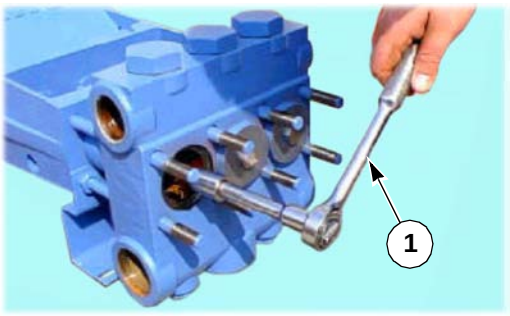
NOTE: Do not remove two nuts **(2)** on opposite, diagonal corners of the fluid cylinder since they keep the fluid cylinder securely mounted on the pump.

2. Remove cylinder covers **(3)**.

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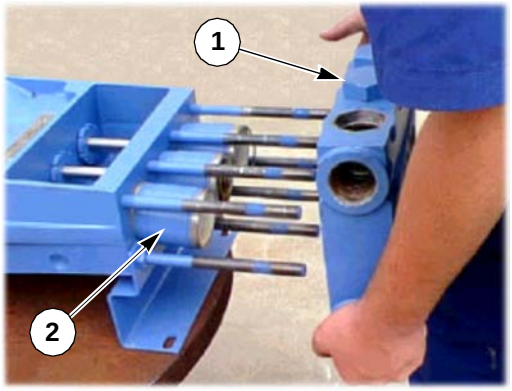
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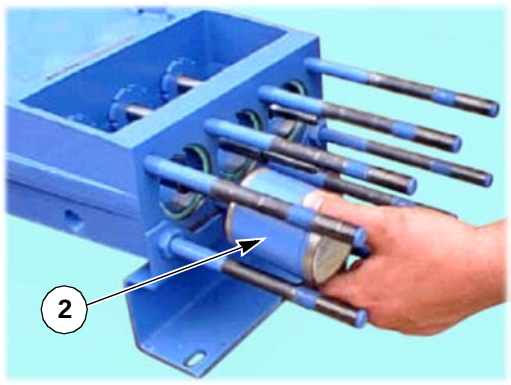




3. Remove the brass hex nuts from the piston assemblies, using socket wrench **(1)** with long extension. These nuts secure the piston assemblies to the crosshead rods.

4. Remove two nuts **(2)** on opposite, diagonal corners of the fluid cylinder.





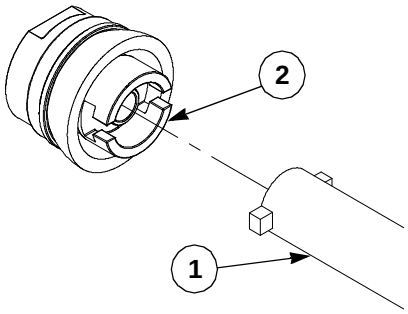
5. Rock fluid cylinder **(1)** to loosen it from cylinder liners **(2)**. Slide the fluid cylinder from the studs. Do not allow the cylinder liners to fall and become damaged.

6. Remove cylinder liners **(2)**.

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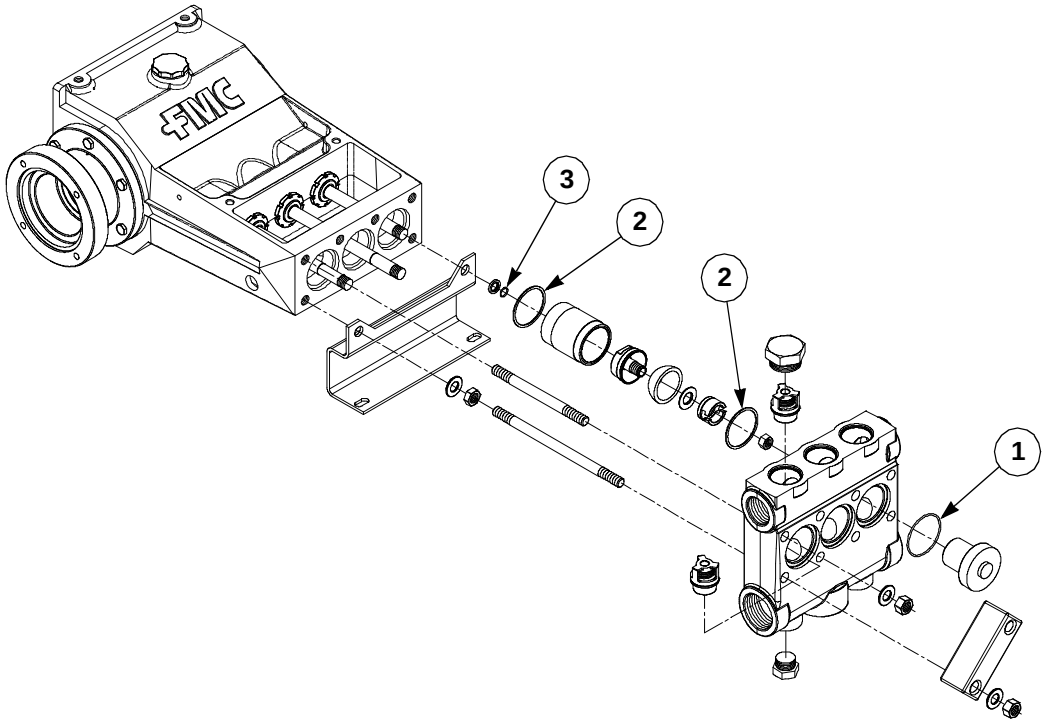
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7. Use a small amount of glycerin on the inner diameter of the cylinder liners to lubricate the surface. Insert FMC piston tool **(1)** inside the cylinder liners until flush with the face of slotted piston nuts **(2)**. Twist the tool to engage and lock the tabs of the tool inside the mating slots of the piston nuts. Push the piston assemblies out of the cylinder liners.

IMPORTANT: The interior surface of the cylinder liners must be smooth and free of cracks and grooves. New piston cups fail prematurely if installed in liners with damaged bores.

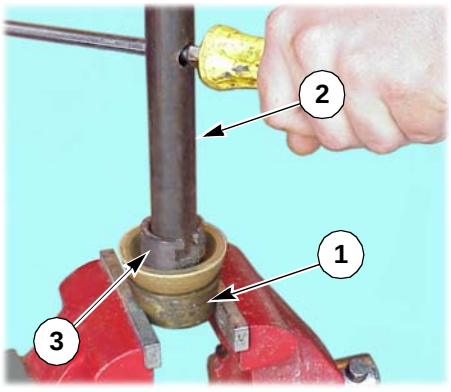


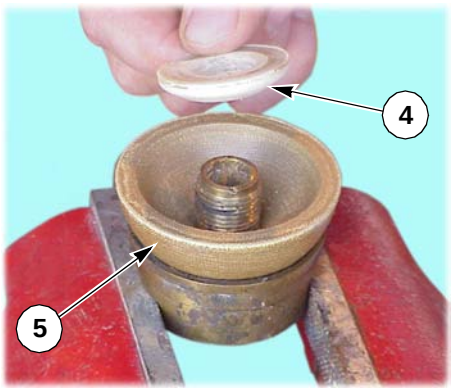
8. Discard old cylinder cover O-rings **(1)**, gaskets **(2)** and seal holder O-rings **(3)**.

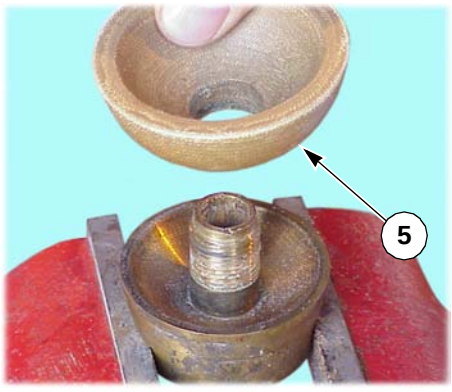
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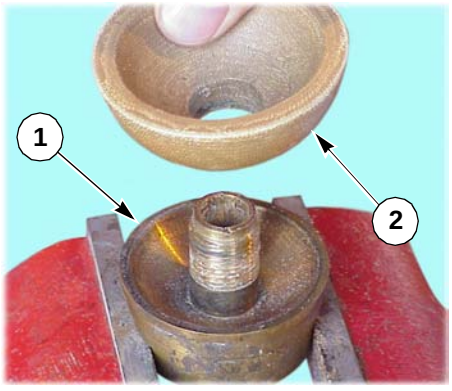


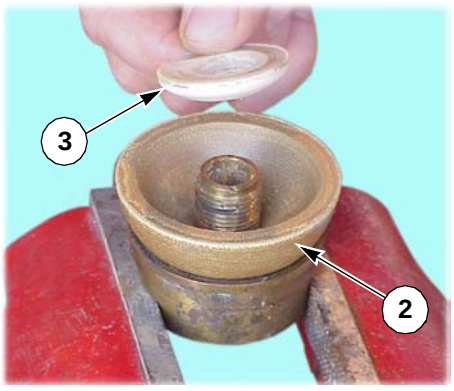


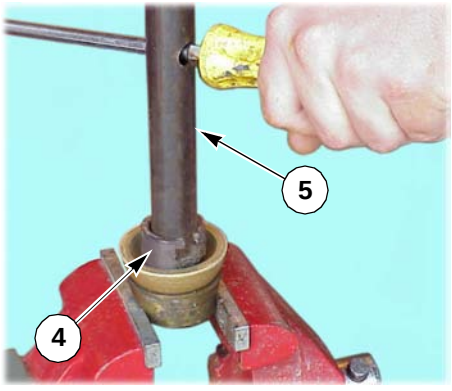


9. Clamp the flats on the bottom of piston cup holders **(1)** in a vise. Using FMC piston tool **(2)**, unscrew piston nuts **(3)**, removing the nuts, piston washers **(4)** and piston cups **(5)**. Discard the piston cups.

Install Piston Cup Seals







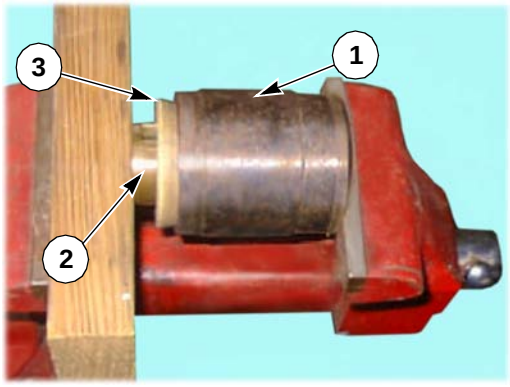
IMPORTANT: Inspect all parts for damage or unusual wear during each step of assembly.

1. Thoroughly clean piston cup holders **(1)**, and clamp the bottom flats in a vise.

2. Assemble piston cups **(2)**, plastic piston washers **(3)** and piston nuts **(4)** onto the piston cup holders. Bolt the FMC torque wrench adapter (not shown) to FMC piston tool **(5)** and torque the nuts to 25 ft-lb (34 Nm).

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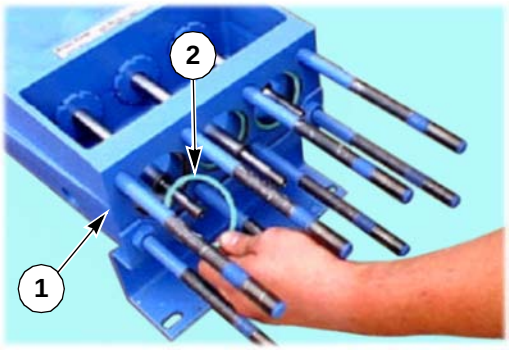


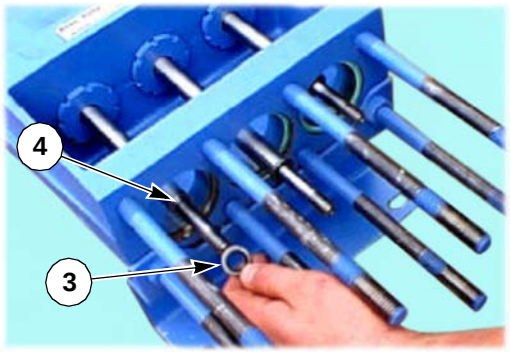
IMPORTANT: The interior surface of cylinder liners **(1)** must be smooth and free of cracks and grooves. New piston cups fail prematurely if installed in liners with damaged bores.

Replace all three piston cups, not just those that show signs of leakage. This ensures maximum operational time between service intervals.

NOTE: Piston assemblies **(2)** must be installed in the cylinder liners with a press or vise. Use a soft jaw vise, wood blocks or another suitable method to protect both ends of the assemblies from damage during assembly.

3. Thoroughly clean cylinder liners **(1)**. Use a small amount of glycerin on the inner diameter of the cylinder liners to lubricate the parts during installation. Press piston assemblies **(2)** into the cylinder liners until sealing lip **(3)** of the piston cups just enters the front of the cylinder liners.





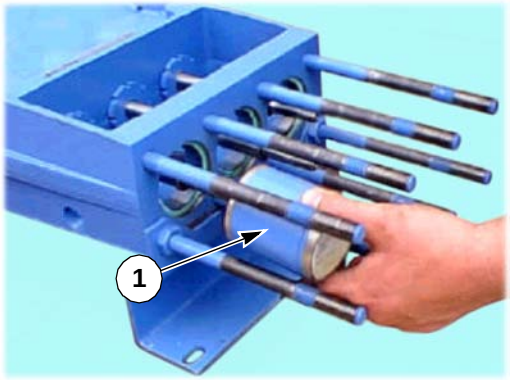
4. Thoroughly clean the three counterbores in power end **(1)** and three counterbores in the fluid cylinder (not shown) for gaskets **(2).** Lightly lubricate six new gaskets with oil, and seat them in the grooves of the power end and fluid cylinder.

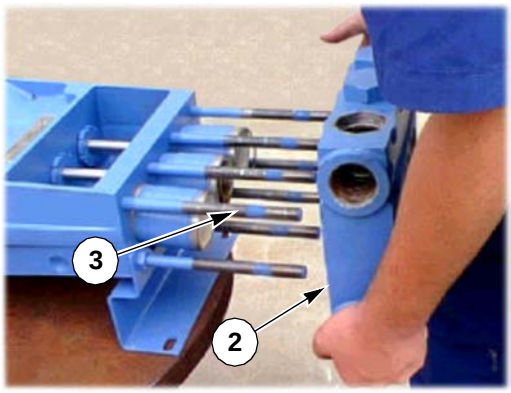
5. Thoroughly clean three metal seal holders **(3)** and their seats **(4)** on the crosshead rods. Slide the seal holders down the rods, pressing them against the seats. Lightly lubricate three new O-rings. Carefully roll the O-rings over the threads of the rods to avoid cutting them; and seat the O-rings in the seal holders.

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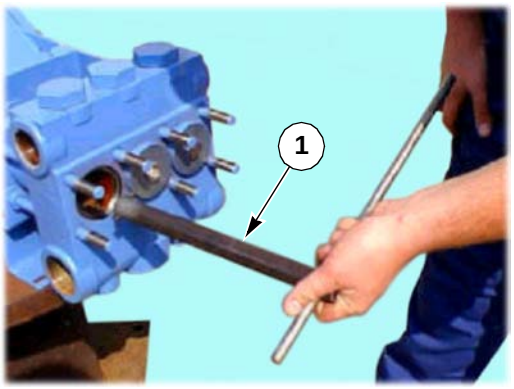


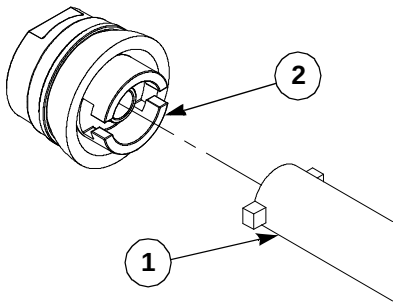


6. Install cylinder liners **(1)**, being careful that they do not fall and become damaged.

The two studs (opposite, diagonal corners) used to secure the fluid cylinder varies on different pumps.

7. Mount fluid cylinder **(2)**. Finger tighten the nuts on two studs **(3)** (opposite, diagonal corners) to secure the fluid cylinder, but do not tighten the nuts.

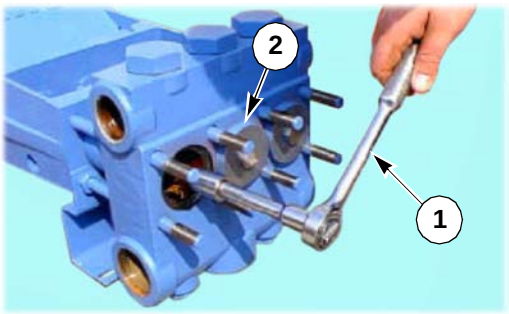


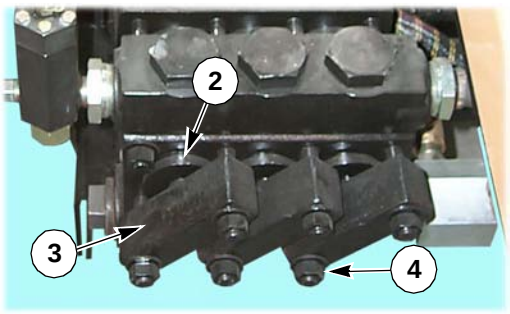


8. Engage and lock the tabs of FMC piston tool **(1)** inside the mating slots of piston nuts **(2)**. Strike the tool with a rubber mallet and fully drive the piston assemblies to their stops.

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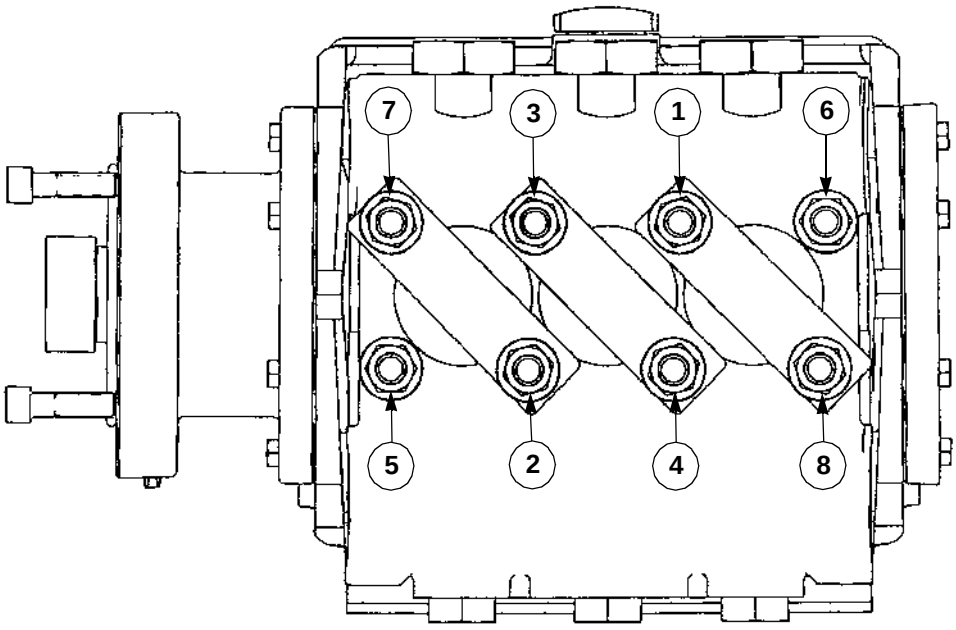
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9. Thread the brass hex nuts on the crosshead rods, using socket wrench **(1)** with a long extension. Torque the nuts to 25 ft-lb (34 Nm).

10. Thoroughly clean the O-ring grooves on cylinder covers **(2)** and the mating surfaces on the fluid cylinder. Lightly lubricate three new O-rings with oil and seat them in the grooves. Install the three cylinder covers and three cylinder cover clamps **(3)**. Finger tighten six nuts **(4)** on the studs.



The corner studs **(5)** and **(6)** may be in differing positions, depending on factory assembly. The torque patterns should be altered accordingly.

11. Torque the nuts on the fluid cylinder in a 3-pass sequence: 30 ft-lb (40 Nm) on the first pass, 60 ft-lb (80 Nm) on the second pass and 90 ft-lb (122 Nm) on the third pass. Follow the above numerical sequence in torquing the nuts.

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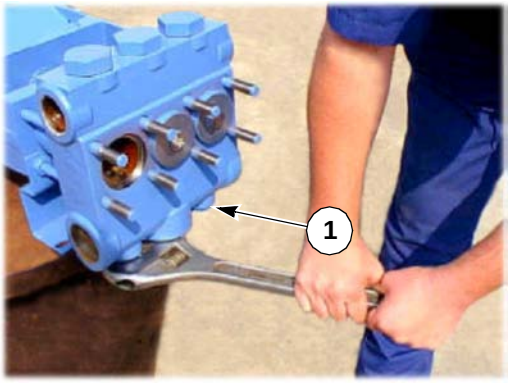
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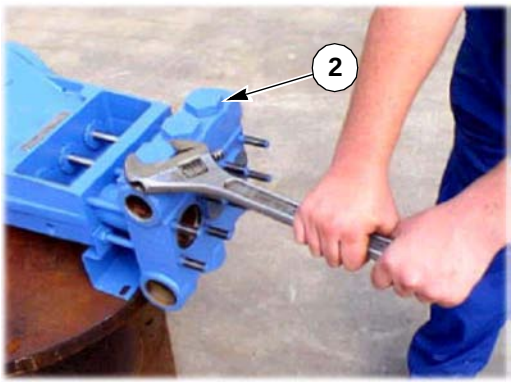
SUCTION AND DISCHARGE VALVE REMOVAL / INSTALLATION

Special Tools and Materials

- torque wrenches capable of producing 30 ft-lb (40 Nm) and 90 ft-lb (122 Nm)
- rubber mallet
- FMC valve tool (Vermeer P/N 240141-017)

Remove Valves



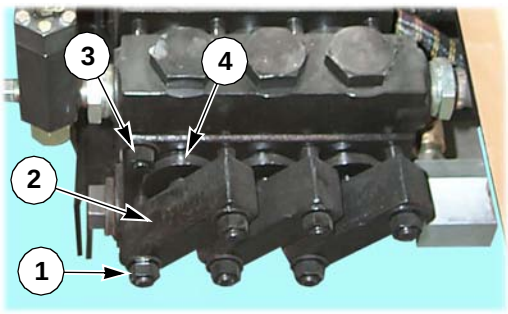


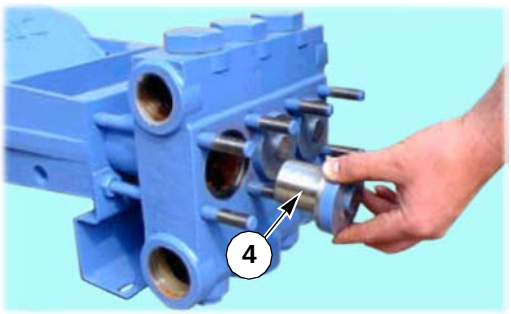
A minimum of 24" (610 mm) of clearance is required above, below and in front of the pump fluid cylinder to allow valve service. Use the outriggers and block as necessary to achieve the correct clearance.

1. Remove three suction drain plugs **(1)** and three discharge drain plugs **(2)**.

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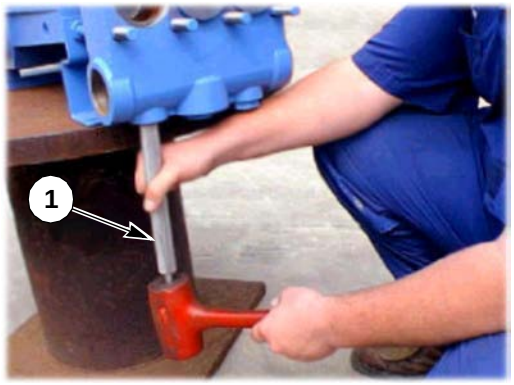


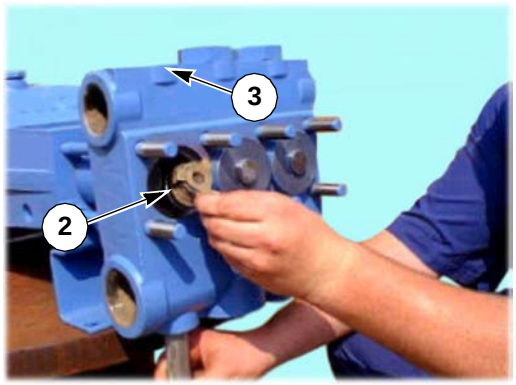


2. Remove six diagonal nuts **(1)** retaining three cylinder cover clamps **(2)**, and pull the clamps from the fluid cylinder.

NOTE: Do not remove two nuts **(3)** on the opposite, diagonal corners of the fluid cylinder since they keep the fluid cylinder securely mounted on the pump.

3. Remove cylinder covers **(4)**.





4. Insert the **large end** of FMC valve tool **(1)** into the fluid cylinder, making contact with the bottom of each suction valve seat **but not the valve body**. Strike the valve tool with a rubber mallet to drive suction valves **(2)** from their seats. Use the valve tool to push the suction valves up and out through the cylinder cover ports.

IMPORTANT: Using undersized tools to remove the valves will cause damage to the valve components.

5. Use the same procedure to remove the discharge valves (not shown) through discharge drain plug holes **(3)** on top of the fluid cylinder.

6. Discard all old O-rings that were disturbed during disassembly.

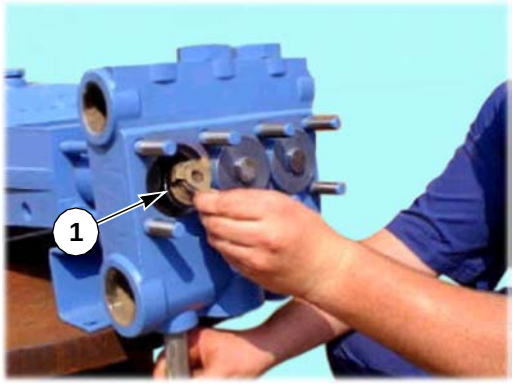
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Install Valves

1. Thoroughly flush the inside of the fluid cylinder to remove all debris. Then, clean the six valve seat tapers inside the fluid cylinder by wiping them with a clean, lint-free towel. Also, clean the surface around all cylinder cover ports, suction drain plug holes and discharge drain plug holes.

IMPORTANT: New valve assemblies are secured using a self-locking taper and must make metal-to-metal contact to be effective. If debris between the valve assemblies and mating valve seat tapers inside the fluid cylinder fails to allow the valve assemblies to seat properly, damage to the new valve assemblies and fluid cylinder will result. Carefully inspect each valve assembly seat and valve seat taper inside the fluid cylinder for visible damage.

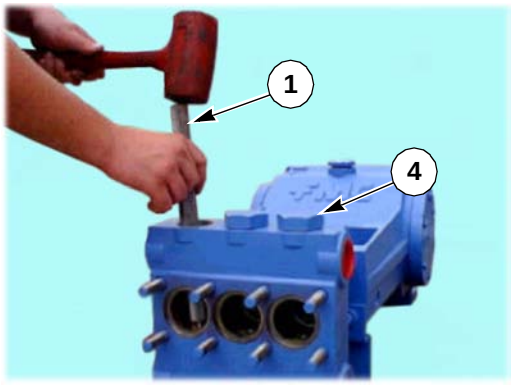


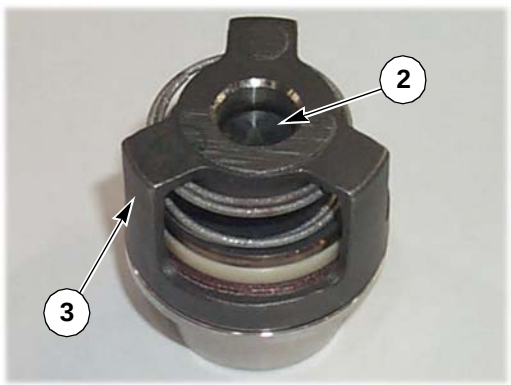
Replace all suction and discharge valve assemblies whenever valve service is required. Replacing only valve assemblies that have visible signs of wear reduces the operating time between service intervals. Replace complete valve assemblies, never individual valve parts.

2. Insert suction valve assemblies **(1)** into the ports of the fluid cylinder. Position the valve assemblies slightly above the valve seat tapers and drop them into place. If dropped straight, the valve assemblies will seize on the taper and cannot be moved by hand.

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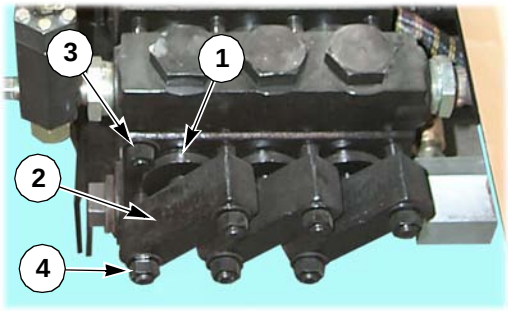


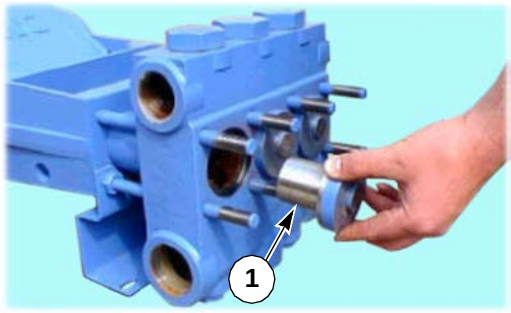


IMPORTANT: Correct use of FMC valve tool **(1)** is critical to prevent permanent damage to the valve assemblies during installation.

3. Mate the small end of the FMC valve tool to valve stems **(2)**, **but not valve cages (3)**. Drive the valve assemblies into the valve seat tapers, striking the tool several firm blows with a mallet. Three blows are usually sufficient. Contact with the valve cages will damage the valve assemblies.

4. Insert the discharge valve assemblies (not shown) into discharge drain plug holes **(4)**, and utilize the same procedure to seat them in the valve seat tapers.





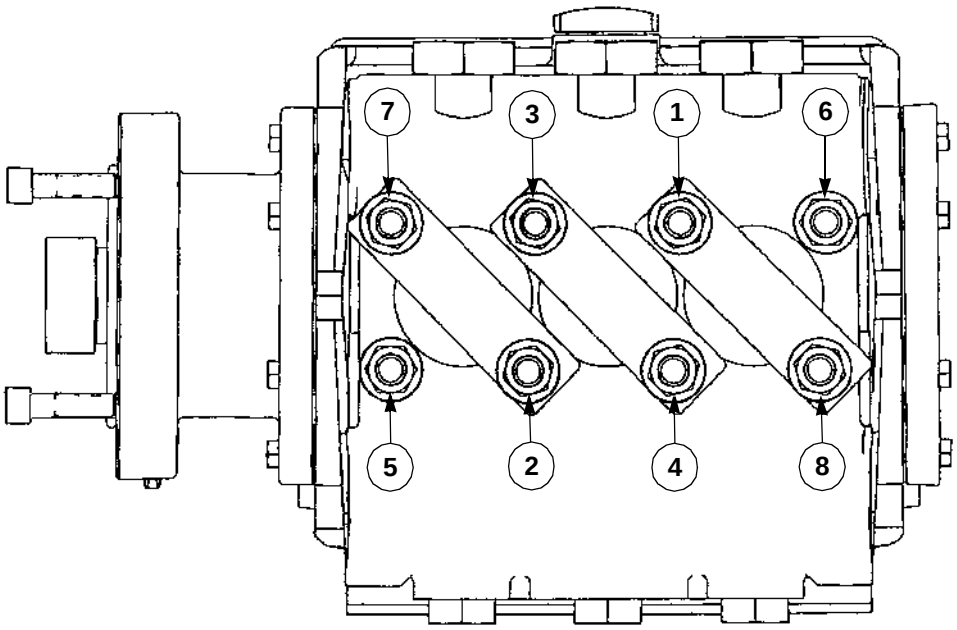
5. Thoroughly clean the O-ring grooves on cylinder covers **(1)**. Lightly lubricate three new O-rings with oil and seat them in the grooves. Install the three cylinder covers and cover clamps **(2)**.

6. Fully loosen two nuts **(3)** on the opposite, diagonal corners of the fluid cylinder. Then, finger tighten two nuts **(3)** and six nuts **(4)**.

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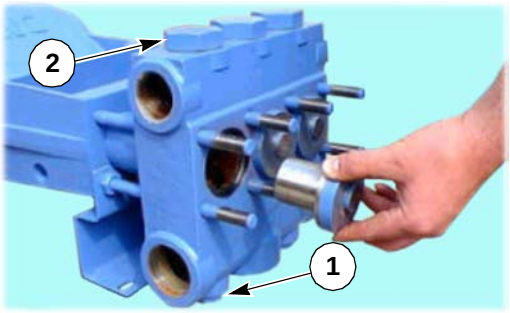
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The corner studs **(5)** and **(6)** may be in differing positions, depending on factory assembly. The torque patterns should be altered accordingly.

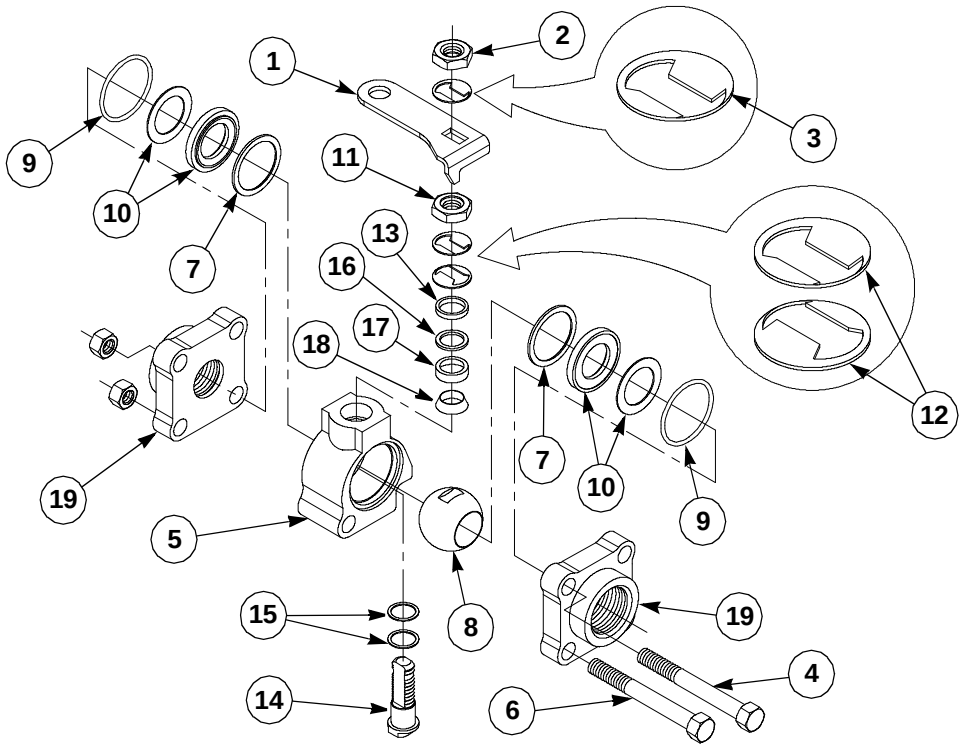
7. Torque the nuts on the fluid cylinder in a 3-pass sequence: 30 ft-lb (40.7 Nm) on the first pass, 60 ft-lb (81.4 Nm) on the second pass and 90 ft-lb (122 Nm) on the third pass. Follow the above numerical sequence in torquing the nuts.



8. Thoroughly clean the O-ring grooves on all suction drain plugs **(1)** and discharge drain plugs **(2)**. Lightly lubricate new O-rings with oil and seat them in the grooves, being careful to not damage them on the threads of the plugs. Thread all plugs in the holes and torque to 45 ft-lb (61 Nm).

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BALL VALVE MAINTENANCE



Special Tools and Materials

- torque wrench capable of producing 300 in-lb (34 Nm)
- silicone or teflon base lubricant

Remove Packings, O-Rings and Seat Sub-Assemblies

IMPORTANT: Drain the system and cycle the valve open and closed once to relieve trapped pressure. Leave the valve in the open position. During disassembly, do not scratch internal bore surfaces.

Note the position of handle **(1)** before disassembly. Also, ball **(8)** must be rotated to the closed position to remove it.

1. Remove nut **(2)**, spring **(3)**, and handle **(1)**. Discard the spring.
2. Loosen the four body bolts, but remove only bolt **(4)**. Swing out body center **(5)**, using bolt **(6)** as the pivot. Remove support rings **(7)** and ball **(8)**, saving them for assembly. Remove and discard O-rings **(9)** and seat sub-assemblies **(10)**.
3. Remove nut **(11)**, springs **(12)**, gland **(13)** and stem **(14)**. Pull stem bearings **(15)** from the stem. Discard the springs, gland and stem bearings.
4. Remove packing support **(16)**. Carefully pry top and bottom packings **(17)** and **(18)** out of the bore. Discard the packing support and packings.

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Install Packings, O-Rings and Seat Sub-Assemblies

1. Thoroughly clean body center **(5)**, stem **(14)** and sealing surfaces on flanges **(19).** Also, clean support rings **(7)**.

IMPORTANT: If lubricant is used on the stem shank, stem bearings, and top and bottom packings, it must be a silicone or teflon base lubricant. Do not use a petroleum base lubricant. Also, do not apply lubricant to the stem threads.

2. Slide new stem bearings **(15)** on the stem and install the stem. Insert ball **(8)** in the body center until the stem tang is engaged, rotating the stem to the open position. The ball is now secure.

Keep the packings and packing support straight during installation.

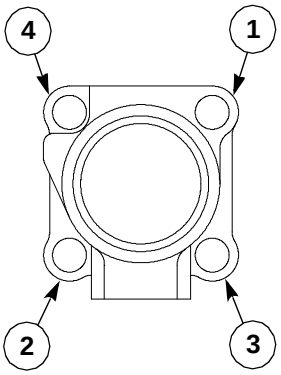
3. Push new bottom and top packings **(18)** and **(17)**, followed by new packing support **(16)**, into the packing bore.
4. Place new gland **(13)** and two new springs **(12)** (convex sides facing each other) on the stem.
5. Thread nut **(11)** on the stem; hold the stem with handle **(1)**; and torque the nut to 100 in-lb (11.3 Nm).

During assembly, the handle must be positioned as it was before disassembly to indicate the proper direction of valve flow.

6. Install the handle, new spring **(3)** (convex side facing handle) and nut **(2)**. Torque the nut to 100 in-lb (11.3 Nm).

IMPORTANT: Lubricate new O-rings **(9)** and new seat sub-assemblies **(10)**, using a silicone or teflon base lubricant. Do not use a petroleum base lubricant.

7. Place support rings **(7)** (chamfered sides toward the ball), seat sub-assemblies (metal springs away from the ball) and O-rings in body center **(5)**.
8. Swing the body center back into position. Install body bolt **(4)** and nut. With the valve in the fully open position, torque the bolts in five stages, using the illustrated numerical, crisscross sequence. Torque values for each stage are as follows: 25 in-lb (2.8 Nm), 50 in-lb (5.7 Nm), 100 in-lb (11.3 Nm), 180 in-lb (20.3 Nm) and 180 in-lb (20.3 Nm).



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Section 110-0:Ground Drive

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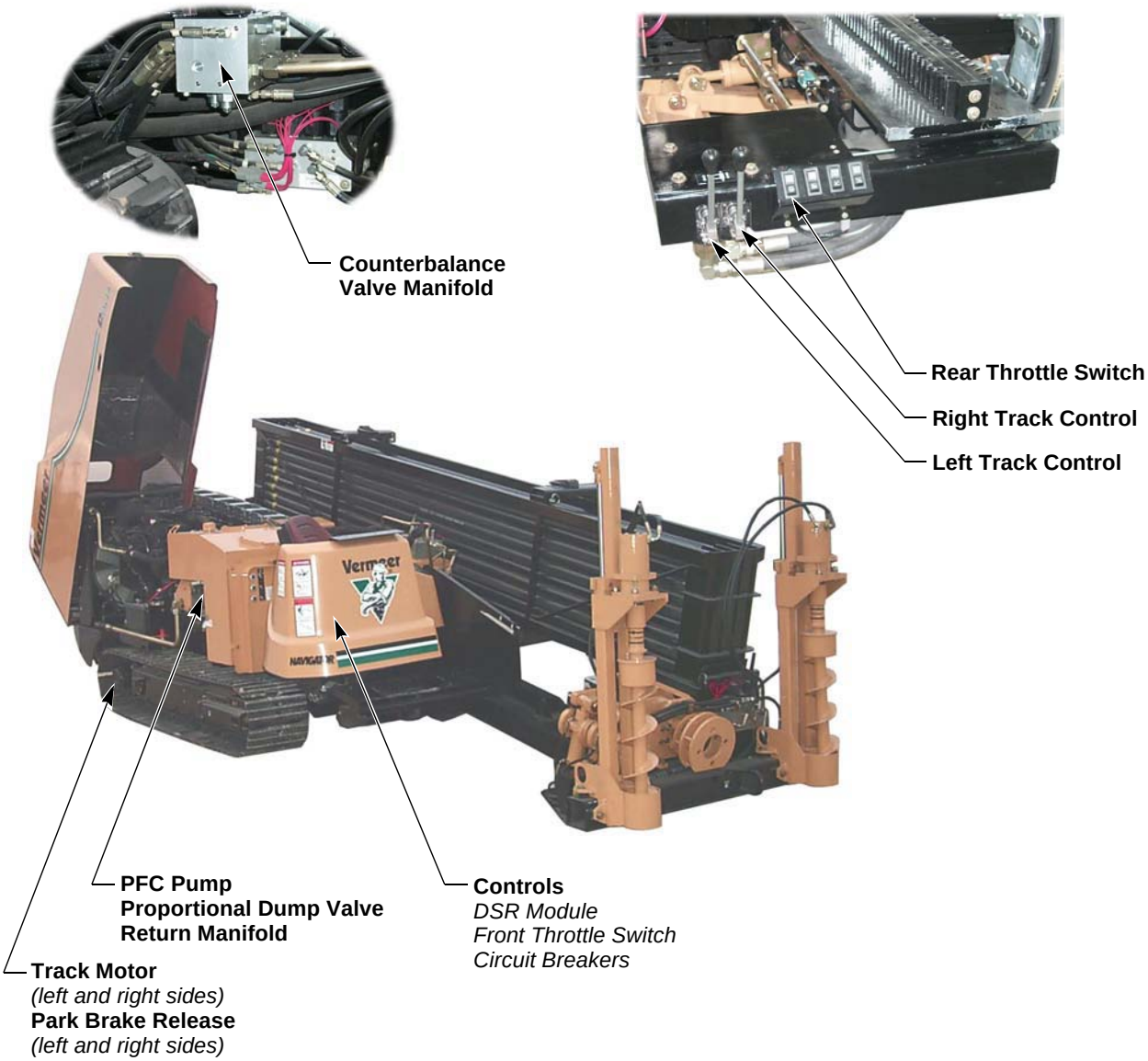
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Section 110-1: Ground Drive Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Ground Drive table of contents (will direct you to system and component information)	110-0-1
Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Engine	30-0-1
Common Hydraulic System	40-0-1
Common Electrical System	50-0-1

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OPERATION OVERVIEW

Towing

In the event of an engine or rotation pump failure, the machine may be towed by disconnecting the final gear reduction state in the planetary gearbox. Refer to section **110-3-1** for the towing procedure.

Engine

The engine drives the PFC pump.

PFC Pump

The PFC pump supplies all the oil to operate the ground drive motors.

Load Sense Solenoid Valve

The load sense solenoid valve is energized any time a hydraulic function is operated with an electric switch. This opens the valve to allow oil flow to the load sense line. This eliminates all external load sense lines except for the ground drive valve LS line.

Track Lockout Valve

The track lockout valve is a “normally passing” (“normally open”) solenoid valve that allows PFC pump flow to the transport valve **unless** the seat switch is closed.

Rotation Charge Pump

The rotation charge pump supplies pilot oil to release the park brake when directed by the park brake release valves.

Track Drive Motors (Left and Right)

The track drive motors receive oil flow from the transport valve by way of the brake valve. They input rotational force to the park brake units.

Park Brake (Left and Right)

Charge pressure is used to release the spring-applied, hydraulically released disc brake units whenever the transport valve sends flow to the brake valve. In the event of engine or rotation pump failure, the park brakes may be released by applying pressure from a portable power source at approximately 300 psi (20 bar). If all other systems are functioning, it would be possible to apply thrust/pullback charge pressure to release the parking brake.)

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Planetary Gearbox (Left and Right)

The planetary gearbox receives motor input by way of the park brake unit and directly drives the track drive sprocket through a planetary gear reduction.

Brake Manifold Valve

Within the brake manifold valve, pressurized oil from the transport manual valve for each track drive motor flows through counterbalance valves. Pressurized oil is also directed through check balls to the park brake release valves.

Transport Valve

The transport valve directs oil to the brake manifold valve to operate the track drive motors. It incorporates a load sense ('LS') port which sends a signal to the 'LS' port on the PFC pump.

Operation

Correct operation of the system requires that the engine is turning at rated RPM, rotation charge pressure is available to the brake valve, counterbalance valves are set correctly, and brake release valves are operating.

SYSTEM SPECIFICATIONS

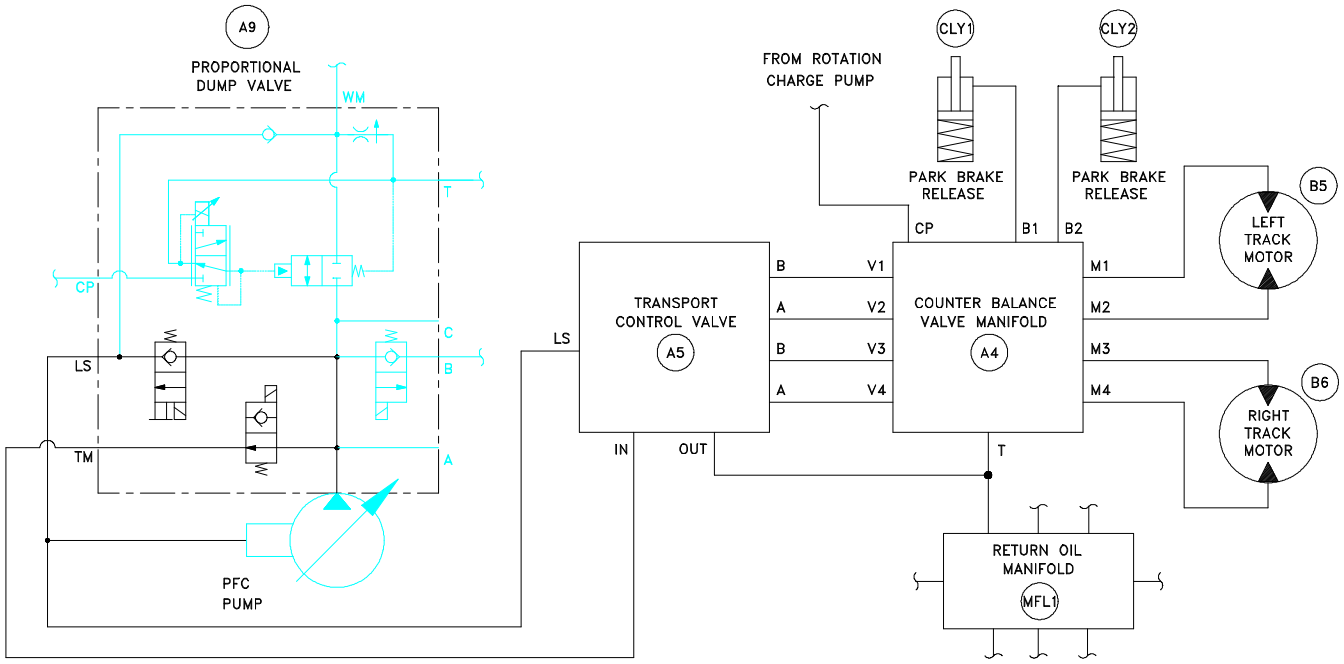
The following specifications are for the ground drive system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
governed engine RPM	2200 rpm
Transport Valve	
make / model	Gresen V-40
Planetary Gearbox	
make / model	Auburn Gear Model 7
Parking Brake	
make / model	Mico 3C-141445-C
Ground Drive Motors	
make / model	Eaton 4000
displacement per revolution	12.5 cid (205 cc)

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HYDRAULIC DIAGRAM



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Hoses

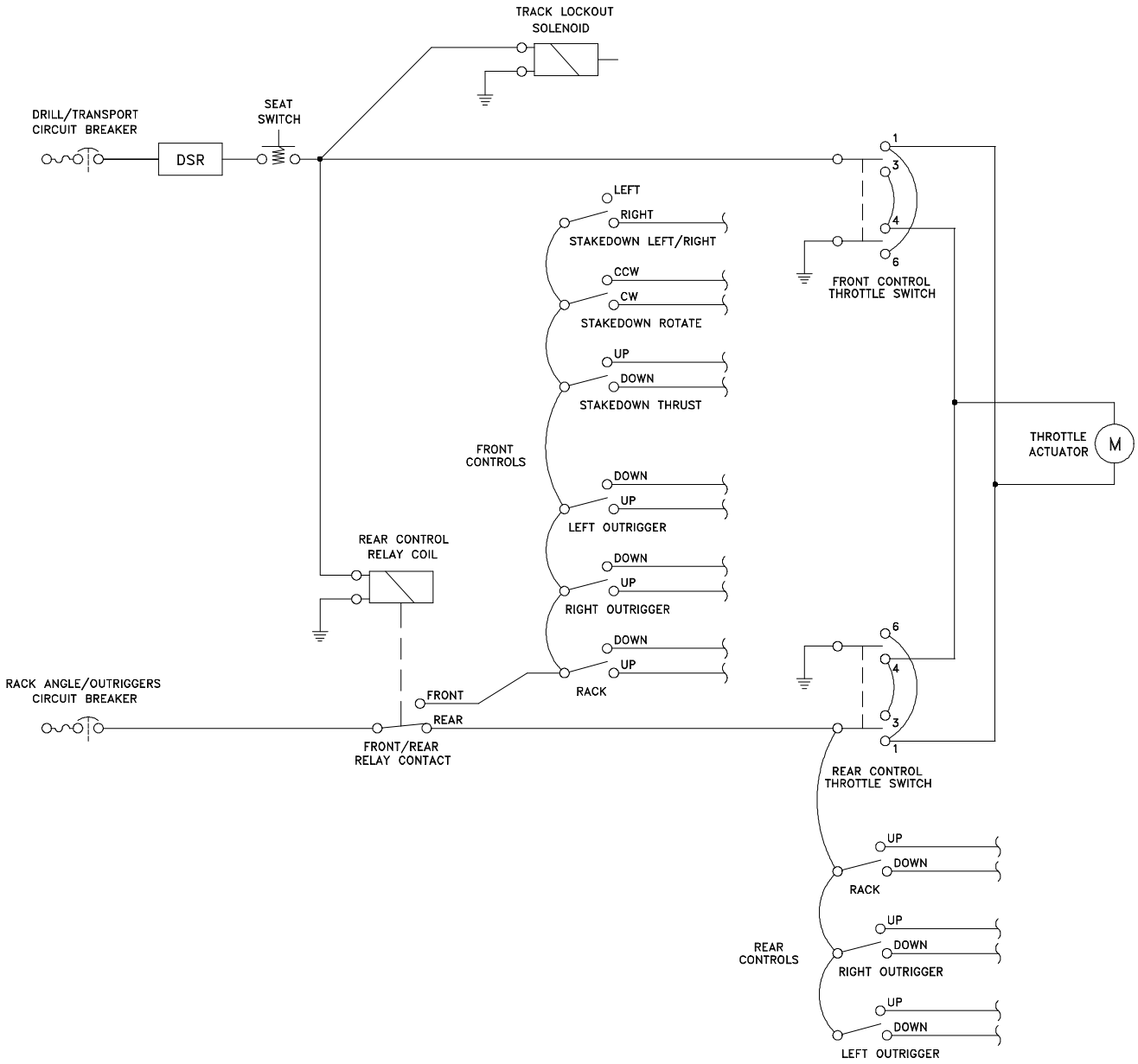
Hose ID/ Pressure	Circuit Type	Function
Park Brake Release(L and R) rotation charge pressure	pilot	Applies charge pressure to release park brake when transport valve pressure is applied to motor ports.
Transport/Brake Valve Return nominal pressure	return	Returns oil from transport valve ‘T’ port and the park brake valve ‘T’ port to the return manifold.
Valve (Left and Right, Forward and Reverse) (V1-V4) implement or return pressure	pressure	Provides pressure to the park brake manifold to release the park brake and send oil past the counterbalance avalves to the track drive motors.
Motor (Left and Right, Forward and Reverse) (M1-M4) implement or return pressure	pressure	Provides oil to rotate the ground drive motors
Rotation Charge	pilot	Provides pilot pressure to release the park brake.

***NOTE**: under “standard operating conditions,” the following pressures will normally be found in the circuits indicated:
“implement pressure = 300–3000 psi (20–200 bar)
“implement load sense” pressure = 300–3000 psi (20–200 bar)
“nominal pressure” = 25–100 psi (1.7–6.9 bar)
“charge pressure” = 300–500 psi (20–35 bar) (same as “low side” pressure)

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ELECTRICAL DIAGRAM



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Section 110-2:Ground Drive Troubleshooting

HOW TO DO TROUBLESHOOTING

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***
5. ***Are the hydraulic components functioning correctly?***

Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking Out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, drill/transport, and rack angle/ outrigger circuit breakers, or DSR) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** The seat switch is the only switch which the operator 'controls' but the related front and rear rack controls each use sever switches. These must be working properly.
5. ***Are all variable resistances OK?*** Make sure the resistance is within tolerances.
6. ***Are all electrical actuators OK?*** Almost always a coil—either in a relay or a solenoid; make sure the current path is complete and the resistance is within tolerance.
7. ***Is the mechanical output OK?*** Even if all electrical functions are OK, a valve may leak or fail to move, or relay contacts may stick or not conduct current.

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Checking Out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is a variable signal based on function demand being delivered to the compensator, either from a variable control such as the transport or water control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motors work ok unless the motors are worn, defective, incorrect replacements, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Some electrically controlled systems using variable current control of proportional solenoids might also change with temperature since current and temperature can be closely related.

Checking Out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

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SYMPTOM: NO TRANSPORT HYDRAULIC POWER

1. Are the machine common systems operating correctly? Operating the machine outside of intended parameters (i.e. in HIGH when it should be in MEDIUM or LOW) can lead to customer complaints. Also, oil level, temperature, and condition, oil cooler problems, or engine speed and power outside of specifications can cause or contribute to faulty operation.

Possible Problem	Possible Effect	What to do
hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
plugged suction screen	A plugged suction screen will cause machine operation problems and eventually will cause extensive equipment damage.	**Clean suction screen.**
charge filters are plugged	Plugged charge filters can affect many aspects of machine operation since charge pressure is used to control other machine functions.	**Replace charge filters.**
engine RPM too low	Hydraulic functions that rely on maximum pump flow will have slow operation since maximum flow is reduced when RPM is reduced.	**Check engine RPM** while operating under load.
overheating	A blocked oil cooler or other conditions causing overheating of the hydraulic oil can cause various problems.	**Check hydraulic oil cooler.**

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SYMPTOM: SOME HYDRAULIC POWER BUT MACHINE WILL NOT MOVE

1. Are the machine common systems operating correctly? Operating the machine outside of intended parameters (i.e. in HIGH when it should be in MEDIUM or LOW) can lead to customer complaints. Also, oil level, temperature, and condition, oil cooler problems, or engine speed and power outside of specifications can cause or contribute to faulty operation.

Possible Problem	Possible Effect	What to do
hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
plugged suction screen	A plugged suction screen will cause machine operation problems and eventually will cause extensive equipment damage.	**Clean suction screen.**
charge filters are plugged	Plugged charge filters can affect many aspects of machine operation since charge pressure is used to control other machine functions.	**Replace charge filters.**
engine RPM too low	Hydraulic functions that rely on maximum pump flow will have slow operation since maximum flow is reduced when RPM is reduced. Low RPM also causes a loss of pump and motor efficiency.	**Check engine RPM** while operating under load
overheating	A blocked oil cooler or other conditions causing overheating of the hydraulic oil can cause various problems.	**Check hydraulic oil cooler.**

2. Is rotation pump charge pressure available? Rotation pump charge pressure is used to release the parking brakes. If rotation charge pressure is unavailable for any reason the brakes will not release.

Possible Problem	Possible Effect	What to do
rotation charge pressure not available	Rotation pump charge pressure is used to release the parking brakes. If rotation charge pressure is unavailable for any reason, the brakes will not release.	**Check that rotation charge pressure is available at the brake valve 'CP' port.**

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3. Is the track lockout system working? The track lockout system is intended to prevent the tracks from being operated when there is an operator present in the seat.

Possible Problem	Possible Effect	What to do
DSR not supplying power	The track lockout solenoid receives current from the DSR module through the seat switch. If the DSR does not supply current or if the seat switch is not closed, the track lockout solenoid cannot be energized. This means that the tracks WILL be enabled even if an operator is present on the seat.	**Check that the DSR is supplying current to the seat switch** (green “acceptable voltage” light must be on) and that the seat switch applies current to the track lockout solenoid.
grounds	If the ground path is missing, is too resistive, or the voltage drop is more than 0.5 V, all electrical operation can be affected.	**Check that the track lockout solenoid is adequately grounded.** Check ground voltage between the lockout solenoid ground and battery negative terminal at rest and while operating an electrical load. Repair any condition causing high ground voltage either at rest or under load.
current path	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path.** Inspect visually or use an ohmmeter or voltmeter.

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4. Are the hydraulic components functioning correctly? Operation of a hydraulic system requires the correct function of pump, flow and direction controls, and actuators.

Possible Problem	Possible Effect	What to do
PFC pump flow problem		**Refer to *Common Hydraulic System*,** page **40-0-1**.
system pressure misadjusted	If PFC pump pressure is misadjusted, there might not be sufficient pressure to track the machine under some conditions.	**Check system relief pressure and pump compensator pressure.**
brake valve not vented	The 'T' line from the brake manifold vents the piloted valves used to release the parking brakes. If the 'T' line from the brake manifold is not vented, the brakes may not release completely if at all.	**Check that the 'T' line is unrestricted.**
ground drive motor counterbalance valve	The ground drive motors use counterbalance valves to prevent runaway of the motors. If the valves have been misadjusted, motors may be hard to turn or could run away down hills.	**Check for evidence of tampering with counterbalance valves.** If they have been adjusted,they must be returned for new ones since there is not currently a procedure to reset the valves.
ground drive motor condition	If the ground drive motors are worn out and inefficient, ground drive function will be impaired.	**After verifying no other system problems, perform a pump flow test.** If pump flow is good, all controls are good, and performance is still unsatisfactory, the motor should be replaced.

5. Is the track too tight? If the track is too tight it could lead to excessive effort to move the machine, especially if pump or motor condition is not good.

Possible Problem	Possible Effect	What to do
track tension	If the track is too tight it could lead to excessive effort to move the machine, especially if pump or motor condition is not good.	**Check and adjust track tension.**

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Section 110-3: Transport Instructions

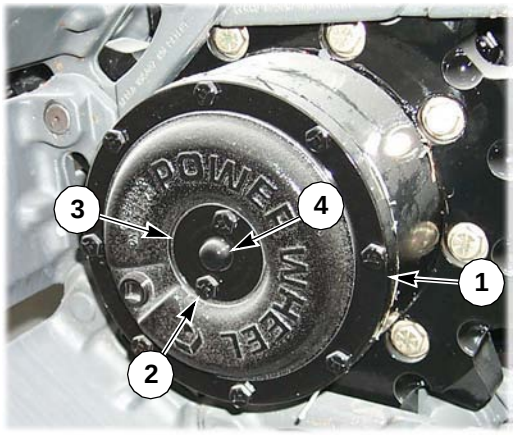
TOWING THE MACHINE

Conditions

If the engine cannot be started, disengaging the sun gear in each track planetary gearbox removes all motor and brake control, allowing the machine to be towed.

WARNING: Machine can move suddenly when planetary gearboxes are disengaged. Serious injury or death is possible if struck by or run over by the machine. Always block both tracks securely before disengaging the planetary sun gears. Securely attach the machine to a towing machine with sufficient capacity to safely move the machine.

Procedure



1. Thoroughly clean the faces of left and right track planetary gearboxes **(1)**. Remove two bolts **(2)** and cover **(3)** on each gearbox.
2. Reverse the covers so projections **(4)** are facing inward and bolt the covers in place. The sun gears are now disengaged.
3. Tow the machine to the new location.
4. Remove covers **(3)**; reverse the covers so projections **(4)** are facing outward as shown; and bolt the covers in place. The sun gears will engage as soon as the teeth are aligned when the motors are powered. Operate the motors slowly in forward and reverse directions to make sure the gears are fully engaged.

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Section 120-0:Stakedown & Rack

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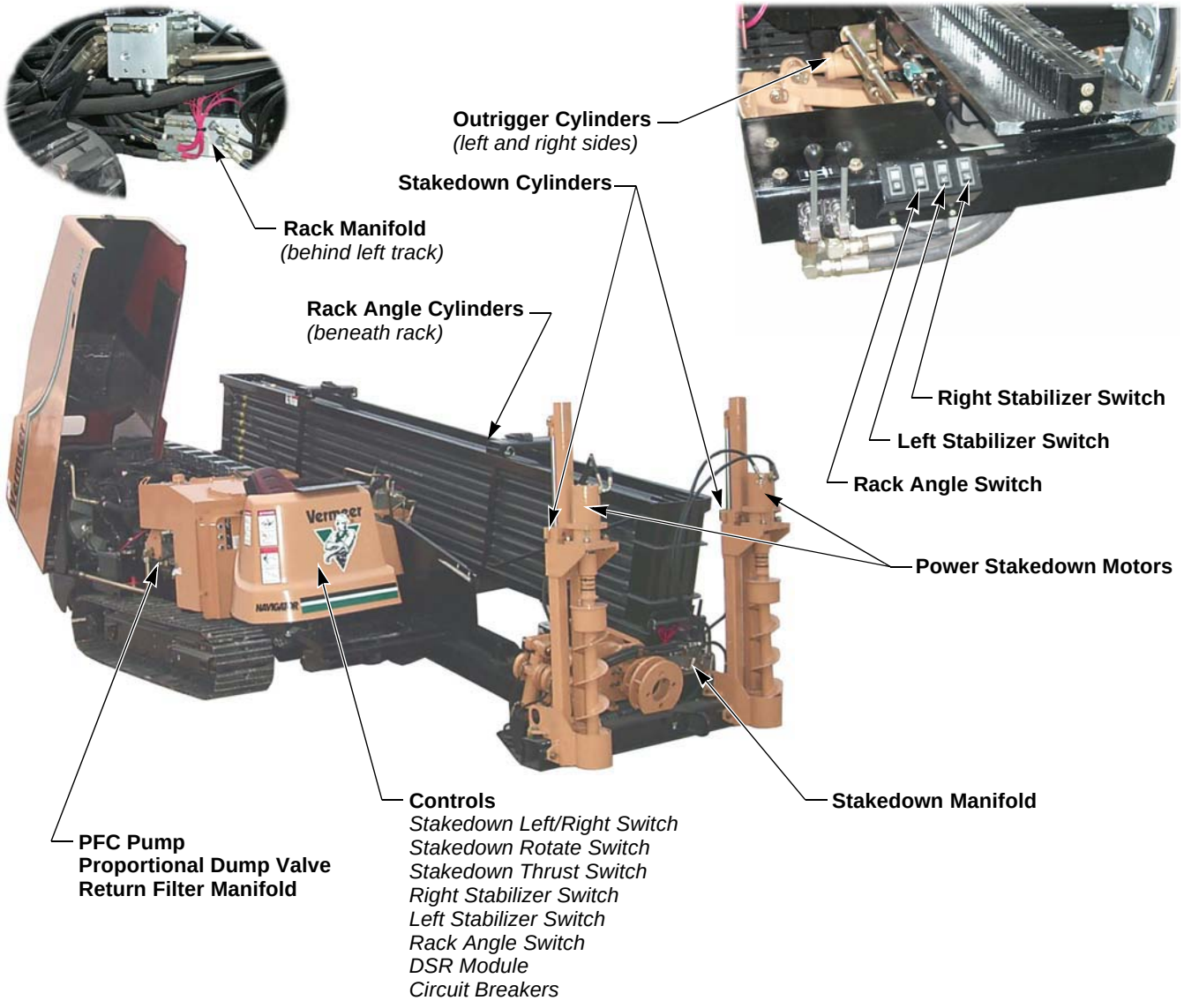
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Section 120-1: Stakedown and Rack Overview

System and Component Locations



Safe work practices and system and component information can be found on the following pages.

Information	Refer to page...
Stakedown and Rack System table of contents (will direct you to system and component information)	120-1-1
Safety (includes *Shutdown Procedure*)	10-1-1
General Information	20-0-1
Engine	30-0-1
Common Hydraulic System	40-0-1
Common Electrical System	50-0-1

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OPERATION OVERVIEW

Rack Tilt and Outrigger Cylinder Lockout Release

The cylinders for the rack tilt contain counterbalance valves. The cylinders for the outriggers contain pilot operated checkballs. A special procedure is required if it is necessary to remove these valves. Contact Vermeer Manufacturing Co. for this procedure.

Engine

The engine drives the PFC pump.

PFC Pump

The PFC pump supplies all hydraulic oil for stakedown and rack position functions.

Load Sense Solenoid Valve

The Load Sense Solenoid valve is energized any time a hydraulic function is operated with an electric switch which causes the pump to go to maximum pressure (pressure compensator pressure). There is no Load sense line from either manifold to the pump.

Stakedown Manifold

A 2-position, 3-way solenoid valve within the stakedown manifold selects right or left cylinder function. An identical valve simultaneously selects between right or left motor functions. Individual 3-position, 4-way solenoid valves select “stakedown” or “remove” functions of the cylinders and motors.

Rack Manifold

Three identical 3-position, 4-way solenoid valves control the action of the rack tilt and stabilizers. The six coils for the rack and stabilizer functions and the single coil for the ball valve function on the rack manifold are all identical “type 10” (20-watt) coils.

Stakedown Motors

The stakedown motors are of the geroler type and can be serviced if necessary.

Operation

Correct operation of the system requires that the engine is turning at rated RPM, PFC pump and load sense systems are working correctly.

SYSTEM SPECIFICATIONS

The following specifications are for the stakedown system in general. For individual component specifications, refer to the appropriate section in this manual.

Specification	Value
General	
governed engine RPM	2200 rpm
Stakedown Motors	
Motor Make/ Model	White Hydraulics CC1047.47 DT660625
Displacement per revolution	66 cid (1082 cc)

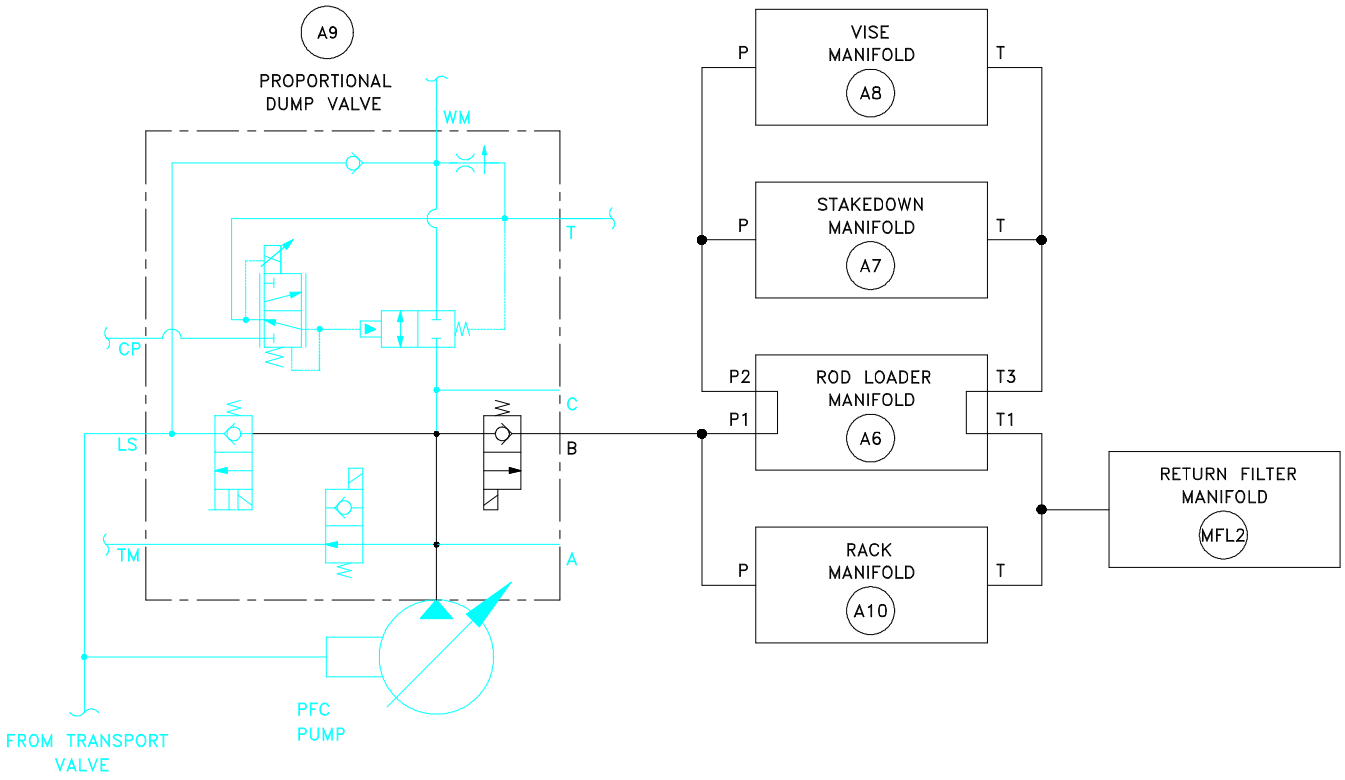
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HYDRAULIC HOSES

Hose ID/ Pressure	Circuit Type	Function
All Functions)	pressure	all hoses shown provide pressure or return for al rack functions.
Return	return	returns oil from to transport valve and then to the tank.

NOTE: under “standard operating conditions,” the following pressures will normally be found in the circuits indicated:
“high side” pressures = 300–6090 psi (20–420 bar)
“low side” pressure = 300–500 psi (20–35 bar)
“nominal pressure” = 25–100 psi (1.7–6.9 bar)
“charge pressure” = 300–500 psi (20–35 bar) (same as “low side” pressure)

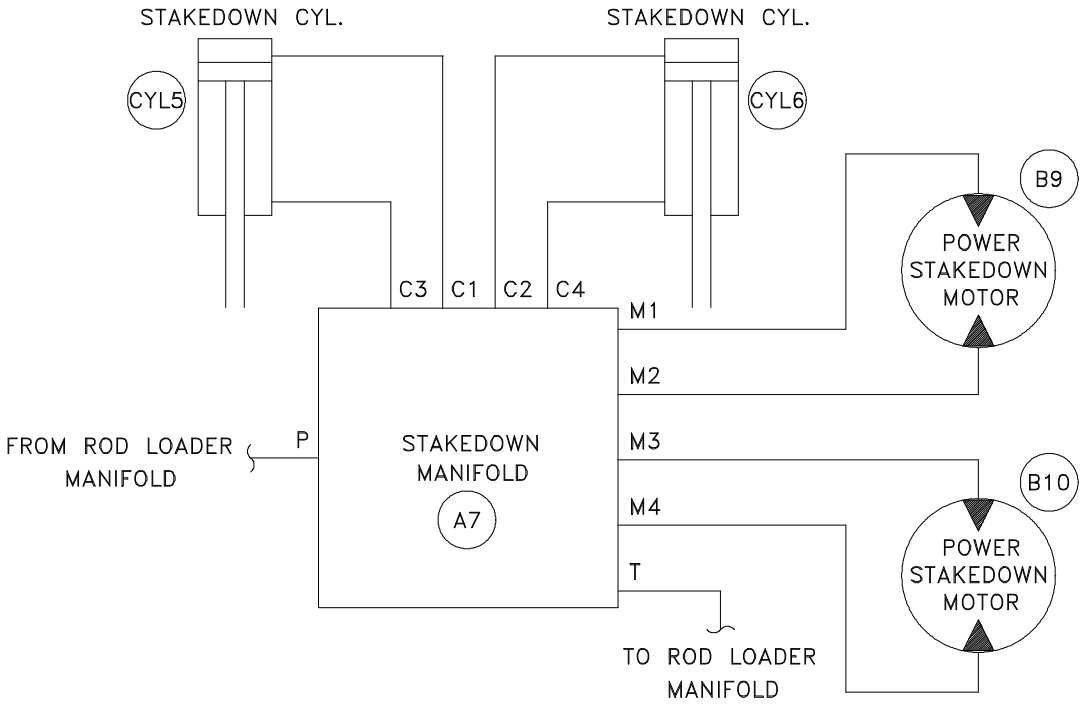
Hose Diagram - PFC Pump to Stakedown Manifold and Rack Manifold



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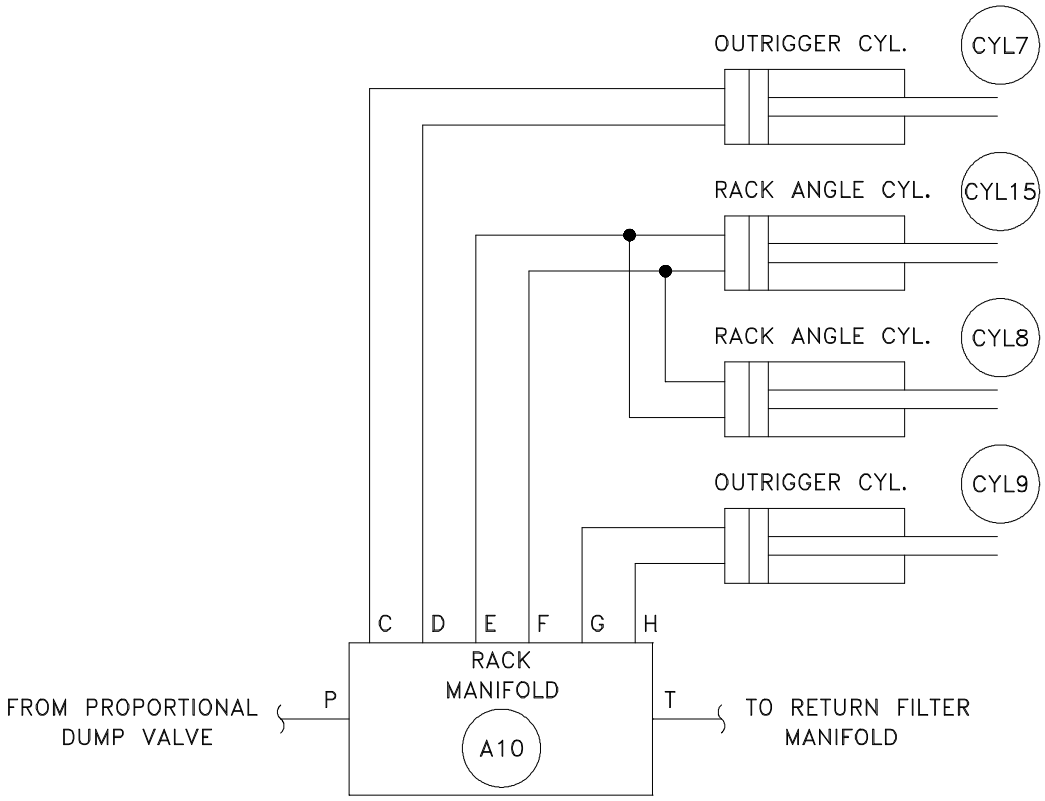
Hose Diagram - Stakedown Manifold



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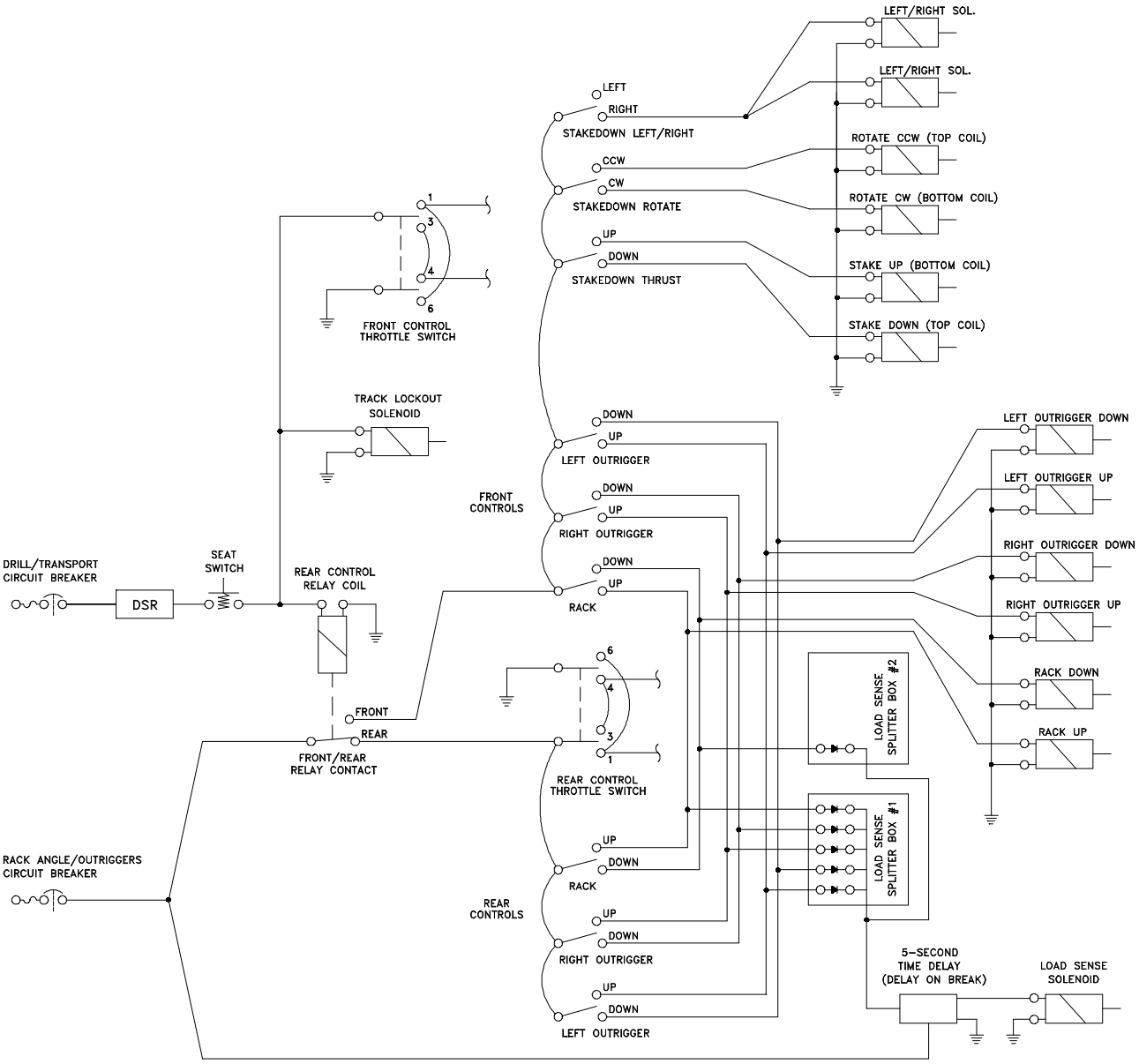
Hose Diagram - Rack



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ELECTRICAL DIAGRAM



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Section 120-2: Stakedown and Rack Troubleshooting

How To Do Troubleshooting

Introduction

This section is a diagnostic aid to troubleshooting. You must refer to other parts of the manual for specific diagnostic steps and procedures. As such, it contains no safety warnings since it is not a procedural guide. The servicing technician must follow all appropriate safety messages found elsewhere in this manual.

Basic Troubleshooting Questions

A successful troubleshooter will answer the following questions:

1. ***Is there a mechanical problem?***
2. ***Are the machine common systems operating correctly?***
3. ***Are the related systems working correctly?***
4. ***Are the controls working correctly?***
5. ***Are the hydraulic components functioning correctly?***

Check Out “Common” and Related Systems

- Always look for problems in common and related systems before doing any difficult test procedures.
- Check the hydraulic and electrical overall schematics and verify that the common systems and related systems are OK.
- Look for electrical systems operating on the same circuit breaker or switch; look for hydraulic systems relying on the same pump or control valve.
- Also look for separate systems that supply or require a control pressure such as charge pressure from a hydrostatic pump being used as pilot pressure for a proportional valve or brake release.
- If a common or related system is not OK, repair that system first, then proceed with troubleshooting if necessary.

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Checking Out Controls

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental electrical-related questions:

1. ***Is the power source (battery, ignition switch, drill/transport circuit breaker, rack angle, DSR) OK?*** Electrical actuators such as relays and coils may operate correctly down to as low as 10.8V, but any system voltage measuring below 12.5V can be suspect, especially if grounds are faulty.
2. ***Are the grounds OK?*** The circuit must be complete to ground, and the voltage drop in the ground circuit must be no higher than 0.5V.
3. ***Is the current path complete?*** Many problems can be traced to a broken wire or faulty pin connection in a plug.
4. ***Are all the switches OK?*** Refer to the overall system schematics to determine what switches are contained within a system or circuit.
5. ***Are all variable resistances OK?*** Make sure the resistance is within tolerances.
6. ***Are all electrical actuators OK?*** Almost always a coil—either in a relay or a solenoid; make sure the current path is complete and the resistance is within tolerance.
7. ***Is the mechanical output OK?*** Even if all electrical functions are OK, a valve may leak or fail to move, or relay contacts may stick or not conduct current.
8. ***If a control module is used, are all of its circuits OK?*** Does a control module system have correct voltage and ground, inputs, and complete current paths on all circuits? Most “module failures” are the result of a problem in the voltage source, current path, ground, switch or resistor function, or actuator failure. Check all those items before replacing a module.

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Checking Out Hydraulics

Unless the problem is obvious, the successful troubleshooter will investigate these fundamental hydraulic-related questions:

1. ***Can the pump deliver correct FLOW?*** Is the inlet restricted? Is the pump worn out? Is the compensator correctly controlling pump stroke?
2. ***Is the system PRESSURE correct?*** Is the compensator set correctly? Is the system relief set correctly?
3. ***Is the system delivering correct pressure on the actuator?*** Is the load sense system functioning correctly? Is a variable signal based on function demand being delivered to the compensator, either from a variable control such as the transport or water control or from a solenoid valve through the load sense solenoid? Are the actuators original equipment or correct replacements?
4. ***Are the motors or cylinders OK?*** Correct pressure and flow at the motor ports will make the motors work ok unless the motors are worn, defective, incorrect replacements, or otherwise defective.
5. ***Are the directional control valves OK?*** Flow must be applied correctly to any actuator for it to function as designed.
6. ***Is there an abnormal resistance to work?*** Pressure in a hydraulic system comes only from “line” (“system”) resistance or from “load” (“actuator”) resistance. Any change from normal will result in changed performance.

NOTE: A dramatic change in operation between **cold conditions** and **warmed up conditions** point toward pump or motor wear, since hot oil leaks more quickly through loose clearances. Some electrically controlled systems using variable current control of proportional solenoids might also change with temperature since current and temperature can be closely related.

Checking Out Mechanical Systems

Always check for mechanical malfunctions—such as defective bearings, binding linkages, and loose fasteners.

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SYMPTOM: STAKEDOWN, RACK TILT, OR OUTRIGGER OPERATION SLOW OR LACKS FORCE

1. Are the machine common systems operating correctly? Operating the machine outside of intended parameters (i.e. in HIGH when it should be in MEDIUM or LOW) can lead to customer complaints. Also, oil level, temperature, and condition, oil cooler problems, or engine speed and power outside of specifications can cause or contribute to faulty operation.

Possible Problem	Possible Effect	What to do
hydraulic oil level low	Low hydraulic oil level can cause a variety of problems.	**Fill hydraulic oil to correct level.**
plugged suction screen	A plugged suction screen will cause machine operation problems and eventually will cause extensive equipment damage.	**Clean suction screen.**
engine RPM too low	Hydraulic functions that rely on maximum pump flow will have slow operation since maximum flow is reduced when RPM is reduced.	**Check engine RPM** while operating under load
overheating	A blocked oil cooler or other conditions causing overheating of the hydraulic oil can cause various problems.	**Check hydraulic oil cooler.**

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SYMPTOM: STAKEDOWN, RACK TILT, OR OUTRIGGER WILL NOT OPERATE

1. Is the hydraulic enable system OK? Each time the engine is started, the hydraulic enable system must be activated.

Possible Problem	Possible Effect	What to do
hydraulic enable system not activated	Each time the engine is started, the hydraulic enable system must be activated in order to operate any implement hydraulic functions.	**Refer to Common Hydraulic System Troubleshooting,** page **40-2-1**.

2. Is the drill/transport circuit live? The stakedown, rack tilt, and outrigger circuits receive power from the drill/transport circuit breaker.

Possible Problem	Possible Effect	What to do
drill/transport circuit breaker tripped	Drill/transport power is provided from the drill/transport circuit breaker. If it is tripped or defective, no current will be provided to the drill/transport control circuit.	**Check that power is available from the drill/transport circuit breaker.**

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2. Are the controls working correctly? The rear control relay applies power to the rack/outrigger control switches in the rear control station if the seat is unoccupied, or in the front if the seat is occupied. The solenoid apply signal also is sent to one of the two load sense splitter boxes to energize the load sense solenoid.

Possible Problem	Possible Effect	What to do
circuit breaker #3 (rack angle/ outrigger) not powered	If the rack angle/outrigger circuit breaker is tripped or not connected to the battery, it will not be possible to operate the rack angle or outrigger controls from either operator station.	**Check circuit breaker status and wiring.**
DSR not providing power to the seat switch.	The DSR requires a minimum of 10.8V to send power to the seat switch. If it does not sense that voltage, rack and outrigger control will remain with the rear controls.	**Check and correct low voltage condition.**
rear control relay	The rear control relay receives coil current from the DSR through the seat switch. It receives supply current from the rack angle circuit breaker (#3). If these power sources are not available or if the relay is defective, it will not be possible to operate the rack angle or outrigger controls from either operator station.	**Check DSR circuit.**
grounds	If the ground path is missing, is too resistive, or voltage drop is 0.5V or more, all electrical operation can be effected.	**Check all grounding locations.** Check ground voltage between ground buss and battery negative terminal under no-load and loaded conditions. Repair any condition causing high ground voltage either at rest or under load.
current path	Any damage to wiring, connectors or connector pins that are not seated or mated correctly or any unintended short to power, resistance, or ground can cause intermittent or constant problems.	**Check the entire current path.** Inspect visually or use an ohmmeter or voltmeter.

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3. Are the hydraulic components functioning correctly? Operation of a hydraulic system requires the correct function of pump, flow and direction controls, and actuators.

Possible Problem	Possible Effect	What to do
PFC pump flow problem	If pump does not deliver full flow, functions will be slow.	Check PFC pump flow. *Refer to Common Hydraulic System, p.* **40-2-1**
system pressure	If the PFC compensator is set too low, the functions will move slowly. If the system pressure relief is functioning near or below the compensator setting, the relief will operate too often, causing oil heating and reduced force from actuators.	Set PFC compensator to 3000 psi (210 bar). Set system pressure relief to 3500 psi (241 bar).
load sense	If the load sense solenoid does not receive a signal, the pump will stay at standby pressure.	Check wiring to load sense solenoid. Check load sense solenoid operation.

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Revision History

Revision	Date	Page(s)	Description
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