

PTO Technical Resource Guide

Foreword

IMPORTANT: Descriptions and specifications in this technical reference guide were in effect at the time of printing. Daimler Trucks North America (DTNA) reserves the right to change specifications or component design at any time without notice and without incurring obligation. Descriptions and specifications contained in this publication provide no warranty, expressed or implied, and are subject to revision and editions without notice.

Refer to www.Daimler-TrucksNorthAmerica.com and www.WesternStarTrucks.com for more information, or contact Daimler Trucks North America, LLC at the following address: 4555 N Channel Ave, Portland, OR 97217.

Environmental Concerns and Recommendations

Whenever you see instructions in this manual to discard materials, you should attempt to reclaim and recycle them. To preserve our environment, follow appropriate environmental rules and regulations when disposing of materials.

Servicing vehicles may result in contact with items known to the state of California to cause harm.

WARNING

Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Always start and operate the engine in a well-ventilated area. If in an enclosed area, vent the exhaust to the outside. Do not modify or tamper with the exhaust system. Do not idle the engine except as necessary.

For more information go to www.P65warnings.ca.gov/products/diesel.

NOTICE

NOTICE: Parts Replacement Considerations

Do not replace suspension, axle, or steering parts (such as springs, wheels, hubs, and steering gears) with used parts. Used parts may have been subjected to collisions or improper use and have undetected structural damage.

Descriptions of Service Publications

The following information describes the different types of DTNA publications.

Workshop/Service Manual—Daimler Trucks North America LLC distributes the following major service publications in paper and electronic formats. Workshop/service manuals contain service and repair information for all vehicle systems and components, except for major components such as engines, transmissions, and rear axles. Each workshop/service manual section is divided into subjects that can include general information, principles of operation, removal, disassembly, assembly, installation, and specifications.

Maintenance Manual—Maintenance manuals contain routine maintenance procedures and intervals for vehicle components and systems. These documents have information such as lubrication procedures and tables, fluid replacement procedures, fluid capacities, specifications, and procedures for adjustments and for checking the tightness of fasteners. Maintenance manuals do not contain detailed repair or service information.

Driver's/Operator's Manual—Driver's/operator's manuals contain information needed to enhance the driver's understanding of how to operate and care for the vehicle and its components. Each manual contains a chapter that covers pre-trip and post-trip inspections and daily, weekly, and monthly maintenance of vehicle components. Driver's/operator's manuals do not contain detailed repair or service information.

Service Bulletins—Service bulletins provide the latest service tips, field repairs, product improvements, and related information. Some service bulletins are updates to information in the workshop/service manual. These bulletins take precedence over workshop/service manual information, until the latter is updated; at that time, the bulletin is usually canceled. The service bulletins manual is available only to dealers. When doing service work on a vehicle

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system or part, check for a valid service bulletin for the latest information on the subject. **IMPORTANT:** Before using a particular service bulletin, check the current service bulletin validity list to be sure the bulletin is valid.

Parts Technical Bulletins—Parts technical bulletins provide information on parts. These bulletins contain lists of parts and BOMs needed to do replacement and upgrade procedures.

DTNAConnect Resources

Web-based repair, service, and parts documentation can be accessed using the following applications on DTNAConnect and provides web-based access to the most up-to-date versions of the publications listed above. In addition, the Service Solutions feature provides diagnostic assistance with Symptoms Search, by connecting to a large knowledge base gathered from technicians and service personnel. Search results for both documents and service solutions can be narrowed by initially entering vehicle identification data.

PartsPro

PartsPro® is an electronic parts catalog system, showing the specified vehicle's build record.

EZWiring

EZWiring™ makes Western Star, Freightliner, Freightliner Custom Chassis Corporation, Sterling, and Thomas Built Buses products' wiring drawings and floating pin lists available online for viewing and printing. EZWiring can also be accessed from within PartsPro.

Recall Campaigns

Recall campaigns cover situations that involve service work or replacement of parts in connection with a recall notice. These campaigns pertain to matters of vehicle safety. All recall campaigns are distributed

to dealers; customers receive notices that apply to their vehicles.

Field Service Campaigns

Field service campaigns are concerned with non-safety-related service work or replacement of parts. All field service campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

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Warnings and Safety Guidelines

Introduction



PTOs operate at high speeds, converting large amounts of engine power for use in fast-moving shafts and accessories. Severe injury or even death may occur if an operator or technician comes into contact with a moving PTO. Special care must be used when operating or maintaining a PTO.

The list of safety hazards presented in this document is not comprehensive. For more information about safe operation and maintenance of PTO equipment, contact the equipment manufacturer.

Before operating a PTO, take time to become familiar with your truck's PTO setup and configuration. Thoroughly read all PTO operator and maintenance manuals. If applicable, affix warning labels to PTO components as instructed. Never tamper with or remove PTO warning labels. Become familiar with all potential hazards and strictly follow all safety guidelines outlined by the manufacturer.

Learning resources are available through DTNAConnect and the Customer Assistance Center (CAC).

See [Fig. 1.1](#) for an illustration of a PTO safety hazard sign.



Fig. 1.1, PTO Safety Hazard Sign

Before you install, operate, or perform maintenance on a PTO, follow these guidelines:

- Read and understand the entire manual before installation or operation of PTO and driven equipment.
- Obtain proper training and/or certification before operating a PTO.
- Make sure the PTO is in proper working order.
- Follow all inspection and maintenance schedules listed in [Chapter 7](#).
- Always match the proper PTO with its intended application.
- Never make modifications to a PTO or drive shaft without first consulting an authorized installer.

Before Operating the PTO

Before operating a PTO in a work environment, take time to understand how to startup, run, and shut down the PTO in a controlled manner. Follow the safety procedures listed below.

- Secure loose clothing or hair before working on or around moving components.
- Park the vehicle on a level surface before performing maintenance or attaching PTO accessories.
- Before working under the vehicle, always place jack stands under the frame rails to ensure the vehicle cannot drop.
- Place the vehicle in neutral or park and apply the brakes.
- Installation or removal of PTO safety equipment is the responsibility of the installer. Do not alter any PTO safety equipment without first notifying the installer.
- Remove any protruding debris from PTO components.
- Do not allow the engine to be started while technicians are under the truck.

During Operation

Some PTO operations only occur after certain controls are set before engaging a PTO. These may include setting the parking brake, engine at idle, foot is off the service brake, foot is off the accelerator pedal, and/or setting the transmission in park or neutral. Follow the safety precautions below when engaging or operating a PTO.

Warnings and Safety Guidelines

- Never allow anyone to go under the vehicle while the engine is running.
- Allow the vehicle, PTO, and driven equipment to warm up when operating in weather where temperatures are near or below freezing (32°F [0°C]).
- Apply power to the PTO gradually to avoid unnecessary stress on gears, splines, and output shafts.
- Keep universal joints in phase to prevent excessive vibration from damaging equipment.
- Minimize excessive telescoping.
- Avoid overtightening slip clutches.
- An operator must always be in the driver seat when the engine is running and the transmission is in gear.
- Never operate the PTO above its intended speed or torque ranges. Consult the manufacturer for operating ranges.
- Do not work near an exposed drive shaft while the engine is running.
- Always disengage the PTO and shut down the engine or motor before performing PTO inspections or maintenance.
- The output shaft of a PTO may still turn if the clutch is disengaged in cold temperatures. This rotation may cause sudden movement of the output shaft and attached drive shaft. This could cause serious injury or death.

Reporting Safety Concerns

To contact Daimler Trucks North America (DTNA) about a concern about a specific vehicle, call the Customer Assistance Center at 855-253-0422 or complete a Product Concern Form.

Introduction to Power Take-Offs

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Introduction to Power Take-Offs

Introduction

Power Take-Offs (PTOs) are mechanical gearboxes that are attached to a transmission. This gearbox transfers power from the engine and transmission, through a driveshaft, to auxiliary equipment such as blowers, lifts, generators, and pumps.

Aperture openings (where the PTO is attached) are located on the bottom, side, top, and rear of a transmission. Some transmissions allow for the attachment of multiple PTOs.

Because of the variety of PTO configurations available, different PTOs may be required for different applications. Some driven equipment may require large amounts of torque or horsepower to perform their jobs.

PTOs may be engaged using mechanical linkages, cables, air pressure, or hydraulic pressure. Various output shaft configurations are available to allow for a driveshaft connection or the attachment of hydraulic pumps directly to the PTO without an intermediate shaft.

Example Applications

For detailed information about PTO vocation types and typical power requirements, see [Chapter 3](#).

The following is a general list of PTO vocations supported by DTNA:

Stationary applications

- Telescoping boom
- Fire and rescue
- Diggers
- Fuel transport

Mobile applications

- Dump truck
- Brush fire or airport fire trucks
- Salt/sand snow plow trucks

Tow and recovery

- Car carriers
- Fixed boom

Refuse

- Front/rear/side loaders



Fig. 2.1, Example PTO Applications

Water trucks

Well drilling

Tractor trailer

- Car hauler
- Bulk feed trailer
- Bulk transfer

Dump trailers

- End/side/bottom dump
- Moving floor
- Low boy trailer

Types of PTOs

Table 2.1 describes the types of PTOs available and their mounting location on the transmission.

Introduction to Power Take-Offs

Types of PTOs	
Type	Description
Front Engine PTO (FePTO)	Mounted on the crankshaft forward flange. This PTO usually powers large hydraulic pumps.
Rear Engine PTO (RePTO)	Typically connected between the engine and transmission. The PTO can be shiftable or constantly engaged. Used for powering hydraulic pumps with additional power transfer capabilities.
Side-Mounted PTO	These PTOs can be mounted on the left or right side, or both sides of a transmission. These are input shaft PTOs but sometimes operate as constant mesh (constantly engaged) PTOs.
Bottom-Mounted and Side-Mounted PTOs	Typically, a main transmission-mounted PTO driven by a gear on the main or counter shaft of the transmission and dedicated to powering the PTO.
Split Shaft PTO	These PTOs divide the drive shaft into two sections: a section that faces the transmission gearbox and another section that faces the rear axle of the vehicle.
Auxiliary Transmission	This PTO is mounted to the auxiliary transmission aperture. It is similar to the main transmission in that it rotates whenever the input shaft to the auxiliary transmission rotates.
Rear-Mounted PTO	A rear-mounted PTO is an extension of the countershaft in the transmission. This type of PTO can rotate when the transmission is in gear or in neutral.

Table 2.1, Types of PTOs

Figure 2.2, Fig. 2.3, Fig. 2.4, Fig. 2.5, Fig. 2.6, Fig. 2.7, and Fig. 2.8 show different PTO mounting options.

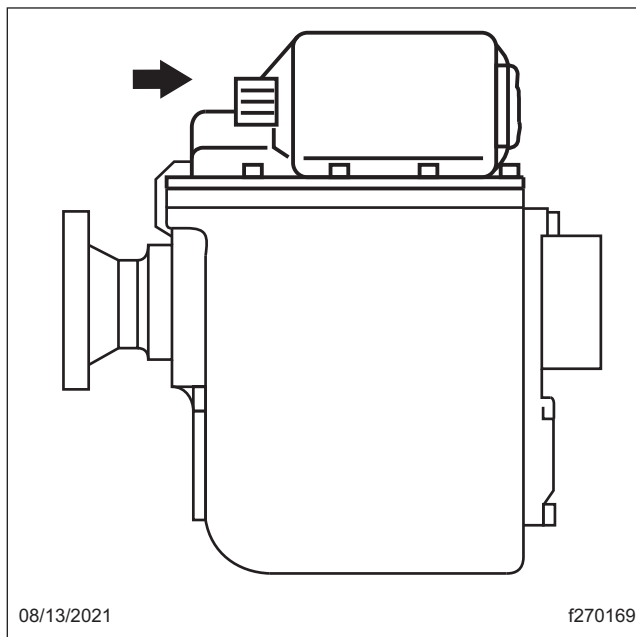


Fig. 2.2, Top Mount on Auxiliary Transmission

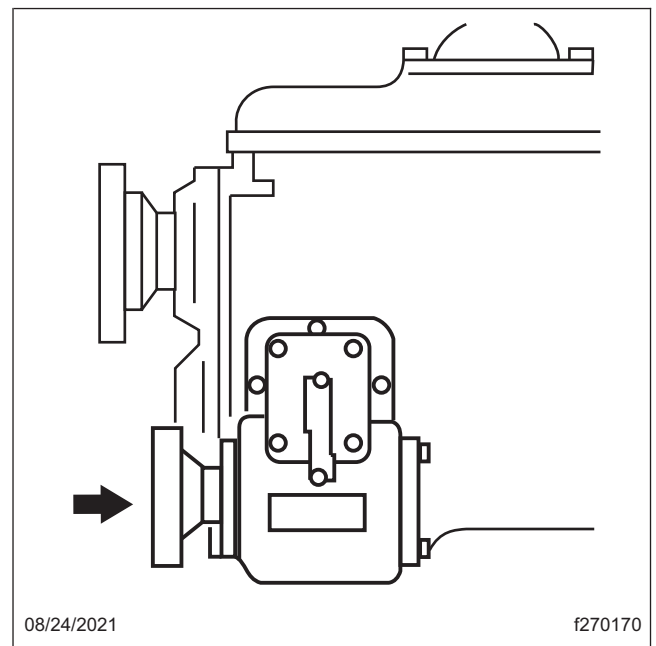


Fig. 2.3, Side Mount

Introduction to Power Take-Offs

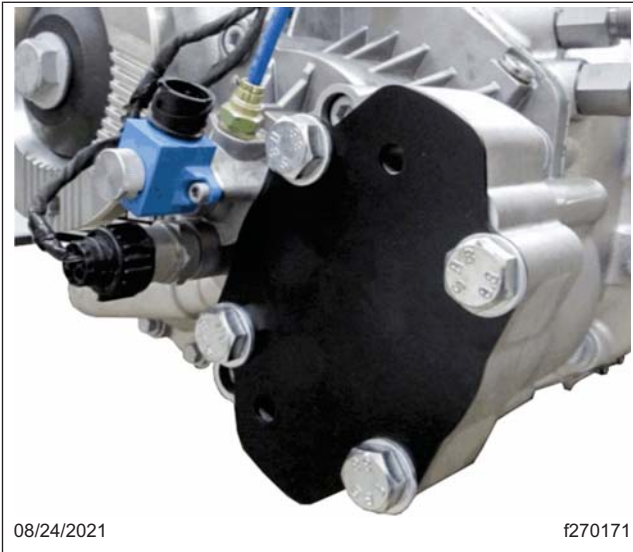


Fig. 2.4, Countershaft (rear transmission mount)



Fig. 2.6, Auxiliary Transmission Input Shaft PTO

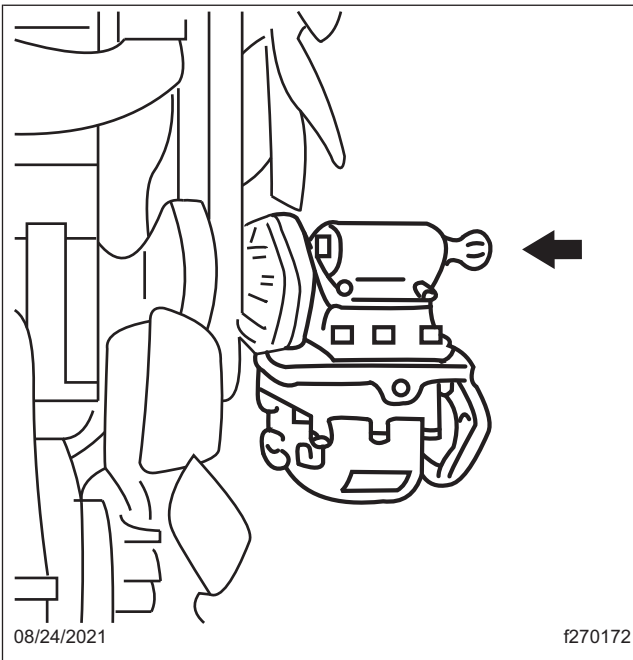


Fig. 2.5, Crankshaft Driven

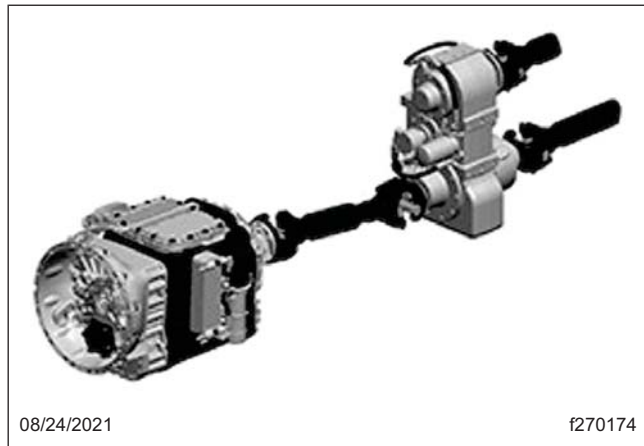


Fig. 2.7, Split Shaft PTO

Multiple PTO Configurations

Many transmissions are capable of handling multiple PTOs for applications such as vacuum trucks and multi-functional tankers. For more information, see your local sales representative.

Introduction to Power Take-Offs

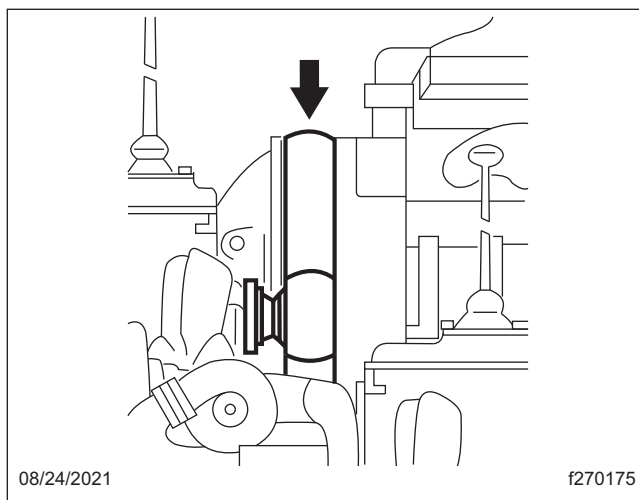


Fig. 2.8, Flywheel (RePTO) Mounted PTO

PTO Components

Figure 2.9 shows an exploded view of a typical PTO.

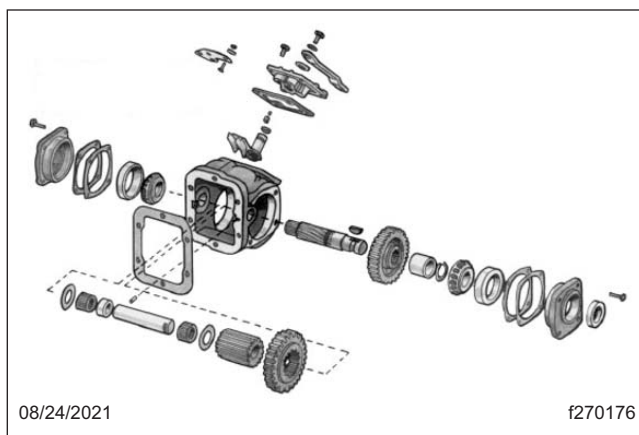


Fig. 2.9, PTO Components Breakdown

Transmission Compatibility

Currently, DTNA offers PTO support for the following transmissions:

PTO Transmission Openings	
Transmission Openings	Description
6 bolt	Located on Allison 1000/2000 series transmissions and Eaton Fuller transmissions.
8 bolt	Located on the bottom of Detroit DT12 and the following Eaton Fuller Endurant and Roadranger transmissions.

- Allison 1000/2000/3000/4000 series transmissions
- Detroit DT12 Automated Manual Transmissions
- Eaton Fuller Endurant or UltraShift Automated Manual Transmissions
- Eaton Fuller Roadranger Manual Transmissions

See **Chapter 5** for information about pairing the proper PTO with a vehicle's transmission.

Transmission Aperture Openings

Table 2.2 describes the types of transmission openings used for mounting PTOs.

Figure 2.10 shows various types of mounting configurations for PTOs.

Figure 2.11 shows Allison 3000 and 4000 series 10-bolt openings.

Figure 2.12 shows Detroit DT12 transmission openings.

Rear mount options are not available on all Eaton Fuller transmissions.

If available, all rear-mount provisions are an option and must be ordered ahead of time for the transmission; retrofit is not possible.

Figure 2.13 shows Eaton Fuller Roadranger manual transmission PTO openings.

Rear mount options are not available on all Eaton Fuller transmissions.

If available, all rear-mount provisions are an option and must be ordered ahead of time for the transmission; retrofit is not possible.

Figure 2.14 shows the location of the ThruShaft PTO opening.

Introduction to Power Take-Offs

PTO Transmission Openings	
Transmission Openings	Description
10 bolt	Used for Allison 3000 and 4000 series transmissions.

Table 2.2, PTO Transmission Openings

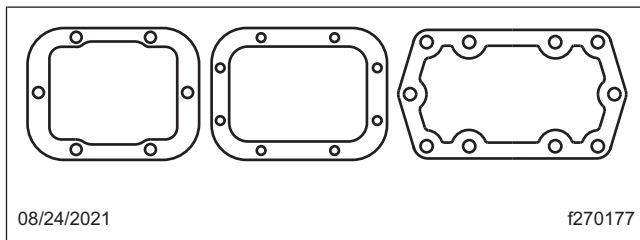


Fig. 2.10, Six, Eight, and Ten Bolt Mounting Configurations

PTO Corner contains in-depth information about PTO programming, sales aids, training guides, and application assistance.

Figure 2.15 shows the PTO Corner area of the DTNAConnect search page.

Daimler Customer Assistance Center (CAC)

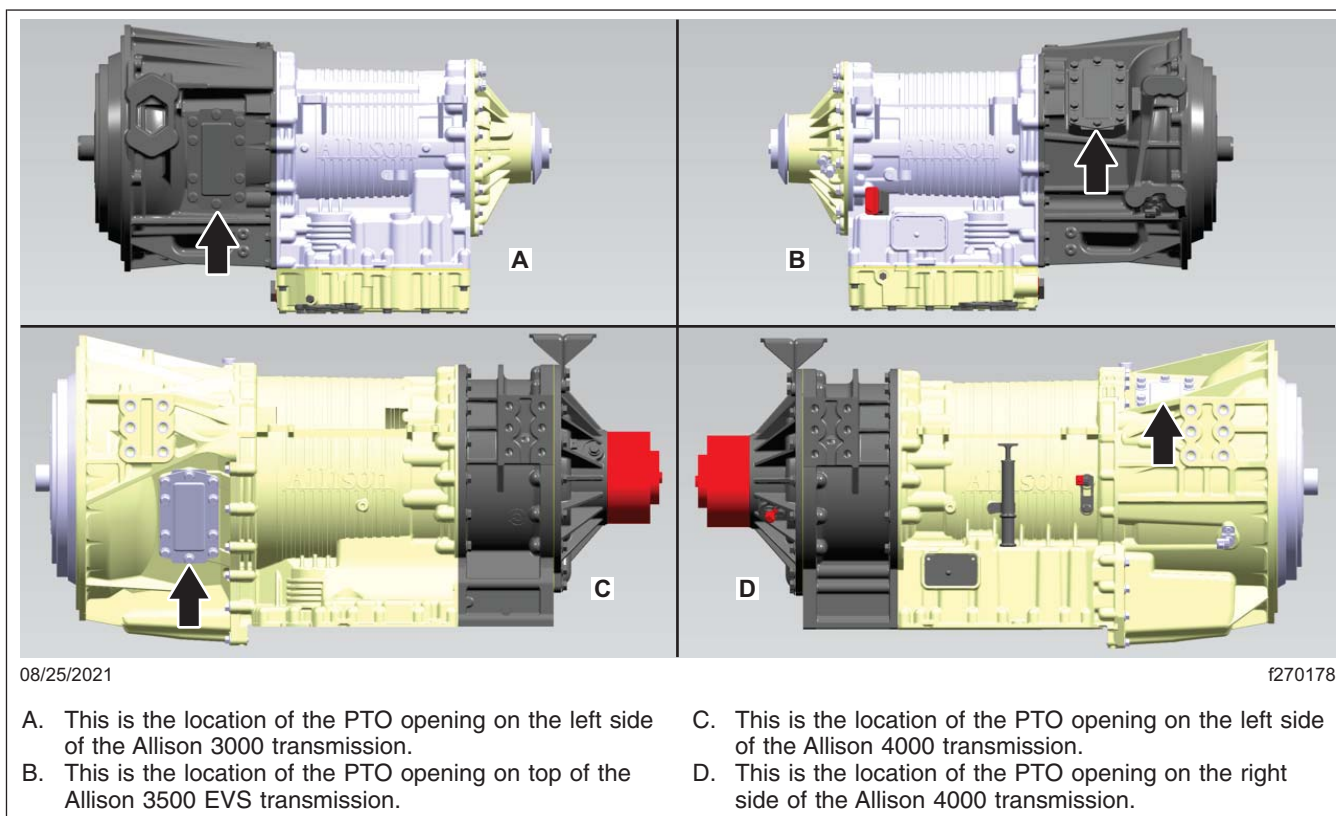


Fig. 2.11, Allison 3000 and 4000 Series 10-Bolt PTO Openings

PTO Documentation and Support

DTNA offers a library of support documentation located in the DTNAConnect Body Builder Guide. The

For technical assistance, go to the Customer Assistance Center web page on DTNAConnect.

<https://dtnacontent-dtna.pr.d.freightliner.com/content/dtna-connect/cac/customerassistancecenter.html>

Introduction to Power Take-Offs

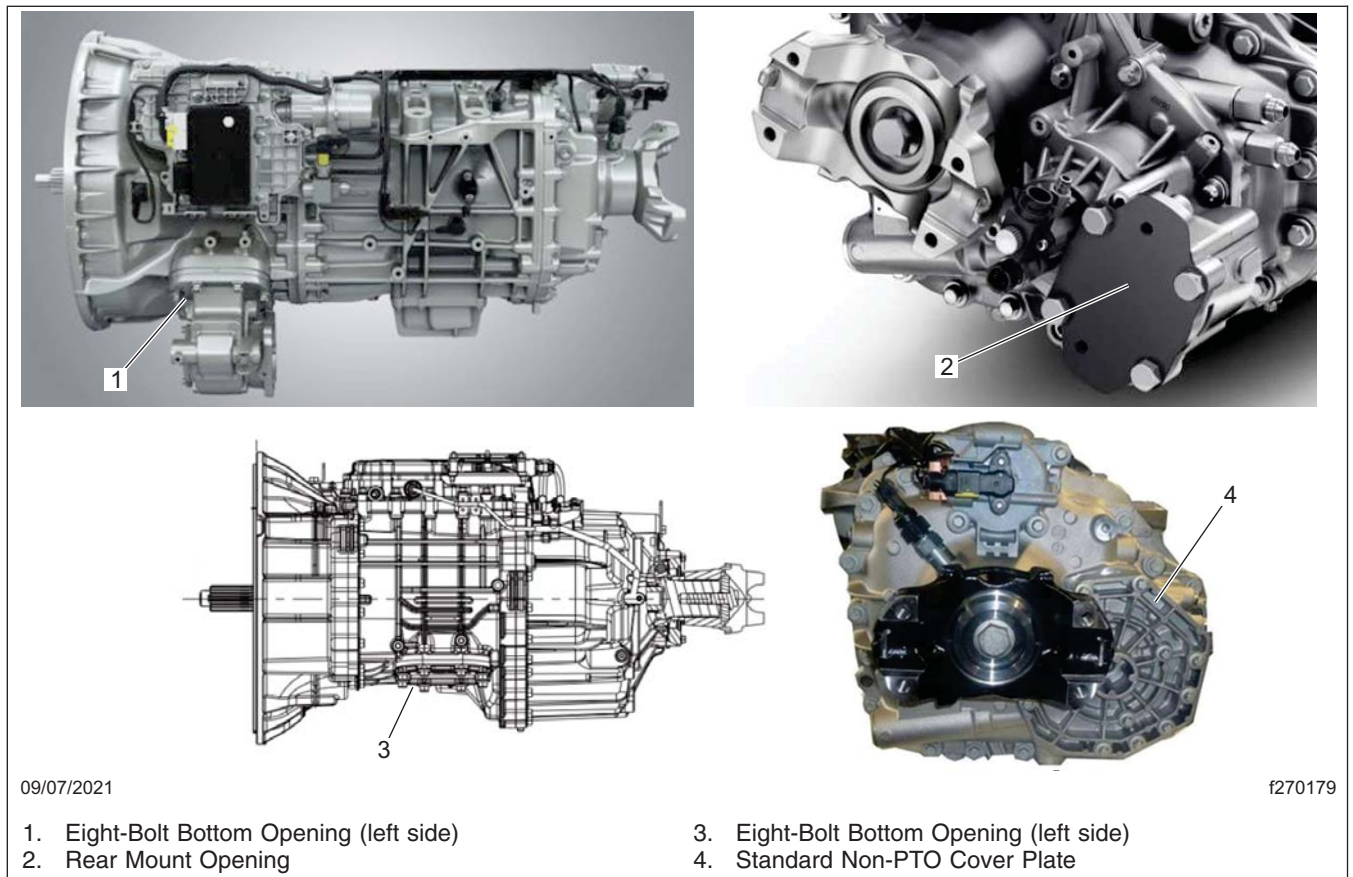


Fig. 2.12, Detroit DT12 Transmission Openings

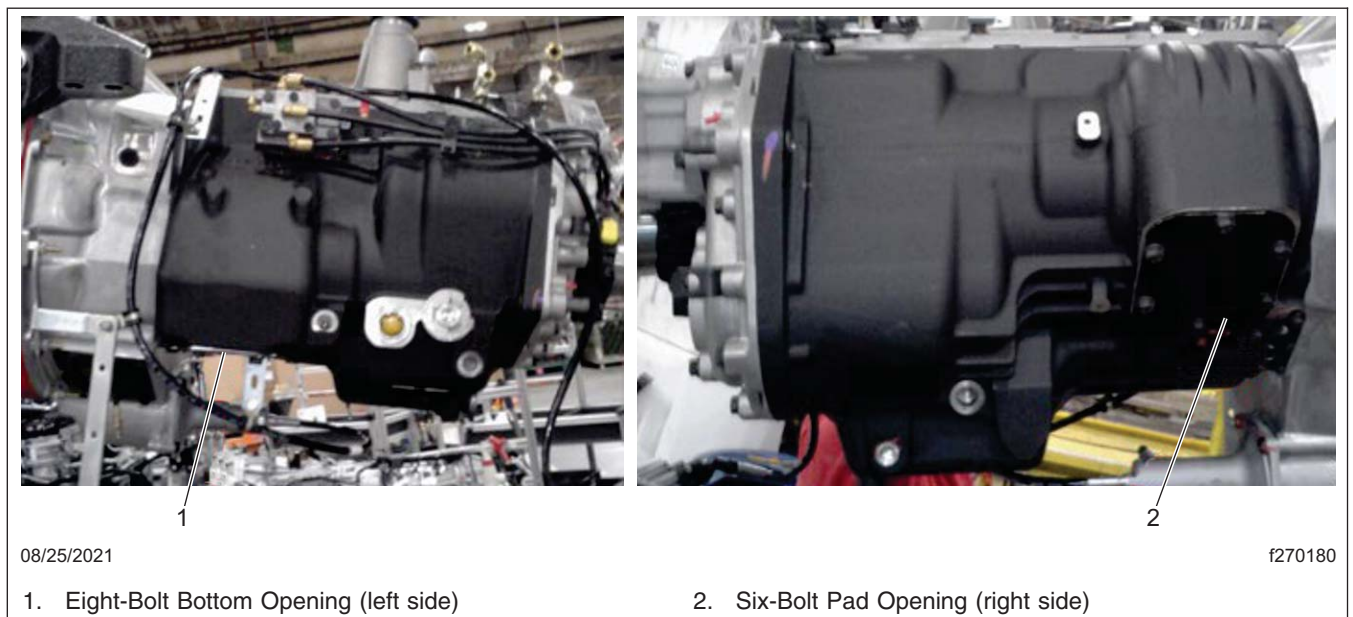
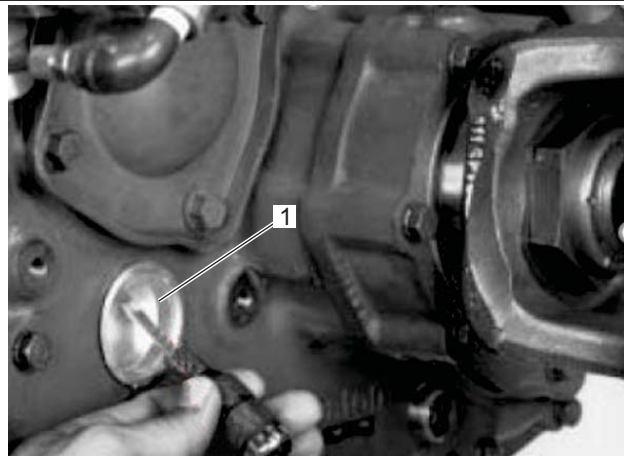


Fig. 2.13, Eaton Fuller Roadranger Manual Transmissions

Introduction to Power Take-Offs



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1. ThruShaft PTO Opening, Left Side of Rear Transmission Case

Fig. 2.14, ThruShaft PTO Opening

Aftermarket Resource Center (ARC)

Web-based training on PTOs and other technical training is available in the Aftermarket Resource Center (ARC) learning platform. For questions on current PTO course availability or access requests, please email sta@daimler.com.

Technical Resource Guides

Search for Technical Resource Guides pages by Model, Area, Axle Position, and Keyword.

Select Model
ALL

Vehicle System
...

Axle Position
...

Keyword Search
data codes, module name, keyword...

Q

☐ + General Intro & Legal Information

☐ + Cab **New!**

☐ + Chassis

☐ + Electrical **New!**

GENERAL INFORMATION

ATS and DEF Modification Guide
(EPA2010_GHG14)_RevC-2015 (pdf, 1 mb)

Exhaust & ATS Mod Guide
(EPA2010_GHG17)_Rev(-)-2018 (pdf, 2 mb)

ADDITIONAL LINKS

PTO Corner

+ PTO Programming Guides

+ PTO Sales

+ PTO Training Guides

+ PTO Installation Guides

+ PTO Application Appendix

+ PTO Parameters

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Fig. 2.15, PTO Corner in the DTNACONNECT Body Builder Guide

Figure 2.16 shows the Daimler Trucks Technical Support page.

Introduction to Power Take-Offs

Daimler Trucks Technical Support

The Daimler Trucks North America Technical Support is here to assist our customers and technicians with everything from Roadside Assistance and locating a dealership, to advanced diagnostics and troubleshooting. Please give us a call, or use the forms below to reach us for assistance with these or any other vehicle technical support needs.

DTTS Tickets (Search/Update/Create)

Click on the above link to Search/Create/Update a technical support inquiry or technical modification request.

DTTS User Guide

Click this link to open the DTTS User Guide.

DTNA Solutions

DTNA Solutions is our Technical Support Community and Knowledge Base. Check it out to connect with other technicians, ask questions in the forums, give feedback, and to search and browse through our Solutions database for known issues and the latest Tech Support News.

POST System Quick Quote Process

Description of the POST System Quote Process

eComponents

Web site to assist in locating small electrical parts such as relays, fuses, connectors, terminals, seals, etc.

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PHONE SUPPORT FOR CUSTOMERS

Freightliner: (800) 385-4357, available 24x7
Sterling: (800) 785-4357, available 24x7
Western Star: (866) 850-7827, available 24x7
Parts Inquiries: (855) 253-0422

PHONE SUPPORT FOR DEALERS

Parts Order: (855) 639-8660
Parts Technical: (855) 253-0422
Service Technical: (855) 253-0422
Detroit: (800) 445-1980, available 24x7

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Fig. 2.16, Daimler Trucks Technical Support

3

PTO Applications

Application Selection Table	3.1
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PTO Applications

Application Selection Table

Table 3.1 represents typical PTO applications. Before selecting or purchasing a PTO, consult your local sales representative for recommendations on

specific PTO application combinations. PTO series that are not in bold are mechanically engaged and, if not engaged properly, will cause gears to clash, causing premature wear. PTOs in **bold** are clutch pack PTOs and will not experience gear clashing.

Typical PTO Applications					
Truck Platform	Torque: lbf-ft (N·m)	Horsepower	Bezares PTO Series	Chelsea PTO Series	Muncie PTO Series
Utility Trucks					
Non-Overcenter Bucket	175-225 (237-305)	33-43	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Overcenter Bucket	175-225 (237-305)	33-43	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Telescopic	175-225 (237-305)	33-43	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Telescopic Articulating	175-250 (237-339)	33-48	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Telescopic Boom Trucks	175-500 (237-678)	33-95	1000, 2000, 8500, 3252	442, 489, 823, 880, 280	TG6, TG8, 828, SH8, CS24
Knuckle Boom	175-250 (237-339)	33-48	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Digger Derick	250-500 (339-678)	38-95	2000, 4100, 8500	489, 680, 880, 823, 280, 870	TG8, SH8, 828
Dump Trucks					
End Dump	170-210 (230-285)	32-40	2000, 3200, 3252	489, 272, 280	TG8, CS8, CS10
Side Dump	180-205 (244-278)	42-50	2000, 3200, 3252	489, 272, 280	TG8, CS8, CS10
Bottom Dump	175-225 (237-305)	33-43	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Moving Floor	233-300 (316-407)	50-70	2000, 4100	489, 860	TG8, SH8
Moving Floor and End Dump Combination	170-300 (230-407)	32-70	2000, 4100	489, 860	TG8, SH8
Fire Trucks					
Pumper/Tankers*	500-670 (678-908)	95-127	3131	870	CS10, CS41
Aerial	175-225 (237-305)	33-43	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Service Trucks					
Service Trucks Typical with Air Compressor, Generator, and Small Crane	140-200 (190-271)	26-42	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Tow and Recovery					
Car Carriers Tilt Body	175-200 (237-271)	33-43	2000, 3200, 3252	489, 272, 280	TG8, CS6, CS10
Fixed Boom	175-200 (237-271)	33-43	2000, 3200, 3252	489, 272, 280	TG8, CS6, CS10
Hook Lift	175-200 (237-271)	33-43	2000, 3200, 3252	489, 272, 280	TG8, CS6, CS10
Rotator	175-200 (237-271)	33-95	2000, 4100, 8500	489, 680, 880, 823, 280, 870	TG8, SH8, 828
Wheel Snatcher	120-225 (163-305)	23-43	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10

PTO Applications

Typical PTO Applications					
Truck Platform	Torque: lbf-ft (N.m)	Horsepower	Bezares PTO Series	Chelsea PTO Series	Muncie PTO Series
Car Transport Trailer	105-155 (142-210)	20-30	2000, 3200, 3252	489, 272, 280	TG8
Refuse					
Front Loader	200-250 (271-339)	38-48	3200, 3252	272, 280	CS6, CS10
Rear Loader	175-220 (237-298)	40-50	3200, 3252	272, 280	CS6, CS10
Side Loader	175-220 (237-298)	40-50	3200, 3252	272, 280	CS6, CS10
Roll Off Containers/Tilt Body	175-220 (237-298)	40-50	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Municipal Trucks					
Salt/Sand and Plow (central hydraulics) [†]	150-200 (203-271)	30-35	3100	280	CS24
Vacuum/Sewer Sucker [‡]	175-500 (237-678)	33-95	2000, 4100, 8500	489, 680, 880, 823, 280, 870	TG8, SH8, 828 CS6, CS10
Miscellaneous Trucks					
Water Trucks for Construction Sites	50-100 (68-136)	10-15	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10
Well Drilling (water)	250-500 (339-678)	38-95	2000, 4100, 8500	489 680 880 823, 280, 870	TG8, SH8, 828
Truck Mounted Cranes	175-600 (237-813)	33-114	1000, 2000, 8500, 3252	442, 489, 823, 880, 280	TG6, TG8, 828, SH8, CS24
Yard Spotter	110-135 (149-183)	21-25	1000	442, 272, 280	TG8, CS6, CS10
Bulk Feed Trailer	250-500 (339-678)	38-95	2000, 4100, 8500	489 680 880 823, 280, 870	TG8, SH8, 828
Bulk Transfer Trailer(pneumatic blower) [§]	175-500 (237-678)	33-95	2000, 4100, 8500	489, 680, 880, 823	TG8, SH8, 828
Fuel Oil Delivery/LP Gas [¶]	10-15 (14-20)	50-100	1000, 2000, 3200, 3252	442, 489, 272, 280	TG8, CS6, CS10

* Fire truck applications are continuous duty. Instead of a 30% derating of the PTO's intermittent torque rating, this application will be derated at 20%. The Chelsea 870 series can operate at a water pump flow rate of up to 1500 gallons per minute.

[†] Central hydraulic plow and salt or sanding trucks require a transmission that provides continuous speed and power to the PTO while in drive mode. This requires an Allison 3000 or 4000 series transmission.

[‡] Pneumatic blowers may require a PTO that increases speeds of up to 180% of engine speed. These (along with sewer sucker vacuum trucks [100 to 150%]) can have a very high inertia on start-up. Both Chelsea and Muncie have options to assist in these applications. Do not use automatic or automated manual transmissions for pneumatic blower applications.

[§] Pneumatic blowers may require a PTO that increases speeds of up to 180% of engine speed. These (along with sewer sucker vacuum trucks [100 to 150%]) can have a very high inertia on start-up. Both Chelsea and Muncie have options to assist in these applications. Do not use automatic or automated manual transmissions for pneumatic blower applications.

[¶] These applications are slower moving (usually a maximum of 700 revolutions per minute [rpm]) and require PTOs with a reduction ratio. These driven objects can spin freely and may require a PTO option that will stop the shaft from rotating when disengaged. This option is found on clutch pack PTOs and not found on mechanically-engaged PTOs.

Table 3.1, Typical PTO Applications

NOTE: Hydraulic pumps typically operate at a PTO range of 90 to 130% of engine speed. Hydraulic pumps have a minimum operating rpm range of 600 to 1000 rpm, depending on the pump and manufacturer. Make sure the PTO operates between the suggested minimum and maximum ranges, as specified by the manufacturer.

4

Useful Equations and Formulas

Power Formulas	4.1
Hydraulic Formulas	4.1
Conversion Chart	4.1

Useful Equations and Formulas

Power Formulas

PTOs must be able to transfer a sufficient amount of power from a vehicle's powertrain to its accessories. Because of the varieties of PTOs and PTO options available, it is important to calculate the amount of power and torque required to run an accessory. A properly matched PTO can provide years of reliable service at minimal cost.

NOTICE

Miscalculating PTO requirements may shorten the life of the PTO, transmission, or the driven object(s).

In North America, a PTO's ability to do work is measured in lbf ft of torque. In other locations, a PTO's capacity is measured in kilowatts (kW).

Figure 4.1 shows common equations used when calculating power requirements.

$$PTO\% = \frac{\text{Driven Object rpm}}{\text{Engine rpm}}$$

$$\text{Engine rpm} = \frac{PTO \text{ rpm}}{PTO\%}$$

$$PTO \text{ rpm} = \text{Engine rpm} \times PTO\%$$

$$\text{Torque (lbf ft)} = \frac{\text{Horsepower} \times 5252}{\text{Driven Object rpm}}$$

$$\text{Horsepower} = \frac{\text{Torque (lbf ft)} \times \text{Driven Object rpm}}{5252}$$

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Fig. 4.1, Power Formulas

Hydraulic Formulas

Table 4.1 lists common abbreviations used when calculating hydraulic formulas.

Common Hydraulic Abbreviations	
Abbreviation	Definition
gpm	gallons per minute

Common Hydraulic Abbreviations	
psi	pounds per square inch
CIR	cubic inch per revolution
rpm	revolutions per minute

Table 4.1, Common Hydraulic Abbreviations

Most gear pumps operate at 85% efficiency. For exact hydraulic pump efficiency rates, consult the manufacturer. Figure 4.2 shows common equations used when calculating hydraulic power requirements.

$$\text{Pump input horsepower} = \frac{\text{gpm} \times \text{psi}}{1714 / 0.85}$$

$$\text{Pump output flow in gpm} = \frac{\text{CIR} \times \text{rpm}}{231 \times 0.85}$$

$$\text{Pump input rpm} = \frac{\text{gpm} \times 231}{\text{CIR} / 0.85}$$

$$\text{Pump displacement (CIR)} = \frac{\text{gpm} \times 231}{\text{rpm} / 0.85}$$

$$\text{Pump flow in gpm} = \frac{\text{Engine rpm} \times PTO\% \times \text{CIR}}{231 \times 0.85}$$

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Fig. 4.2, Hydraulic Formulas

Conversion Chart

Table 4.2 lists formulas for common unit conversions.

Conversion Chart		
From	To	Multiply By
horsepower (hp)	watts	745.7
horsepower (hp)	kilowatts (kW)	0.7457
foot pounds (lbf·ft)	Newton meters (N·m)	1.356
gallons (U.S.)	cubic inches (in ³)	231
gallons (U.S.)	liters	3.785
cubic inches (in ³)	cubic centimeters (cm ³)	16.39
cubic inches (in ³)	liters	0.01639

Useful Equations and Formulas

Conversion Chart		
pounds per square inch (psi)	BAR	0.06895
pounds per square inch (psi)	kilo Pascal (kPa)	6.895

Table 4.2, Conversion Chart

5

Selecting a PTO

Overview	5.1
Calculating Torque and Horsepower Requirements	5.1
Determining Rotation Direction	5.2
Assembly Arrangements	5.2
Choosing Driven Equipment Connections	5.2
Mounting Locations	5.6
Duty Cycles	5.7
Speed, Reverse Gear, and Clearance Requirements	5.7
Geared Adaptors	5.8

Selecting a PTO

Overview

With many PTO options available, selecting a PTO can be challenging. Information about the intended application, power requirements, and mounting options must be gathered before selecting the proper PTO. This chapter covers the following topics:

- Calculating torque and horsepower requirements
- Determining rotation direction
- Assembly arrangements
- Choosing driven equipment connections
- Mounting locations
- Duty cycles
- Speed, reverse gear, and clearance requirements
- Geared adaptors

Calculating Torque and Horsepower Requirements

The first step in selecting a PTO is to match the proper transmission with the application requirements. Before selecting a PTO, follow the steps below:

1. Determine which transmission make and model is installed on the vehicle. Transmission ID information is printed on a plate, usually located on the lower-right side of the transmission (Allison and Eaton Fuller) or on the rear case (Detroit). See [Fig. 5.1](#).

2. Determine the type of equipment to be driven by the PTO. Different types of driven equipment have different power requirements:

- hydraulic pumps used in dump trucks and aerial devices are the most popular (gear, vane, piston)
- product pumps used in the transfer of water or liquids
- pneumatic blowers
- mechanical winches
- generators

For specific operating requirements for each type of accessory, contact the equipment manufacturer.

3. Enter the horsepower requirements for the PTO accessory: _____

4. Enter the operating revolutions per minute (rpm) of the engine and driven equipment:

Determine the percentage of engine speed that the PTO should operate and the torque capacity required for proper operation using the following formulas.

Note that engine rpm may need to be adjusted to meet the power requirements of the PTO-driven equipment.

Approximate engine rpm during operation: _____

Desired operating rpm of driven equipment: _____

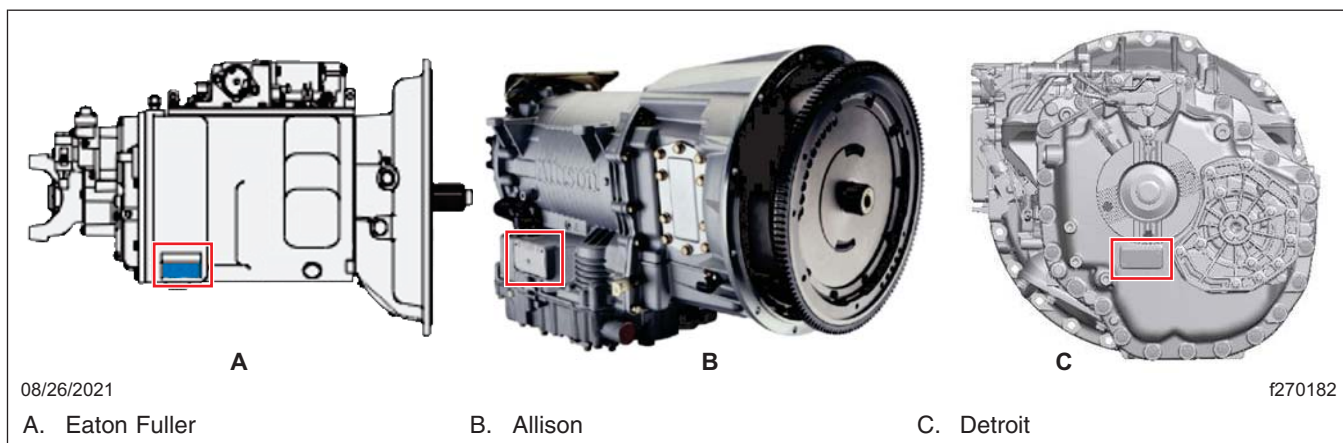


Fig. 5.1, Locating Transmission Identification Information

Selecting a PTO

- Compare the application's PTO requirements with manufacturer specifications to best match the available PTO.

Use the formulas shown in [Fig. 5.2](#)

$$PTO\% = \frac{\text{Driven Object rpm}}{\text{Engine rpm}}$$

$$Torque = \frac{\text{Horsepower} \times 5252}{\text{Driven Object rpm}}$$

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Fig. 5.2, PTO Requirement Formulas

Example:

dump pump: 30 gallons per minute (gpm)

system pressure: 2000 pounds per square inch (psi)

pump efficiency: 90%

pump operating speed: 1200 rpm

engine speed: 1000 rpm

The selected PTO should have a torque rating of 170 lbf-ft or greater and operate at 120% of engine speed.

Determining Rotation Direction

PTO-driven equipment may require the PTO shaft to rotate clockwise or counter clockwise. PTO rotation direction is described in relation to the rotation of the engine.

The terms ENG or CRNK refer to a PTO that rotates in the same direction as the engine. OPP describes a PTO that rotates in the opposite direction of the engine.

Rotation of the driven equipment is determined by viewing the rear of the vehicle.

Table 5.1 describes the types of transmission openings used for mounting PTOs.

PTO Shaft and Engine Rotation		
Driven Item Shaft Rotation	Counter Clockwise	Clockwise
PTO shaft rotation in catalogs	OPP	ENG/CRNK

Table 5.1, PTO Shaft and Engine Rotation

Figure 5.3 shows engine rotation viewed from the front and rear.

See **Fig. 5.4** for a diagram of engine and shaft rotation.

Rotation of the driven equipment is determined by viewing the rear of the vehicle. See **Fig. 5.5**.

Figure 5.6 shows counter clockwise and clockwise rotation of the PTO shaft and engine.

Assembly Arrangements

The PTO is normally specified with the output shaft below the centerline of the PTO and the shaft pointing toward the rear of the truck.

Figure 5.7 shows the four basic assembly arrangements for each manufacturer.

Choosing Driven Equipment Connections

There are two main types of connections between a PTO and the driven objects: direct mount pump flange (recommended) and drive shaft.

Direct Mount Pump Flange

Direct mount pump flange connections provide a direct connection between the PTO and driven equipment. SAE and ISO pump flanges are very popular and simplify installation. This type of connection eliminates exposed driveline and is popular on hydraulic pumps. **Figure 5.8** shows a diagram of direct mount pump flanges.

Flanges and shafts for the vocational truck market are found in the following combinations.

SAE Flanges:

- SAE 'A' two or four bolt with a 3.250 inch pilot diameter
- SAE 'B' two or four bolt with a 4.000 inch pilot diameter

Selecting a PTO

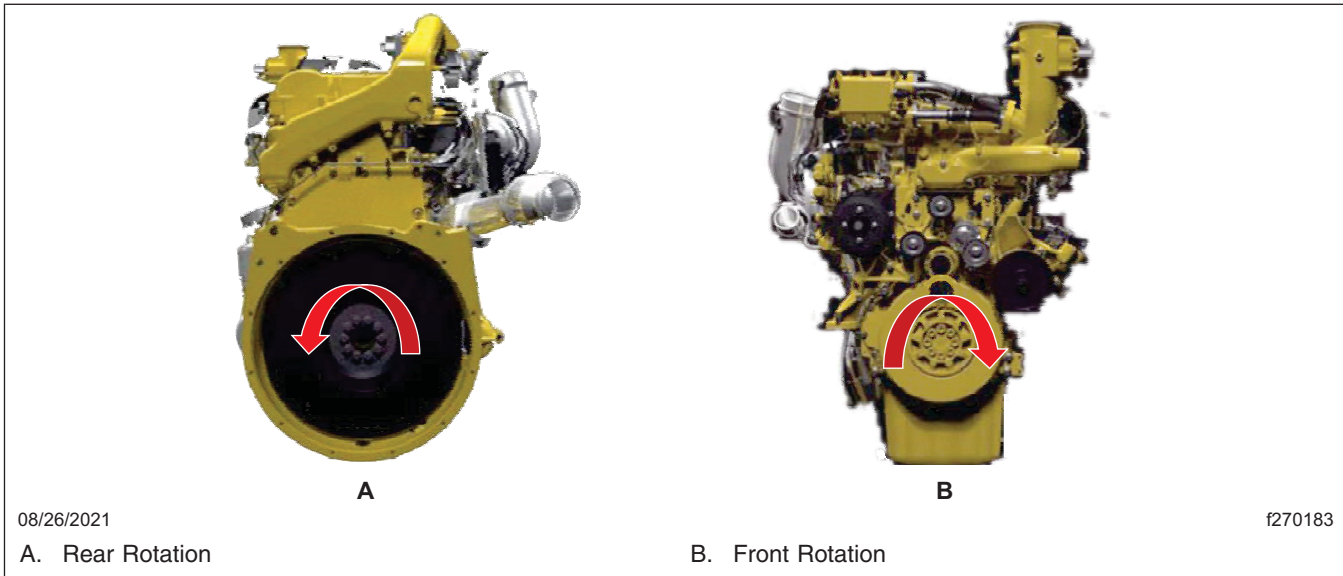


Fig. 5.3, Rotation Viewed from the Rear and Front of the Engine

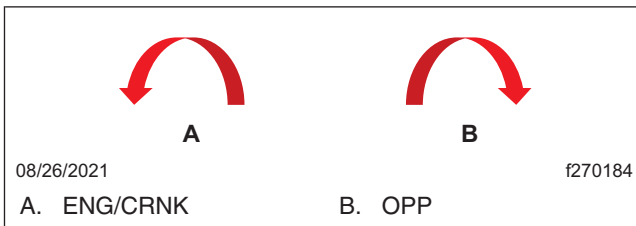


Fig. 5.4, Engine Rotation

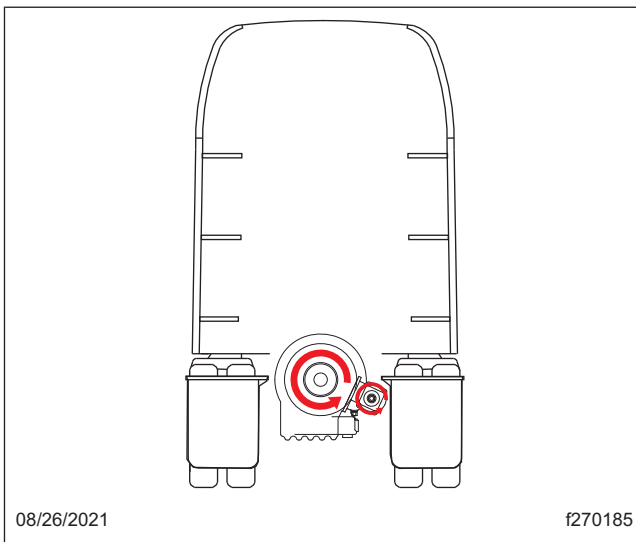


Fig. 5.5, Crankshaft Rotation

- SAE 'C' two or four bolt with a 5.000 inch pilot diameter

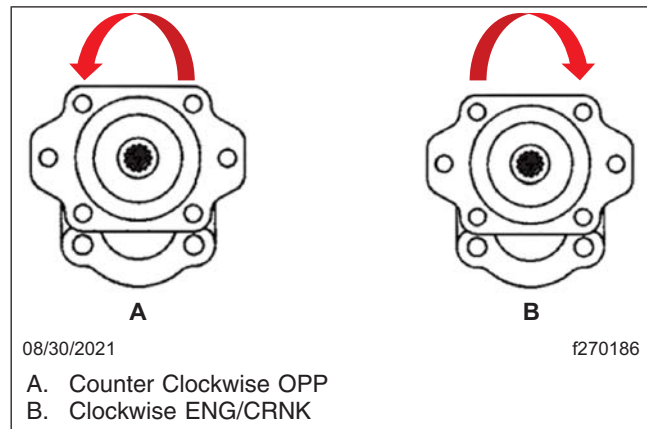


Fig. 5.6, PTO Shaft and Engine Rotation

- SAE 'D' two or four bolt with a 6.000 inch pilot diameter

SAE Shafts:

- SAE 'A' nine tooth 0.625 inch diameter
- SAE 'AA' 11 tooth 0.750 inch diameter
- SAE 'B' 13 tooth 0.875 inch diameter
- SAE 'BB' 15 tooth 1.000 inch diameter
- SAE 'C' 14 tooth 1.250 inch diameter
- SAE 'D' 13 tooth 1.750 inch diameter

SAE 'A' and 'AA' shafts are found with the SAE 'A' flange.

Selecting a PTO

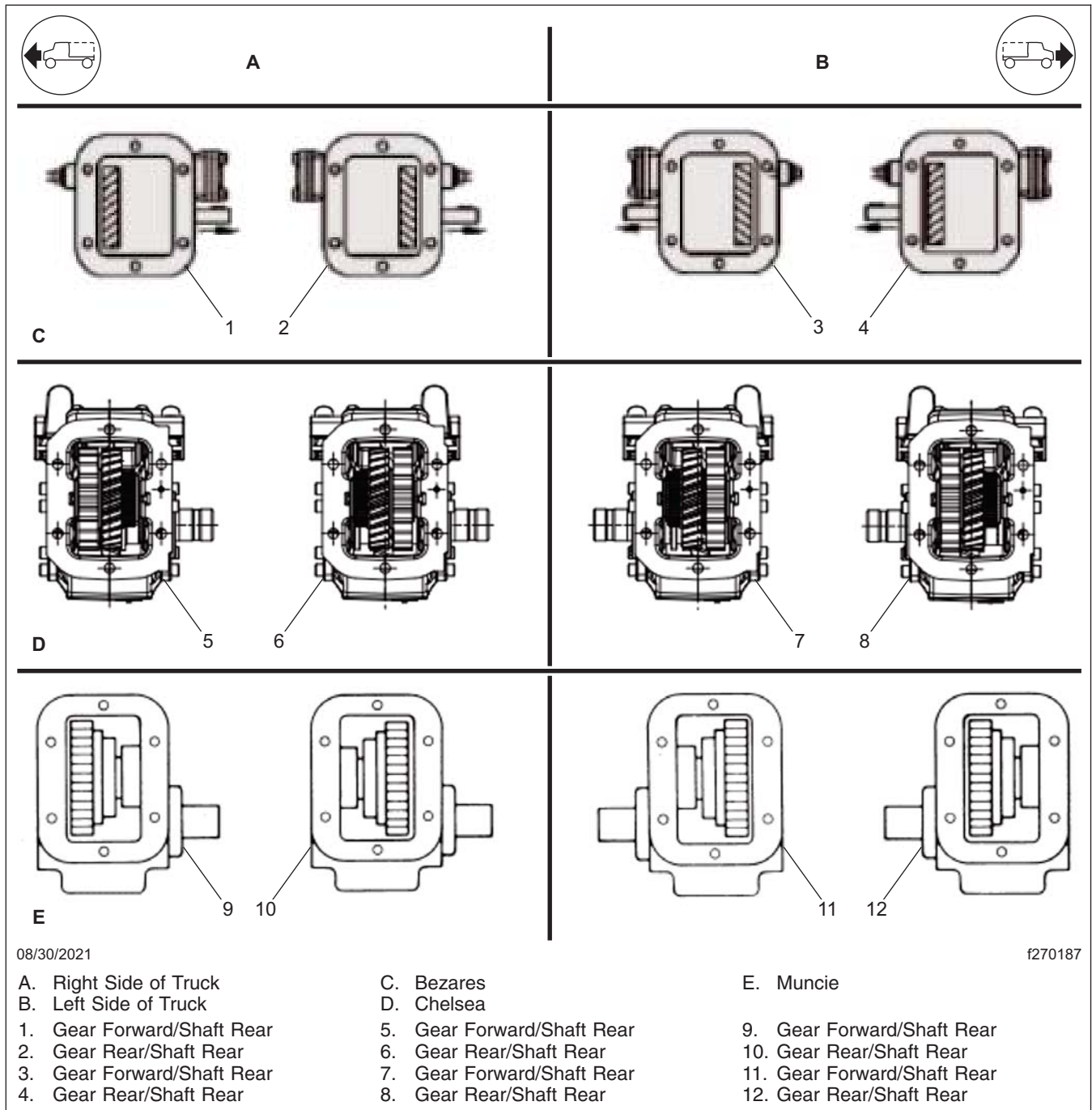


Fig. 5.7, PTO Assembly Arrangements

SAE 'B' and 'BB' shafts are found with the SAE 'B' flange.

Occasionally, SAE 'C' shafts will be available with an SAE 'B' flange.

ISO Flanges and DIN Shafts

One common ISO flange and DIN shaft combination is found in North America:

Selecting a PTO

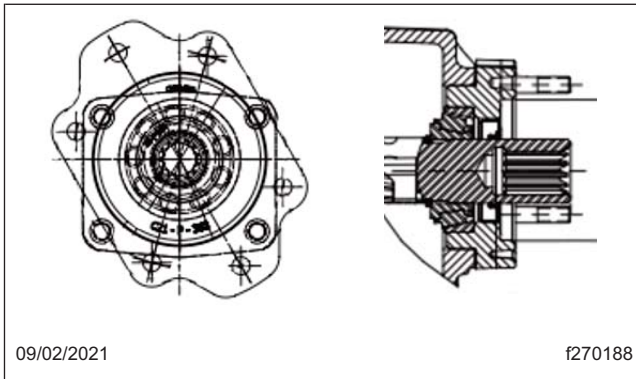


Fig. 5.8, Direct Mount Pump Flanges

- ISO 7653 flange 80 mm pilot and a DIN 5462 shaft eight tooth 36 mm diameter

Pump Mounting

A direct-mount pump may require additional support when mounted to the transmission if:

- The pump weighs more than 40 lb.
- Total length is greater than 18 in from the centerline of the PTO to the end of the pump.
- Support bracket should have four connecting points: two on the transmission and two on the pump.

Consult each PTO manufacturer for their recommended mounting guidelines.

Each PTO manufacturer has several pump flange positions or flanges that may be rotated that will assist in clearing obstructions under the truck. The proper combination of shafts and flanges will make it easier to select the right output shaft.

Drive Shaft and Flange Selection

This will require a companion flange (different from a pump flange), a companion flange yoke, or end yoke with a driveline between them to transfer the power and rotation to the driven object. **Figure 5.9** shows a typical driveline and flange setup.



Fig. 5.9, Drive Shaft

Figure 5.10 illustrates three flange options:

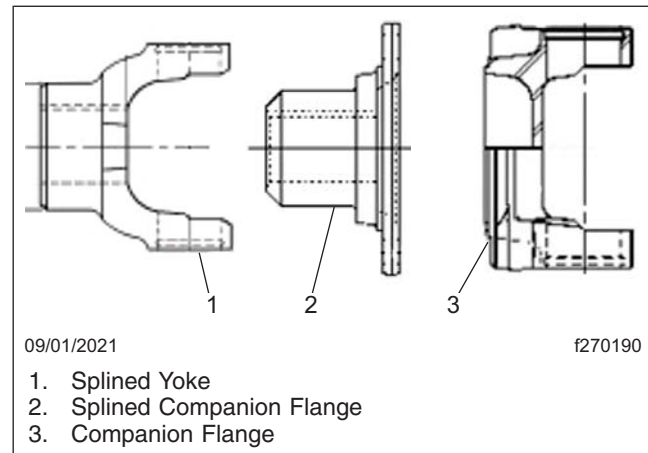


Fig. 5.10, Flange Options

Options to consider with a flange and shaft combination include:

- driveline operating angle
- critical operating speeds of the driveshaft

Consult the PTO manufacturer and driveline manufacturer for recommendations on the proper size and length of the driveline components.

WARNING

Rotating auxiliary drive shafts may cause serious injury or death if the following safety precautions are not followed:

- Do not go under the vehicle when the engine is running.
- Do no work on or near an exposed shaft when the engine is running.
- Shut off the engine before working on the PTO or driven equipment.
- Secure all loose clothing and hair when working around a driveline shaft.
- Exposed rotating drive shafts must be guarded.

Selecting a PTO

Mounting Locations

Manufacturers offer a variety of PTOs that can be paired to match the mounting requirements of available transmissions. Note that when selecting a PTO

mounting option, the location is determined by viewing the truck from the rear and looking forward.

Table 5.2 describes the relative mounting locations for common PTOs.

PTO Mounting Locations		
Transmission Manufacturer	Mounting Bolts	Relative Position Options
Allison Transmissions		
1000/2000 Series	6	Left side: 9 o'clock Right side: 3 o'clock
3000 Series	10	Left side: 9 o'clock Right side: 3 o'clock
3500 EVS Series	10	Left side: 9 o'clock Right side: 1 o'clock
4000 Series	10	Left side: 9 o'clock Right side: 1 o'clock
Detroit Transmissions		
DT12	8	Bottom left side: 9 o'clock Rear-mount right side counter shaft
Eaton Fuller Transmissions*		
Advantage Series Transmissions		
Advantage (FA models)	8	Bottom left side: 7 o'clock Right side: 5 o'clock
	3	Left side of rear case/Thrushaft™†‡ Right side: 5 o'clock
Endurant		
FS Series (medium duty)	6	Left side: 9 o'clock Right side: 3 o'clock
F and FO Series (medium duty)	6	Left side: 8 o'clock Right side: 4 o'clock
	4	Directly below main output shaft‡
Roadranger RT Series§	8	Bottom left side: 7 o'clock
	6	Right side: 5 o'clock
	3	Rear mount lower left side of rear case‡¶
FR Series (heavy duty manual)	8	Bottom left side: 7 o'clock
	6	Right side: 5 o'clock
	3	Lower left side of rear case‡ Upper right side of rear case¶
UltraShift Heavy Duty Automated (FAO, FAOM, FAM, FO, FOM, FM, RTO)	8	Bottom left side: 7 o'clock
	6	Right side: 5 o'clock
	3	Lower left side of rear case‡
Auxiliary Transmission (AT 1202)	8	Top side: 12 o'clock
	6	Bottom side: 6 o'clock

Selecting a PTO

PTO Mounting Locations		
Transmission Manufacturer	Mounting Bolts	Relative Position Options
Chelsea		
912 Series	Three 8-bolt openings	Top, left, and right side: one opening used for a shift cover
Muncie		
SS66	Two 6-bolt openings	Left and right side
SS88	Two 8-bolt openings	Left and right side

* The selected transmission must be equipped with the correct options to meet the application requirements. Some Eaton Fuller transmissions are equipped with a heavy duty bearing capable of 500 lbf.ft of capacity for PTO applications. Some models come with a standard bearing capable of 350 lbf.ft of capacity for PTO applications, however a heavy-duty bearing may be ordered as an option for increased capacity.

† This option must be approved by Eaton Fuller.

‡ If available, this option must be ordered in advance.

§ The selected transmission must be equipped with the correct options to meet the application requirements. Some Eaton Fuller transmissions are equipped with a heavy duty bearing capable of 500 lbf.ft of capacity for PTO applications. Some models come with a standard bearing capable of 350 lbf.ft of capacity for PTO applications, however a heavy-duty bearing may be ordered as an option for increased capacity.

¶ Available on select transmissions.

Table 5.2, PTO Mounting Locations

Duty Cycles

PTOs are rated for either intermittent or continuous duty.

- Intermittent duty cycle PTOs are run for five minutes or less out of every 15 minutes of operation.
- Continuous duty cycle PTOs operate for more than five minutes out of every 15 minutes of operation.

Torque handling requirements for continuously operating PTOs must be increased. This increased torque

requirement is determined by dividing the torque required by 0.7. For example, 140 lbf.ft of torque divided by 0.7 equals 200 lbf.ft of torque.

Speed, Reverse Gear, and Clearance Requirements

The manufacturers listed in [Table 5.3](#) offer PTOs that include forward and reverse rotation.

PTO Mounting Locations—Speed, Reverse Gear, and Clearance Requirements		
Transmission Manufacturer	Mounting Bolts (qty.)	Description
Bezares		
6000	6	One speed forward and one speed reverse
6800	8	
8000	8	
Parker Chelsea		
340	6	One speed forward and one speed reverse
348	8	
863	8	
Muncie Power		

Selecting a PTO

PTO Mounting Locations—Speed, Reverse Gear, and Clearance Requirements		
Transmission Manufacturer	Mounting Bolts (qty.)	Description
RL6	6	One speed forward and one speed reverse
RL8	8	

Table 5.3, PTO Mounting Locations—Speed, Reverse Gear, and Clearance Requirements

Geared Adaptors

Geared adaptors connect to the PTO on the transmission side and provide the PTO additional clearance from any obstructions located under the truck such as back axles or transmission bulges. Extra gears connect the PTO to the transmission and can also be used to change the rotation of the output shaft. **Figure 5.11** shows three geared adaptor options:

See **Table 5.4** for a list of PTO gear adaptors.

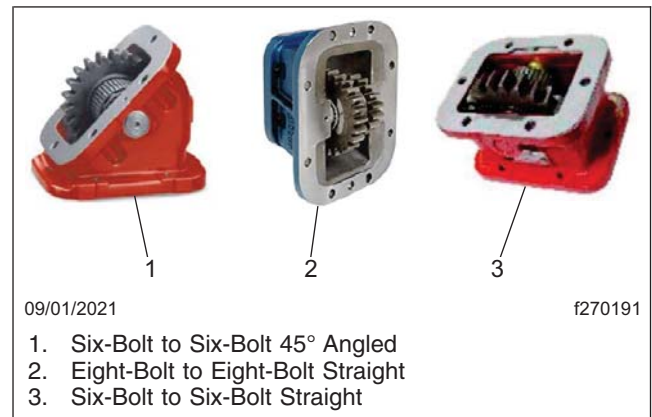


Fig. 5.11, PTO Geared Adaptors

PTO Geared Adaptors			
Manufacturer	Mounting Bolts	Mount Depth	Body Type
Bezares			
AD626	6 to 6	Standard	Straight
AD726	6 to 6	Deep	Straight
AD645	6 to 6	Standard	45° Angled
AD745	6 to 6	Deep	45° Angled
Parker Chelsea			
626X	6 to 6	Standard	Straight
626Z	6 to 6	Deep	Straight
630X	6 to 6	Standard	30° Angled
630Z	6 to 6	Deep	30° Angled
645X	6 to 6	Standard	45° Angled
645Z	6 to 6	Deep	45° Angled
628X	8 to 6	Standard	Straight
628Z	8 to 6	Deep	Straight
Muncie Power			
40TU6830-1	6 to 6	Standard	30° Angled
40TU6830-2	6 to 6	Deep	30° Angled
40TU6845-1	6 to 6	Standard	45° Angled
40TU6855-1	6 to 6	Standard	55° Angled

Selecting a PTO

PTO Geared Adaptors			
Manufacturer	Mounting Bolts	Mount Depth	Body Type
40TU6886-1	8 to 6	Standard	Straight

Table 5.4, PTO Geared Adaptors

Daimler Trucks North America (DTNA) recommends package protecting PTOs on all trucks by selecting a customer furnished code. Ordering pre-installed PTOs ensures physical interference issues will be resolved before truck delivery. This includes rerouting items like transmission dipsticks, wiring, and plumbing out of the intended PTO and pump installation envelope.

NOTE: Besides the combinations listed in the technical resource guide, dealers can request that a package study be conducted by DTNA for other possible configurations.

6

PTO Controls and Engagement

Engagement Controls	6.1
Engagement Procedures by Transmission Type	6.3

PTO Controls and Engagement

Engagement Controls

This chapter describes various shift control options from several PTO manufacturers. More information about PTO controls and engagement can be found in the PTO Corner section of the Body Builder Guide on DTNACONNECT. Ordering factory-installed PTO controls is much easier and more cost effective than installing controls at a later time. Contact your local sales representative for factory-installed PTO control options.

Figure 6.1 shows an example PTO control layout.

transmissions. PTO manufacturers use the following types of shift controls.

- wire/cable
- lever
- air
- electric
- electric over air
- electric over hydraulic

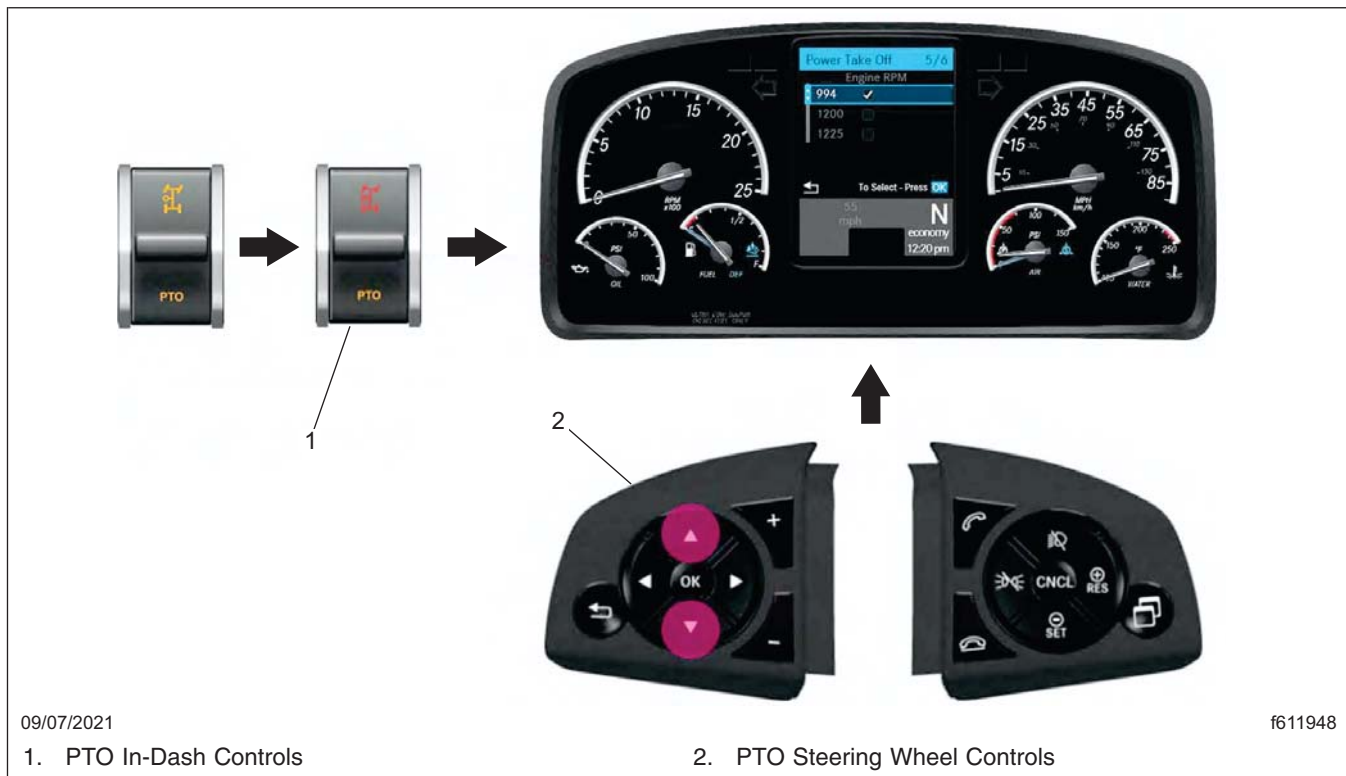


Fig. 6.1, Example Pre-Installed PTO Control Configuration

Review all owner manuals and warning labels before operating a PTO. All safety and operation decals should be placed (and not tampered with) on the truck as instructed by the PTO owner manual.

Mechanical Shifters

This shifter type uses sliding gears or dog clutches to allow the transfer of power from the transmission to the PTO accessory. Mechanically-shifted PTOs are normally used on manual transmissions but can also be found on Allison 1000/2000/2500 series automatic

Wire/Cable Shift Control

Wire or cable shift PTOs have a cable attached to a lever on the shift cover and have the cable/wire routed to the cab of the truck. A rotary motion at the shift cover engages the sliding gear or dog clutch gears inside of the PTO. **Figure 6.2** shows an example wire/cable shift control.

Lever Shift Control

Lever shift PTOs are rarely used in modern vocational vehicles. The lever shift mechanism in the PTO

PTO Controls and Engagement

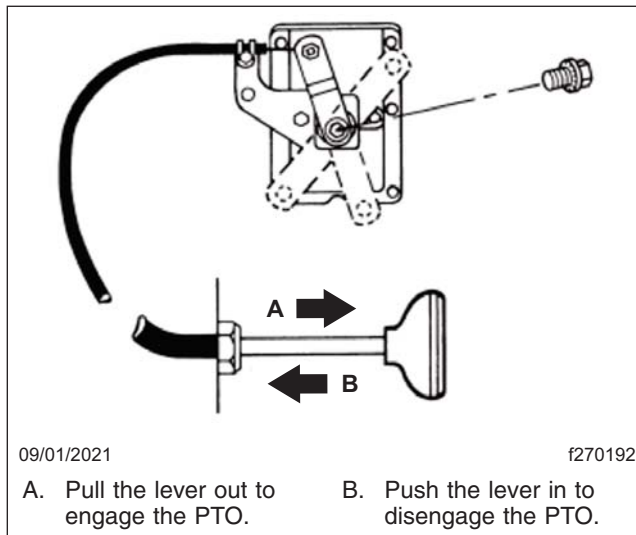


Fig. 6.2, Wire/Cable Shift Control

is engaged using a linear motion. An eye bolt and a series of rods and linkages engage the PTO using a shift lever located in the cab. See [Fig. 6.3](#). These components must be provided and installed by the fabricator.

Air Shift or Electric-Over-Air Shifters

Air shift or electric-over-air shifters use a linear motion to engage the PTO gears. A piston located on the end or inside of the PTO cover moves the shift mechanism when air pressure is applied to the cover. See [Fig. 6.4](#) for an example of a manufacturer-supplied shifter.

Single-Acting Manual Air Shifters

These shifters are actuated using a control valve located in the cab. The shifter uses the truck air supply to activate the PTO. When off, the PTO is forced out of engagement using a spring that automatically disengages the PTO. This type of engagement/disengagement system is typically found on medium duty PTOs with smaller diameter gears such as a six-bolt and small eight-bolt units.

Double-Acting Manual Air Shifters

These shifters are actuated using a valve located in the cab. The shifter uses the truck air supply to positively engage and disengage the PTO. This type of shifter is typically found on larger eight-bolt PTOs with large diameter gears. The increased mass of the PTO gears require more force to disengage than a single-acting manual air shifter can provide.

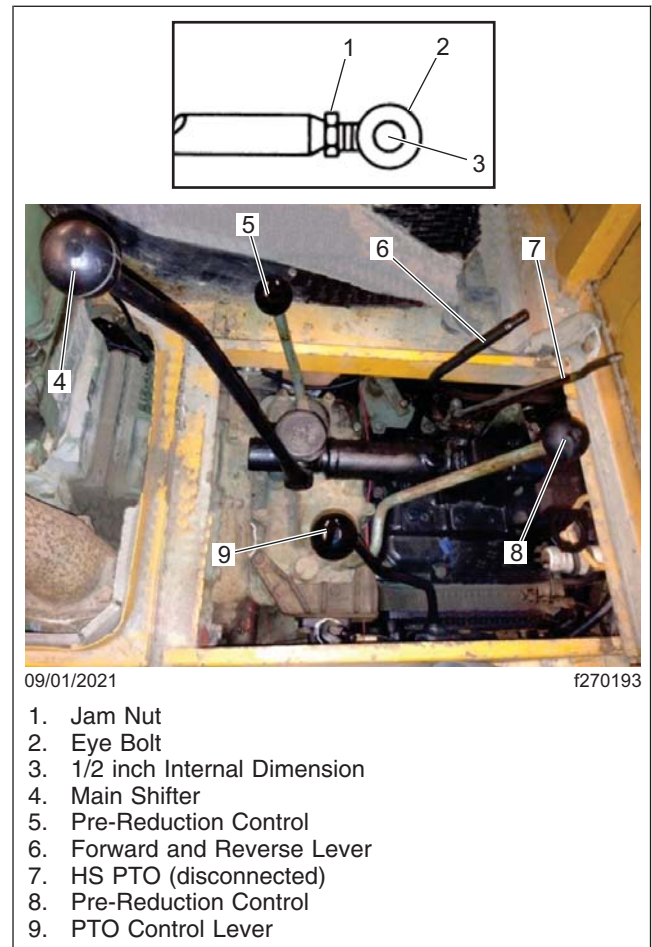


Fig. 6.3, In-Cab Lever Shift Controls



Fig. 6.4, PTO Manufacturer Shift Valve

PTO Controls and Engagement

Electric Shift

Three types of electric shift PTOs available are:

- solenoid
- electric motor
- gerotor pump

These PTO shift types are found on medium duty units that would normally have a single acting air shifter. **Figure 6.5** shows a typical electric shift PTO.

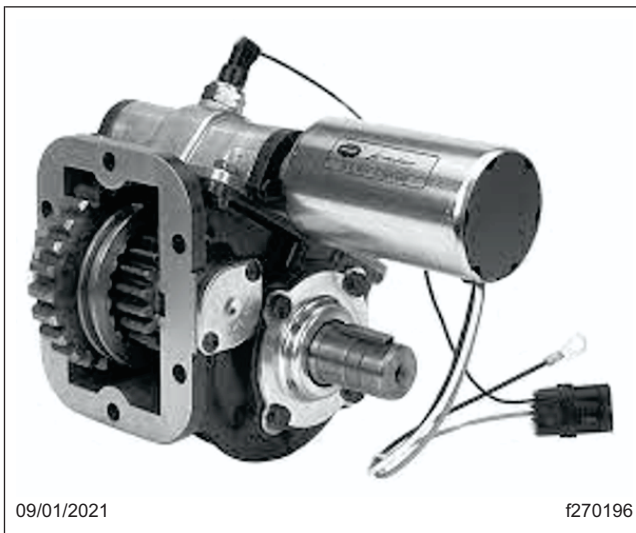


Fig. 6.5, Solenoid Electric Shift PTO

Electric-Over-Air Shifter

This shifter operates the same way as a single-acting manual air shifter except that a solenoid valve actuated by an On/Off switch in the cab manages the airflow from the truck to the PTO.

Constant Mesh/No Shift

These PTOs have no moving shift parts and are constantly engaged. Once the engine is started, the PTO immediately sends power to the PTO accessory. Constant mesh PTOs provide power at all road speeds and are normally found on automatic transmissions. This type of PTO is not popular on manual transmissions, as any load through the PTO to the transmission gears can make shifting difficult. **Figure 6.6** shows a typical constant mesh PTO.

Hot Shift/Power Shift

Hot shift/power shift PTOs are typically found on manual transmissions and automatic transmissions



Fig. 6.6, Constant Mesh Allison 10-Bolt PTO

and use air or hydraulic pressure to compress the disks within the clutch pack. This type of PTO can be engaged without gear grinding.

WARNING

During extreme cold weather operation (32°F [0°C] and lower), momentary high torque can be transmitted to disengaged hot shift or power shift controlled PTOs. This may cause unexpected output shaft rotation. Variations in transmission oil viscosity between the PTO clutch plates could cause unexpected movement of driven equipment, resulting in possible serious injury, death, or equipment damage.

Engagement Procedures by Transmission Type

This section describes the engagement procedures for several types of PTOs available today.

Eaton Fuller Transmission Engagement Procedures

These engagement procedures apply to Eaton Fuller or any manually-shifted transmissions with sliding gear or dog clutch style PTOs.

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop and set the parking brakes.
2. Shift the transmission to neutral.

PTO Controls and Engagement

3. Disengage the clutch and wait for the transmission and/or PTO gears to stop turning.
4. Engage the PTO.
5. Once engaged, the PTO light on the dash should illuminate. The PTO is now operational.

For mobile operation, complete steps 1-5 above then follow the steps below:

1. Apply the service brake.
2. Release the parking brake.
3. Select the drive gear.
4. Remove your foot from the service brake.
5. Apply throttle, as required.
6. Activate the PTO switch and make sure the PTO light is illuminated.
7. Move the vehicle forward at a slow speed (15 mph [24 km/h] or less).

UltraShift® Transmissions with Eaton Transmission Control Modules (TCM) Engagement Procedures

NOTE: Fuller UltraShift transmissions are not approved for PTO applications that would require the engine to operate at less than 1000 rpm for heavy duty transmissions and 1200 rpm for medium duty transmissions. The following procedures apply to six and eight-bolt opening PTOs.

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the parking brake.
3. Apply the service brake.
4. Place the transmission in drive (this stops the countershaft from rotating for PTO engagement).
5. Engage the PTO and make sure the PTO light is illuminated.
6. Shift the transmission to neutral (this allows the countershaft to rotate for PTO operation).
7. Release the service brake.
8. Increase the engine rpm (minimum 1000 rpm for heavy-duty transmissions) to operate the PTO.

NOTE: Remote throttle controls are not approved for this operation.

For mobile operation, complete steps 1-5 above then follow the steps below:

1. Shift the transmission to drive (this allows the countershaft to rotate for PTO operation).
2. Release the service brake.
3. Increase the engine rpm as required, to move the vehicle and operate the PTO.

UltraShift® Countershaft PTO Operation (Chelsea 541 Series) Engagement Procedures

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the parking brake.
3. Apply the service brake.
4. Place the transmission in drive (this stops the countershaft from rotating for PTO engagement).
5. Engage the PTO.
6. Shift the transmission to neutral (this allows the countershaft to rotate for PTO operation).
7. Release the service brake.
8. Increase the engine rpm (minimum 1000 rpm for heavy-duty transmissions) to operate the PTO.

NOTE: Remote throttle controls are not approved for this operation.

For mobile operation, complete steps 1-5 above then follow the steps below:

1. Shift the transmission to drive (this allows the countershaft to rotate for PTO operation).
2. Release the service brake.
3. Increase the engine rpm as required, to move the vehicle and operate the PTO.

Allison 1000/2000/2500 Series Transmissions Engagement Procedures

The PTO drive gear on Allison 1000/2000/2500 series transmissions is located on the torque converter. For manually-shifted PTOs, you must stop the torque converter from rotating.

PTO Controls and Engagement

To engage manually-shifted PTOs with a dog clutch or sliding gears, see the steps below.

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the parking brake.
3. Apply the service brake.
4. Place the transmission in drive (this stops the countershaft from rotating for PTO engagement).
5. Engage the in-cab PTO switch until the PTO engaged light activates.
6. Shift the transmission to neutral.
7. Release the service brake.

For mobile operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the service brake.
3. Shift the transmission to drive (this allows the countershaft to rotate for PTO operation).
4. Engage the PTO switch until the PTO light illuminates.
5. Release the service brake to start mobile operation.

Hot Shift/Power Shift Engagement Procedures

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the parking brake.
3. Engage the PTO switch (PTO is operating) and increase engine speed between 800 and 1000 rpm. The PTO light should illuminate.

For mobile operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the service brake.
3. Engage the PTO switch (PTO is operating) and increase engine speed between 800 and 1000 rpm. The PTO light should illuminate.
4. Release the service brake to start mobile operation.

Allison 3000/4000 Series Transmissions Engagement Procedures

The PTO drive gear on Allison 3000/4000 series transmissions is located in front of the torque converter and will rotate when the engine is started. Only hot shift/power shift PTOs (with internal friction disk clutch packs) or constant mesh/no shift PTOs are used on Allison 3000/4000 transmissions.

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the parking brake.
3. Engage the PTO switch (PTO is operating) and increase engine speed between 800 and 1000 rpm. The PTO light should illuminate.

For mobile operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the service brake.
3. Engage the PTO switch (PTO is operating) and increase engine speed between 800 and 1000 rpm. The PTO light should illuminate.
4. Release the service brake to start mobile operation.
5. Release the service brake to start mobile operation.

Detroit™ DT12 Transmissions Engagement Procedures

The following information applies to Detroit DT12 transmissions with bottom-mounted eight-bolt PTOs with rear openings.

For stationary operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Apply the parking brake.
3. Select the programmed PTO operating speed.
4. Place the transmission in neutral.
5. Engage the eight-bolt or rear PTO. The indicator light on the PTO switch will blink, turning solid once the PTO is operating. If the PTO light deactivates after blinking for ten seconds, this indicates that the PTO is not operating.
6. Several programmable ramp-up speeds are available for the PTO. After the PTO is engaged,

PTO Controls and Engagement

the engine will ramp up to the first selected speed.

7. To disengage the PTO, unload the PTO/system and then disengage the PTO.

For mobile operation, perform the following steps:

1. Bring the vehicle to a stop.
2. Shift the transmission to neutral.
3. Engage the eight-bolt or rear PTO.
4. Shift the transmission into gear while depressing the service brake.
5. Release the service brake and allow the vehicle to move.
6. To disengage the PTO, disconnect the driven equipment, then disengage the PTO while the vehicle is moving or stopped.

NOTE: Bottom eight-bolt and rear-mount PTOs are approved for stationary and launch gear use only.

NOTE: The transmission cannot shift gears while the vehicle is being driven. Do not shift manually with the bottom eight-bolt or rear PTO engaged.

NOTE: Setting optional ramp-up speeds and other interlocks is currently beyond the scope of this document.

7

PTO Maintenance

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PTO Maintenance

Safety Precautions

Safety precautions in this section apply to all procedures within this group.



When performing PTO maintenance, shut down the engine or motor, set the parking brake, and chock the tires. Never work on a PTO with the engine running. Before working under the vehicle, always place jack stands under the frame rails to ensure the vehicle cannot drop. Failure to follow these steps could result in serious personal injury or death.

To avoid damage caused by severe vibration, regular inspection and maintenance should be performed to

keep PTOs running optimally. With proper care, PTOs and PTO accessories will provide many years of reliable service. This chapter covers PTO and PTO shaft maintenance. For PTO accessory maintenance, contact the manufacturer.

NOTICE

Failure to conduct routine inspections and service on PTOs could result in damage to the PTO, transmission, vocational accessories, or engine.

Scheduled Maintenance Intervals

Table 7.1 lists the recommended PTO maintenance intervals.

PTO Inspection and Maintenance Schedule*				
Service Task	Two Weeks After Installation	Daily	Monthly	Yearly
Inspect PTO seals and surrounding areas for leaks and proper fit.	•	•	•	
Check all air, hydraulic, shifting cables, and lines for bends, corrosion, or physical damage.	•	•	•	
Tighten all air, hydraulic, and mounting hardware according to manufacturer specifications.			•	
Check transmission and PTO fluid levels.	•	Per vehicle manufacturer recommendation		
Check for cracks or damage to the PTO case.		•		
Check all fasteners and tighten all bolts and nuts on the PTO according to manufacturer specifications.	•		•	
Inspect flanges and end yokes for damage or corrosion. Lubricate if necessary.			•	
Ensure all splines are properly lubricated.			•	
Inspect wiring for loose or melted wires. Replace broken wiring harness ties.			•	
Check for excessive noise or rattling while running the PTO	•	•	•	
Monitor the PTO warning and engagement lights.	As required for proper PTO operation			
Remove the PTO and inspect it for corrosion, chips, and general wear on gear teeth and output shafts. Replace gears and shafts, if needed.				•
If a burnt odor is detected, inspect clutch plates for burn marks or wear. Replace if needed.	As needed			
Repair or replace damaged components.	As needed			

* Severe duty applications that are rated for continuous PTO duty may require more frequent maintenance. Contact the PTO manufacturer for severe duty maintenance schedules.

Table 7.1, Inspection and Maintenance Schedule

PTO Maintenance

PTO U-Joint, Shaft Inspection, and Maintenance

PTO universal joints (U-joints) and shafts operate in exposed conditions and require periodic maintenance to prevent seizing. Bending fatigue, torsional overload, and corrosion could shorten the life of PTO components or cause PTO shaft failure.

PTO Spline Lubrication

Some PTOs require special types of grease when used with direct-mounted pump splines. These special greases are formulated to reduce the effects of

torsional vibrations, which result in fretting corrosion on the PTO internal splines as well as pump external splines. When greasing splines, use the grease supplied by the manufacturer. For information about specific PTO grease requirements, contact the PTO manufacturer. Recommended PTO shaft and service intervals are listed below.

NOTE: Some PTO manufacturers include optional grease Zerk fittings or a wet spline sump option on some PTOs equipped with a pump flange. Maintenance procedures for these accessories may vary.

PTO Spline and Shaft Inspection and Maintenance		
Service Task	Normal Duty (20 hours)	Severe Duty (8 hours)
Check that the PTO shaft moves freely.	•	•
Inspect the PTO shaft keyway for proper fitting.	•	•
Inspect yokes for proper alignment (phasing) and ensure they move freely.	•	•
Engage the PTO and check for excessive vibration at idle and during ramp up.	•	•
Remove and inspect shaft for corrosion.	•	•
Ensure all splines and the shaft ends are properly cleaned and lubricated.	•	•
Replace worn yokes and/or PTO shafts.	As needed	

Table 7.2, PTO Spline and Shaft Inspection and Maintenance

Manual PTO Transmission Maintenance Steps

Refer to the PTO transmission manufacturer for specific maintenance intervals and procedures.

Automatic PTO Transmission Maintenance Steps

Refer to the PTO transmission manufacturer for specific maintenance intervals and procedures.

8

Troubleshooting

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Troubleshooting

Introduction to Troubleshooting

This section describes how to troubleshoot basic mechanical PTO issues. For more information about troubleshooting specific PTO models, visit the manufacturer web site. With proper care, PTOs can provide many years of reliable service.

Because of the different types of controls available for PTO engagement, DTNA recommends becoming familiar with the engagement operation of the PTO.

NOTE: Troubleshooting software and parameter configuration of PTOs is beyond the scope of this document. For more information, visit the PTO Corner located in the DTNAConnect Body Builder Guide section or contact the Customer Assistance Center (CAC) for assistance.

PTO Damage Prevention

To prevent damage to the PTO:

- Always match the proper PTO unit to the intended application. Mismatched PTOs may cause damage to the transmission, PTO, or driven accessories.
- Driver and PTO operator error is the leading cause of PTO failure. Understanding how PTOs work and how to operate PTOs can help prevent a majority of failures and help resolve common problems that may arise during operation.
- Damage to PTO gears and bearings are usually caused by overuse of the auxiliary over-drive gears with the main box in lower gear ratios.
- When shifting and running PTOs, practice smooth and steady ramp-up to prevent sudden jumps in torque from the transmission to the PTO. This will prevent PTO gear teeth from being chipped or damaged.

Troubleshooting General PTO Problems

Problem—Broken PTO Teeth

Problem—Broken PTO Teeth	
Possible Cause	Remedy
Abrupt clutch releases may cause PTO teeth to wear prematurely or break.	Always release the clutch slowly when operating the PTO. Sudden clutch releases while operating the PTO can also cause gear tooth damage. Driven equipment with a high inertia startup (such as pneumatic blowers) can cause damaged teeth.

Problem—Noisy PTO Operation

Problem—Noisy PTO Operation	
Possible Cause	Remedy
Improperly installed PTO or an improperly matched accessory may cause excessive noise when operating the PTO.	Always consult PTO/accessory manufacturer torque and horsepower requirements and carefully follow all installation instructions. Certain noises may indicate the following problems: • Grinding—caused by improper shifting. • Hissing or thumping—may be caused by possible bearing failure. • Rattling—may be caused by low engine RPM torsional, faulty injector, or too much backlash in the PTO. • Other unusual sounds can be caused by a lack of lubrication or by the use of improper lubricants. Check manufacturer specifications for more information. • Squealing at higher speeds—may be caused by too little backlash (gears are mounted too tight).

Problem—Excess Vibration During PTO Operation

Problem—Excess Vibration During PTO Operation	
Possible Cause	Remedy
Improperly selected or installed drivelines may cause excess vibration while operating the PTO.	Always consult PTO/driveline manufacturer torque and horsepower requirements and carefully follow all installation instructions.

Troubleshooting Power Shift PTOs

Problem—The Power Shift PTO is not Engaging

Problem—The Power Shift PTO is not Engaging	
Possible Cause	Remedy
Faulty electrical connection during PTO operation may prevent the PTO from engaging.	Check and replace any blown fuses. Check and replace any damaged or corroded wires and terminals.
Low transmission oil level may cause the PTO to seize, preventing PTO engagement.	Make sure that the transmission oil level is filled according to manufacturer specifications.

Troubleshooting

Problem—The Power Shift PTO is not Engaging	
Possible Cause	Remedy
Kinked or obstructed hydraulic lines may prevent the PTO from receiving control input.	Check and replace any damaged hydraulic lines.
Improper PTO installation may prevent PTO gears from engaging transmission gears.	Check for excessive leaks in and around the PTO. Tighten all bolts according to manufacturer specifications. Check to make sure gear backlash is set between 0.006 to 0.012 inch (0.15 to 0.3 mm).
A faulty solenoid may prevent the PTO from receiving engagement input controls.	Check for proper operation of the solenoid valve and replace as needed.

Problem—The PTO is Engaging but not Operating Under Load

Problem—The PTO is Engaging but not Operating Under Load	
Possible Cause	Remedy
Low hydraulic pressure may cause the PTO to operate incorrectly.	Check to make sure the hydraulic pumps are operating properly. Check for bends or kinks in the hydraulic lines. Replace if needed.
A faulty or worn clutch may cause the PTO to slip or not operate under load.	Remove and inspect the clutch assembly. Replace worn clutch plates or components as needed.

Problem—The Power Shift PTO Will not Disengage

Problem—The Power Shift PTO Will not Disengage	
Possible Cause	Remedy
A faulty solenoid valve may prevent the PTO from disengaging.	Check and replace the solenoid valve. Clean and replace any connections.
The clutch is damaged.	Clutches exposed to extreme wear or heat may cause plates to be welded together. Inspect and replace any damaged housing or plates.
The PTO has faulty pressure or indicator switches.	The PTO may actually be disengaged, but the pressure switch or cab switch may indicate engagement. Check that all switches are operating properly. Ensure that the terminals and wires are not damaged or corroded.

9

Glossary of Terms

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Glossary of Terms

Glossary of Terms

Adaptor Gear—a single gear assembly that connects to the transmission PTO drive gear and transfers power to the PTO input gear. This gear is used when the distance between the PTO and transmission needs to be increased. The adaptor gear also reverses the rotation of a PTO shaft.

Aperture—SAE standard opening on the transmission that allows for installation of the PTO. This opening has six, eight, or ten bolt-mounting points. Some transmissions do not meet the SAE standards and require special components for mounting.

Assembly Arrangement—location of the output shaft in relation to the gear. Generally, the output shaft faces the rear of the vehicle.

Auxiliary Transmission Input Shaft PTO—this PTO is driven from a gear on the auxiliary transmission input shaft. It turns whenever the input shaft to the auxiliary transmission is turning. To operate the PTO, the main transmission must be in gear.

Auxiliary Transmission Rear PTO (split shaft)—this PTO only spins when the main transmission is in gear and the auxiliary transmission is in a gear that directs power to it.

Backlash—backlash is the clearance between two meshing gears on the PTO. Recommended distance to prevent premature gear wear is between 0.006 to 0.012 inch (0.15 to 0.3 mm). Backlash can be adjusted by adding or removing mounting gaskets.

Bottom-Mounted PTO—some PTOs are mounted on the side near the bottom of the transmission. The DT transmission side PTO is considered a bottom-mounted PTO.

Clutch Brake (drag brake)—this device stops rotation of the input shaft of a transmission when the transmission is in neutral and the clutch is fully open.

Constant Mesh—available for Allison transmissions. Constant mesh PTOs spin whenever the engine spins because they are driven from a gear before the torque converter.

Continuous Engagement—some PTOs are constantly engaged and do not shift, providing continuous power to PTO accessories. The amount of power supplied to PTO accessories varies greatly, depending on the speed of the motor.

Counter Shaft—secondary shaft on which the PTO gear frequently rotates. Some transmissions have

single counter shafts while others have twin counter shafts.

Deep Mount PTO—PTO whose input gear extends further into the transmission case. This allows for direct contact with the transmission PTO drive gear.

Dog Clutch—describes a PTO gear that has square teeth for the internal engagement of the PTO. All moving gears must be stopped to prevent any clashing and small metal particles from being shaved off and contaminating the transmission or PTO.

Double Acting PTO—a PTO that uses one motion or signal to engage the PTO and a signal to disengage the PTO. This arrangement helps prevent torque lock.

Electric over Hydraulic or Air—this PTO variation is common on Allison transmissions, (the air version is more common on Eaton Fuller transmissions) which supply hydraulic fluid or air as a source of power to the PTO. An electric signal is used to activate hydraulic or air power that forces friction discs together to transmit power to the PTO output shaft. When the electrical signal is removed, the discs separate and rotational power is disengaged.

Engine Speed—speed in which the engine runs, measured in rpm.

Extended Shaft—a PTO or option that provides a long enclosed output shaft that places the PTO output at the rear of an Allison transmission, allowing for clearance with larger pumps, or provides a better driveline angle for remote-mounted equipment.

Filler Block—a spacer plate located between the transmission and the PTO. The filler block allows for gear mesh adjustments. Available in SAE six or eight-bolt patterns.

Flywheel Housing—housing where the clutch and flywheel (if used) are located. The flywheel typically has a large gear that connects to the starter motor.

Front Engine PTO (FePTO)—front mounted PTO that transmits power from the crankshaft forward flange. This type of PTO can be shifted or operated continuously. These types of PTOs usually run large hydraulic pumps.

Gear Ratio—relationship of the number of teeth on the output gear to the input gear. Expressed as a ratio (for example, 1:3).

Greaseable Pump Shafts—this PTO option provides a grease Zerk fitting on the closed in PTO bearing cover that allows grease to the female splines of the

Glossary of Terms

shaft through a rifle drilled bore up the length of the shaft.

Helical Gear—a gear whose teeth are cut at an angle across the gear with either a right or left-hand slant.

Hot Shift/Power Shift—this PTO variation is common on Allison transmissions but works with any transmission. The PTO uses a friction clutch that operates like a manual transmission clutch. Power is gradually applied to the driven shaft until it reaches the same speed as the transmission drive shaft.

Idler Shaft—the shaft located inside of the PTO that holds the PTO input gears or the reverse idler gear in place.

Input Gear—the PTO gear that meshes with the transmission output gear.

Input Speed—speed of the transmission gear (rpm) when it is connected to the PTO input gear.

Intermittent Operation—PTOs that are used for short periods at a time (normally between 5 to 15 minutes). If enough heat builds up inside the PTO during intermittent operation, then the operation is considered continuous.

Lockup Torque Converter—this condition occurs when hydraulic pressure from the transmission is applied to the torque converter. This compresses the torque converter discs eliminating slip and creating a direct drive.

Main Shaft—output and input shaft of a transmission that provides power to the vehicle axles.

Lockup Torque Converter—this condition occurs when hydraulic pressure from the transmission is applied to the torque converter. This compresses the torque converter discs eliminating slip and creating a direct drive.

Output Gear PTO—driving gear which meshes with another gear to turn the output shaft.

Lockup Torque Converter—this condition occurs when hydraulic pressure from the transmission is applied to the torque converter. This compresses the torque converter discs eliminating slip and creating a direct drive.

Output Shaft PTO—provides power to the driven object. An output shaft PTO may have a companion flange or yoke on the end of the shaft, or may have a female spline to allow direct mounting of hydraulic pumps.

Overdrive—this configuration is used for maximum fuel economy at highway speeds.

Pitch (Gear)—the measure of the size of the gear teeth determined by the number of teeth in a given area measured at the pitch line. PTO gear pitch is normally classified as 5, 6, or 7 pitch.

Pitch Line—the midway point on the gear tooth located between the base of the gear and the tip of the tooth.

Pitch Line Velocity—speed of gear rotation in feet per minute (fpm) of a gear measured at the pitch line.

Pressure Angle—the angle formed (in degrees) by a line drawn perpendicular to the pitch line, and a line drawn from the same point on the pitch line tangent to the tooth profile.

Rear Engine PTO (RePTO)—a PTO that is typically connected to a transmission output shaft between the transmission and clutch. This PTO typically operates continuously and powers a hydraulic pump, but drive shaft outputs are also possible.

Rear-Mounted/Countershaft PTOs—these PTOs are mounted on the rear of the transmission and are likely to be countershaft shaft driven. The long shaft inside of the transmission provides power to the rear of the transmission where the PTO is mounted.

Single Acting PTO—most PTOs are single acting. An electric signal, air pressure, or physical motion activates the PTO. When the signal, air pressure or physical motion changes, a spring disengages the PTO.

Sliding Gear—describes a PTO gear that has helical or spur cut teeth for the internal engagement of the PTO. All moving gears must be stopped to prevent any clashing and small metal particles from being shaved off and contaminating the transmission or PTO.

Split-Shaft PTO—PTOs designed to allow one engine to power either the vehicle drive axle or the auxiliary equipment by switching the mode of operation with the shift mechanism on the split shaft.

Spur Gear—a gear whose teeth are cut straight across the front of the gear, as opposed to the helical gear, whose teeth are cut diagonally across the gear at a left or right-handed angle.

Torque Converter—on a fully automatic transmission (Allison), the torque converter transfers power to

Glossary of Terms

the transmission intermediate gearing and allows the vehicle to completely stop with the engine turning.

Torque Lock—when a PTO is engaged and under load with the engine running, significant forces on the gears will keep them meshed. During shutoff, the spring return on the PTO may not be able to provide enough force to disengage the gears. This situation is called torque lock.

Wet Spline—an option on PTOs that allows hydraulic fluid from the transmission to fill the PTO pump flange cavity allowing for lubrication between the mating shafts.

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