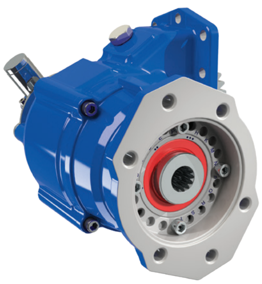
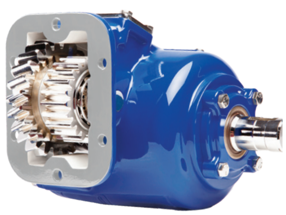
NINTH EDITION

UNDERSTANDING

POWER TAKE-OFF SYSTEMS

MUNCIE®

Corporate Headquarters • ***Muncie, Indiana***

Manufacturing Division • ***Tulsa, Oklahoma***

MUNCIE POWER PRODUCTS QUALITY POLICY

Muncie Power Products is dedicated to providing quality products and services that will satisfy the needs and expectations of our customers. We are committed to the continual improvement of our products and processes to achieve our quality objectives, minimize costs to our customers, and realize a reasonable profit that will provide a stable future for our employees.

TABLE OF CONTENTS

POWER TAKE-OFF DEFINED

Power take-offs (PTOs) are mechanical gearboxes that attach to apertures provided on truck transmissions and are used to transfer the power of the vehicle engine to auxiliary components, most commonly a hydraulic pump. The hydraulic flow generated by the pump is then directed to cylinders and or hydraulic motors to perform work. In some PTO applications such as generators, air compressors, pneumatic blowers, vacuum pumps and liquid transfer pumps, the PTO provides power, in the form of a rotating shaft, directly to the driven component.

The PTO we are most familiar with is the side-mounted PTO, although there are also models that attach to the rear of certain transmissions and **split shaft** PTOs that are mounted by removing a section of the vehicle's main driveline. Rear-mounted PTOs are frequently referred to as countershaft PTOs; however, many side-mounted PTOs are also **countershaft** PTOs because they are driven by gears on the transmission's counter shaft. You may hear people refer to "side countershaft" and "rear countershaft" PTOs to make a distinction.

The transmissions commonly found in class 4 and larger vehicles will have provisions for the mounting of a PTO. Generally there are two apertures, one on each side of the transmission, but some smaller transmissions may have only one. When discussing aperture location one refers to the passenger side of the truck as the "right" and the driver's side as the "left." Many popular Eaton Fuller transmissions have a PTO aperture on the bottom (offset to the left), and some Allison automatic transmissions have a top aperture.

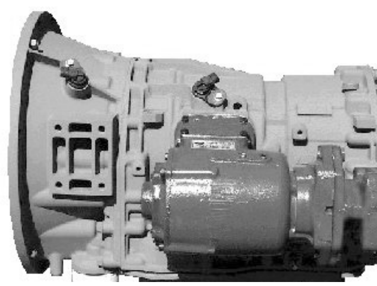
The PTO may be engaged by means of a cable, lever, air pressure, electric/air, electric, or hydraulic pressure.

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. The **Society of Automotive Engineers (SAE)** has established standard mounting face dimensions for hydraulic pumps and PTOs are made to accept these. These are referred to, from smallest to largest, as the SAE A, B, D, E, and F.

TRUCK CLASSIFICATION BY GVWR

(Gross Vehicle Weight Rating)

Class 1	*Less than 6,000 lb.*
Class 2	*6,001 – 10,000 lb.*
Class 3	*10,001 – 14,000 lb.*
Class 4	*14,001 – 16,000 lb.*
Class 5	*16,001 – 19,500 lb.*
Class 6	*19,501 – 26,000 lb.*
Class 7	*26,001 – 33,000 lb.*
Class 8	*33,000 lb. and up*

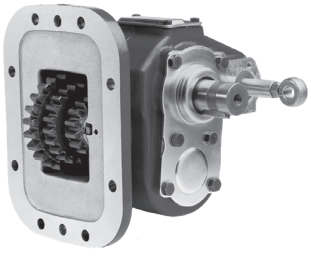


Transmission with PTO and hydraulic pump installed

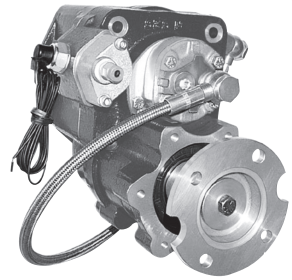
Air Shift Cover

Cable Shift Cover

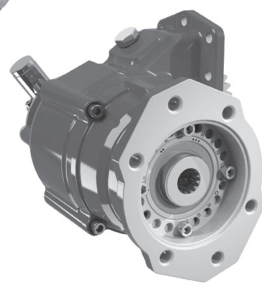
Lectra Shift Cover



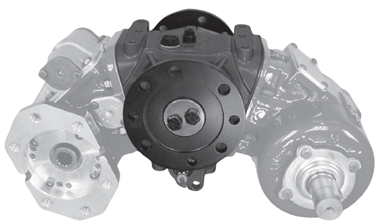
RL Series



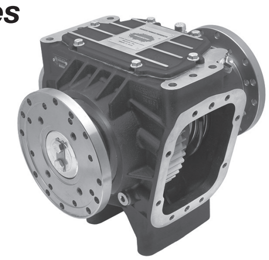
RS Series



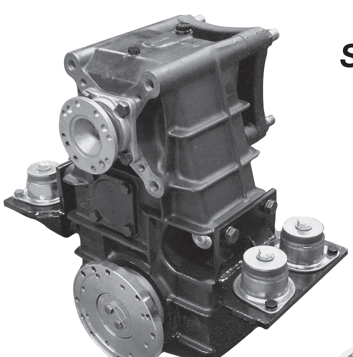
A20 Series



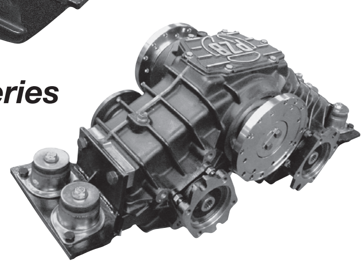
SS66 Series



SS88 Series



SSV Series



SSH2 Series

SECTION 1:
POWER TAKE-OFFS: A BRIEF HISTORY

The earliest documented use we have of a PTO is 1919, when a PTO was utilized to power an air compressor to inflate tires on a Cadillac automobile. By the 1930s, PTO apertures were standard on truck transmissions and PTOs were being used to power winches, dump bodies, and garbage trucks. Early PTO manufacturers included Gar Wood, Central Fiber Products, Spicer, Tulsa Winch, Arrow, and Braden; these early manufacturers no longer exist as PTO manufacturers. Braden and Tulsa Winch still exist as successful manufacturers of mechanical and hydraulic winches. Eventually, Central Fiber and Spicer were acquired by Dana Corporation and their PTO products were combined into the Chelsea PTO line. Parker Hannifin Corporation now owns Chelsea.

Muncie Power Products began in Muncie, Indiana, in 1935 as Muncie Parts Manufacturing Company, a distributor of auto parts. By the late 1930s, the company developed an interest in PTOs and by the 1960s, began an expansion that would make Muncie Power the largest PTO distributor in North America. The company name changed to Muncie Power Products, Inc. in 1979. In 1981, Muncie Power, then a distributor for Dana's Chelsea line, entered into a partnership with the Tulsa Winch Company and began to manufacture a new PTO design under the Muncie Power name. In 1986, Muncie Power purchased the Tulsa manufacturing facility from its parent company. In 1999, Muncie Power joined the Interpump Group to become, along with two other Interpump Group PTO manufacturers (PZB and Hydrocar), a part of the world's largest PTO manufacturing entity.

Single gear power take-offs

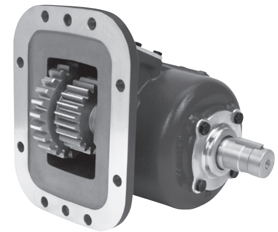
The original PTO was a single gear unit with a gear that slid into mesh with a transmission gear, resulting in output shaft rotation. **Single gear PTOs** are still marketed today although their popularity has greatly diminished. ***The TG Series has taken over to replace the single gear units.*** Single gear PTOs are inexpensive and simple to service. However, they lack many of the features, such as the ability to accept direct-coupled hydraulic pumps that are popular with today's truck equipment installers. Single gear PTOs also are limited by their torque and horsepower capabilities. You will find them used primarily on single axle dump trucks and agricultural hoists.

Multi-gear power take-offs

Multi-gear PTOs, like the Muncie Power TG Series, are the most common type of PTO because of their versatility. This type of PTO offers the user many features, such as direct pump mounting, shifter choice, and numerous speed ratios and horsepower capabilities that make it an ideal choice for almost any type of truck-mounted equipment. This common PTO is found on dump trucks, roll-off hoists, wreckers, aerial bucket trucks, tank trucks, and truck-mounted cranes.

Reversible power take-offs

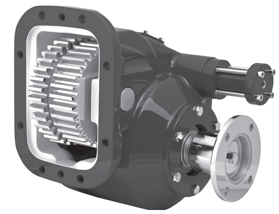
Another type of PTO that is experiencing decreasing popularity are the **reversible PTOs**. Traditionally, reversible PTOs were used to provide power in two directions to mechanical winches and liquid transfer pumps. As hydraulic drives replace mechanical drives in these applications there is less need for the reversible PTO. One remaining benefit to reversible models is that they can be used in applications where a rotation opposite that provided by the standard multiple gear PTO is required. Care must be taken not to exceed the PTO's torque capacity, which, in its reverse gear, is often similar to that of the single gear PTO.



SH Series

8-bolt power take-offs

One of the largest PTOs is the **8-bolt** PTO providing torque capacities of up to 500 ft.lbs. These PTOs are used for high torque applications such as pneumatic blowers, vacuum pumps, and large winches. 8-bolt PTOs are available in single speed models. Hydraulic pumps can be direct-coupled and the PTO can be air actuated.



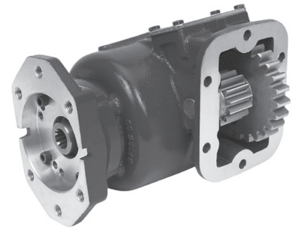
82 Series

Clutch shift power take-offs

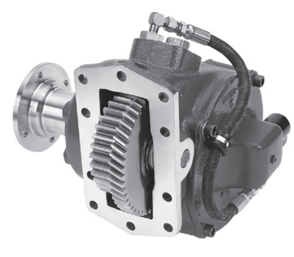
The newest design PTOs are the **clutch type.** Commonly called clutch shift, power shift, or hot shift PTOs, these models engage by means of friction disks rather than sliding gears. Used for many years on Allison automatic transmissions, this type of PTO can also be fitted to many popular manual transmissions.

Clutch type PTOs offer many advantages over traditional multiple gear models, not the least of which is their ability to be engaged and disengaged with the vehicle in motion. This feature also helps to prevent accidental PTO and transmission damage from improper shifting practices. While clutch type PTOs cost more than multi-gear models initially, their increased torque and horsepower ratings, along with the added safety benefits, make them worthy of consideration; particularly on expensive automatic transmissions. Clutch type PTOs are commonly used on refuse, utility, and emergency equipment.

A30 Series

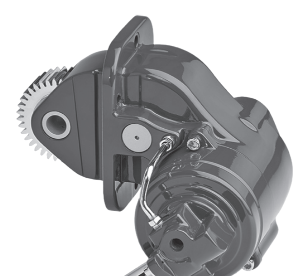


CS6 Series



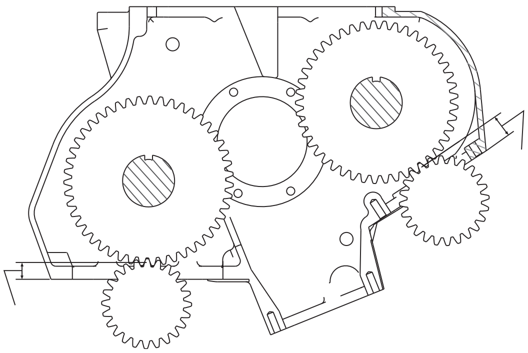
CS10 Series

TG Series



FR6Q Series

TWIN COUNTERSHAFT TRANSMISSION



SECTION 2: TRANSMISSION APERTURE

The transmission's PTO aperture may be of the 6-bolt, 8-bolt, or 10-bolt type, referring to the number of fasteners used to attach the PTO to the transmission. The 6- and 8-bolt openings are SAE standard sizes. The 10-bolt opening is exclusive to automatic transmissions manufactured by Allison, Caterpillar, and Ford. The PTO apertures of foreign transmissions, or U.S.-made transmissions with metric bolts, are referred to as nonstandard openings.

SAE standards pertaining to transmission-mounted PTOs

J704 - Openings for 6- and 8-bolt truck transmission-mounted PTOs

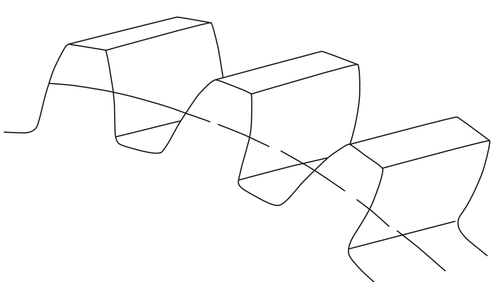
J744 - Mounting dimensions for direct coupled hydraulic pumps

J772 - Clearance envelopes for 6-bolt, 8-bolt, and rear truck transmission-mounted PTOs

J2662 - Torque ratings for power take-off mounting pads

J2555 - Vehicle idle gear rattle evaluation procedure

In addition to size and bolt pattern, there is also an SAE standard gear mounting depth, referred to as the **pitch line to mounting face (PLMF)** dimension. This is 1.085 inches for a standard 6-bolt opening and .810 inch for a standard 8-bolt. Muncie Power designs PTOs to these mounting dimensions and allows for nonstandard mounting depths by utilizing gear adapters to reach deep gears, or spacers (sometimes referred to as filler blocks), to adjust for shallow gears. Gear adapters are also frequently used to mount standard SAE specification PTOs to imported transmissions with non SAE bolt patterns. See page 15 of this book for more information on the use of gear adapters.



Pitch line

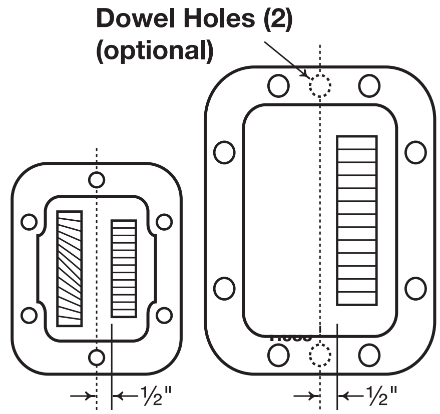
The pitch line of a gear is a reference line which represents the point on a gear tooth where load is transferred to a meshing gear during operation. While this is not a visually identifiable point, it is typically at about the mid-point of a gear tooth depending on the specific design profile of the tooth. The pitch line is an imaginary circle drawn by connecting this point on each gear tooth and is used as a reference point for establishing gear depth and for determining **pitch line velocity (PLV)**, a linear representation of the gear's speed used to calculate available horsepower (HP). PLV is measured in feet per minute (FPM) rather than revolutions per minute (RPM). The higher the PLV, the more available horsepower. A small transmission with a low pitch line velocity might be suitable for a dump body or aerial bucket, but may not be able to provide enough power to run a large, multiple section hydraulic pump, or a pneumatic blower. For these applications a transmission with high PLV is required.

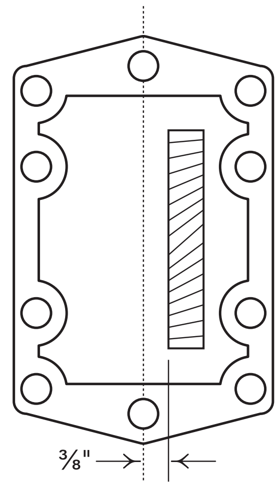
PLV is a function of the internal gearing of the transmission and the diameter of the transmission's PTO drive gear. horsepower available at the PTO drive gear can be calculated by the formula:

$$\mathbf{HP = PLV \times Engine\ RPM \times K \div 1{,}000}$$

The **K** factor in the above equation represents the amount of horsepower per foot of PLV that the transmission can provide: .038 hp./ft. for 6-bolt apertures, .085 hp./ft. for 8-bolt and .049 hp./ft. for 10-bolt.

The standard location of the PTO drive gear in an SAE 6- or 8-bolt opening is ½ inch to the front or rear of the vertical centerline of the aperture. (On 10-bolt openings it is ⅜ inch.) SAE standard openings with standard gear locations allow for PTO models that are easily interchanged from one transmission to another. Nonstandard openings often require transmission-specific PTOs.





SECTION 3:
POWER TAKE-OFF INPUT GEAR

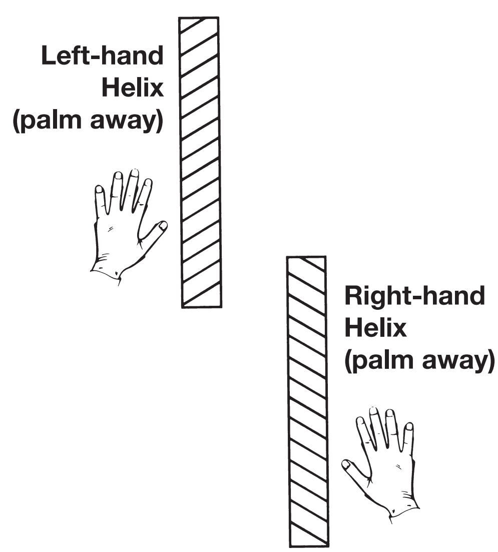
PTO input gears are designed to mesh with the transmission's PTO drive gear and transmit power to the PTO output shaft. Muncie Power works closely with truck transmission manufacturers to insure that the PTO gear matches the mounting depth, pitch, pressure angle, and helix angle of the transmission gear.

Spur and helical gears

There are two gear designs in use in truck transmissions: **spur** and **helical**. Spur gears are those which have teeth cut parallel to their shaft bore. While spur gears are more common, they are not as quiet as helical gears, which have teeth cut at an angle to their shaft bore. A negative consequence of utilizing helical gears, particularly those with high helix angles, is the side thrust forces that can be generated by high torque transmissions. PTOs for transmissions with high helix angle gears frequently must utilize specially coated thrust washers in their input assemblies to tolerate these loads.

Spur Gear ***Helical Gear***

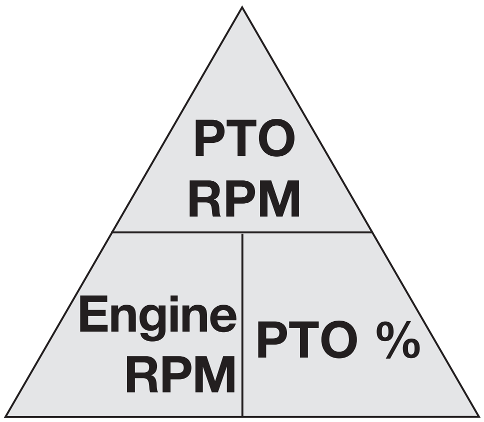
Helical gears are further identified as being either left-hand or right-hand gears. The illustrations, to the right, demonstrate how to identify a gear as a left- or right-hand helical gear. A transmission gear with a left-hand helix will require a right-hand meshing PTO gear and vice versa.



The pitch of a gear is determined by the number of teeth in a given area. The more teeth, the finer the pitch. A quick way to identify the approximate pitch of a gear is to measure the number of teeth in a 3-inch area of its circumference. If you count six teeth it is a six pitch gear, 10 teeth and it is a 10-pitch gear. Gears with high pitch counts are generally quieter than low pitch gears. The most common gear design we see in truck transmissions is the 6-pitch spur gear, although, as gear manufacturing improves, we are seeing manufacturers moving more and more to helical gearing and finer gear pitches in an effort to provide quieter operation.

SECTION 4:

POWER TAKE-OFF SPEED AND ROTATION



Engine RPM × PTO % = **PTO RPM**

PTO RPM ÷ Engine RPM = **PTO %**

PTO RPM ÷ PTO % = **Engine RPM**

In the above equations PTO % is expressed as a decimal.

e.g.: **85% = .85, 125% = 1.25, etc.**

Determining PTO shaft speed
PTO output shaft speed is dependant upon truck engine speed, transmission gearing, pitch line velocity, and the internal gear ratio of the PTO. To simplify the selection, Muncie Power calculates the transmission data and catalogs PTOs according to their output shaft speed relationship to the truck engine. In the Muncie PTO Quick Reference (QR) Catalog, you will see PTO speed expressed as a percentage of engine speed. You can then determine the PTO speed in RPM by multiplying the engine speed by the PTO percentage.

Engine Speed × PTO % = PTO Shaft Speed

All PTO driven components have an operating speed range and the PTO is selected which will properly match the desired engine operating speed to the required component input speed. This can be determined by referring to the written specifications of the driven component or consulting with your PTO supplier.

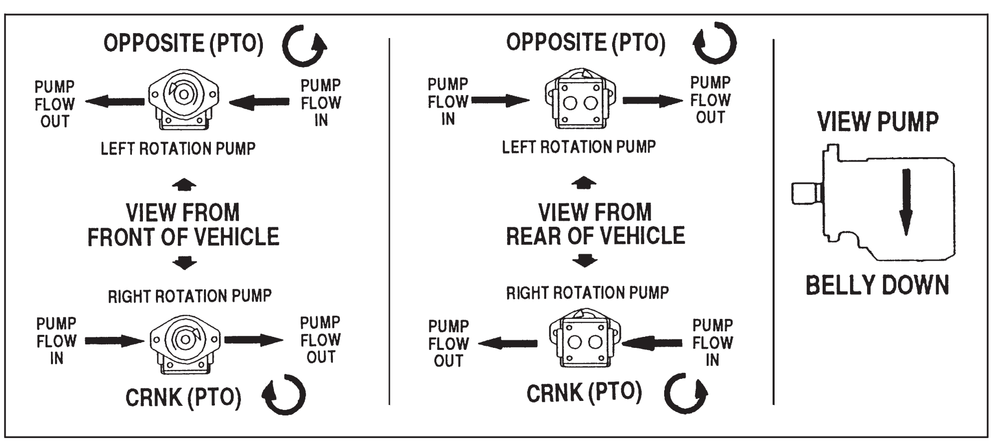
PTO Shaft Speed ÷ Engine Speed = PTO %

Engine crankshaft rotation
In addition to speed, it is also necessary to note the direction of rotation of the PTO output shaft.

To avoid confusion this is stated in terms of the engine crankshaft rotation: All engine crankshafts turn in the same rotation, clockwise when viewed from the front. Thus, PTO shaft rotation is noted as being the same as engine (CRNK) or the opposite of engine (OPP). To avoid component damage, it is important to ensure that the PTO rotation matches the component requirement.

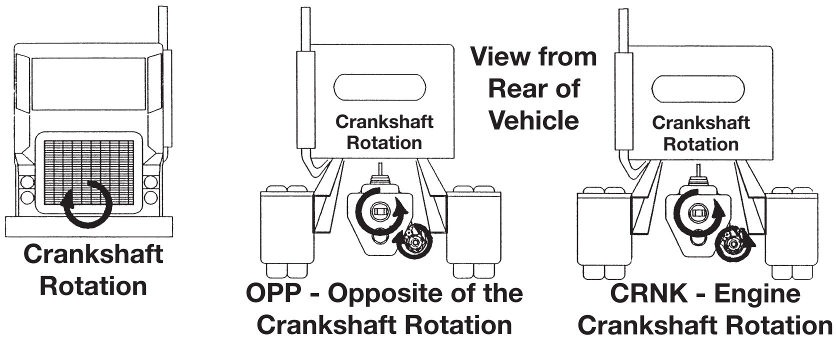
In most instances, the PTO rotation for a manual transmission is OPP and for an automatic it is CRNK—Ford automatic transmissions are the exception.

PUMP ROTATION BASED ON PTO SHAFT ROTATION



SECTION 5:
POWER TAKE-OFF SELECTION

Proper PTO selection requires specific knowledge of the vehicle's transmission and of the driven component. With this information, selection is a relatively simple process.



What do you need to know to select a PTO?

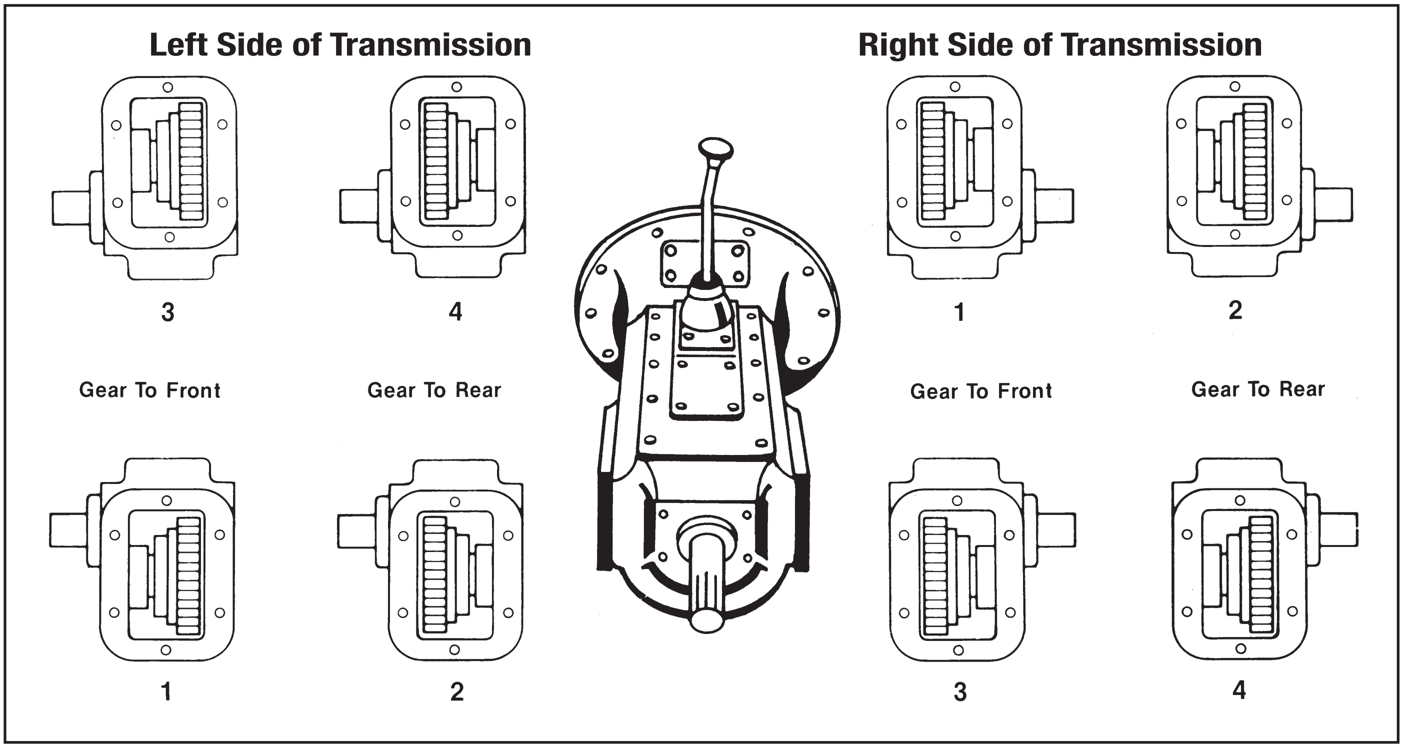
1. The transmission make and model number which can be found on the manufacturer's tag on the transmission itself or, with a new vehicle, on the build sheet. The truck dealer may also be able to identify the transmission through the Vehicle Identification Number (VIN).
2. To which aperture the PTO will be mounted? This is generally dependant on the available space around the PTO aperture and the PTO envelope space. Note the presence of exhaust pipes, spring hangers, air tanks, etc.
3. The speed requirement of the driven component and or the desired PTO percentage.
4. The required direction of rotation of the PTO shaft. This will not present a problem if you are providing both PTO and pump.
5. The torque and horsepower requirement of the driven component. This will often determine the PTO series to be used.
6. If the driven component is to be a direct-coupled hydraulic pump, the mounting face and shaft dimensions of the pump.
7. The method by which the PTO will be engaged.

NOTES ON REPLACING AN EXISTING PTO

*It is **not** uncommon for a PTO's shift cover or output type to be changed. Make sure that the tag number matches the physical description of the PTO.*

If the PTO is being replaced due to premature failure, review the application before replacing. Don't repeat someone else's mistake.

MUNCIE POWER PTO ASSEMBLY ARRANGEMENTS



SECTION 6:
MUNCIE POWER PTO MODEL NUMBER

Muncie Power uses a 13-character model number, divided into three segments, to describe the PTO, see page 12 for an example. Model numbers for the A20 and F20 use a 15-character number, see page 13 for examples.

- The first segment describes the series and mounting pad.
- The second segment describes the gears in the PTO.
- The third segment describes the shifting method, assembly, output shaft and options.

Sample model number similar to the one on page 12 is
TG6S-M6505-A1BX

TG – The first two characters of the model number—TG—identifies this PTO as a Triple Gear Series. Other examples are Clutch Shift (CS and MC1), Constant Drive (CD), Super Heavy Duty (SH), and Reversible (RL).

6S – These characters identify the mounting pad as being a 6-bolt, SAE standard or an 8S, 8-bolt SAE standard. 6B and 8B designate 6- and 8-bolt with metric fasteners.

M65 – In the second number segment, we find two sets of characters that identify the PTO input gear. The first character, a letter, identifies the transmission make: "M" for Mack, "S" for Spicer, "A" for Allison, etc. "U" (Universal) is used when a gear matches transmissions from several manufacturers. The next two numbers designate the gear pitch, how widely spaced the gear teeth are.

05 – The last two numbers in this segment describe the internal gear ratio of the PTO. In this example, if one were to rotate the input gear one complete revolution, the output shaft would rotate ½ revolution, thus the internal ratio is 05. The output shaft of a 09 ratio PTO would rotate 9⁄10 of a rotation and a 15 ratio PTO's shaft would rotate 1.5 times with each rotation of the input gear.

A – In the third model number segment, the first letter indicates the type of shifting mechanism the PTO has: "A" for air, "C" for cable, "H" for hydraulic, etc.

1 – The next number, 1, 2, 3, or 4, is the PTO's assembly arrangement; the assembly relationship of the housing, input gear, and output shaft. 1 and 3 are the most common, as they fit transmissions whose PTO drive gears are located to the front of the mounting aperture.

B – The third character, "B" in the example, is a designator for the output shaft. There are round, keyed shafts for driveshaft connections and numerous combinations designed to direct-couple hydraulic pumps.

X – The last character designates any special features or options. In the example, "X" indicates that there are no options.

There is a more detailed breakdown on the next page.

MODEL NUMBER CONSTRUCTION CHART

TG-6S-U60-04 C-1-B-X

PTO Type
- TG — Triple Gear

Mountings
- 6S — SAE 6-Bolt Std. Mtg.
- 6D — SAE 6-Bolt Non-Std. Mtg. (N81, S68 & W80)
- 6N — SAE 6-Bolt Non-Std. Mtg. (Isuzu NPR, Spicer S71, S73, I85, & M80)
- 8S — SAE 8-Bolt Std. Mtg.
- 8D — SAE 8-Bolt Non-Std. Mtg.
- 8F — SAE 8-Bolt Non-Std. – Eaton
- 8M — SAE 8-Bolt Extra Deep Mtg. (S68)
- 6A — SAE 6-Bolt Std. Mtg. w/ 29TK3863 (for N56)
- 6B — SAE 6-Bolt Std. Mtg. – Metric Studs
- 6C — SAE 6-Bolt Non-Std. Mtg. – Metric Studs
- 6F — SAE 6-Bolt Std. w/Dowel Pins – Metric Studs (F84/F86)
- 6K — SAE 6-Bolt Non-Std. Mtg. – Less Stud Kit
- 6L — SAE 6-Bolt Std. Mtg. – Less Stud Kit
- 8B — SAE 8-Bolt Std. Mtg. – Metric Studs
- 8C — SAE 8-Bolt Non-Std. Mtg. – Metric Studs
- 8K — SAE 8-Bolt Non-Std. Mtg. – Less Stud Kit
- 8L — SAE 8-Bolt Std. Mtg. – Less Stud Kit

Transmission Input Gear Options
- I84 — Aisin
- A69 — Allison
- C57 — Clark
- C60 — Clark
- C61 — Clark
- C70 — Clark
- C76 — Clark
- D94 — Dodge
- E80 — Eaton
- F10 — Fuller
- F11 — Fuller
- F56 — Fuller
- F61 — Fuller
- F62 — Fuller
- F63 — Fuller
- F65 — Fuller
- F66 — Fuller
- F70 — Fuller
- F75 — Fuller
- F84 — Fuller
- F86 — Fuller
- F89 — Fuller
- G70 — GMC
- G73 — GMC
- G79 — GMC
- G85 — Getrag
- H65 — IHC
- I80 — Isuzu
- I85 — Isuzu
- M65 — Mack
- M80 — Mercedes
- M83 — Mercedes
- M89 — Mitsubishi
- M90 — Mitsubishi
- N60 — New Process
- N81 — New Process
- N10 — New Venture
- N78 — New Venture
- N79 — New Venture
- N80 — New Venture
- N56 — Nissan
- N92 — Nissan
- R68 — Renault
- R85 — Renault
- S60 — Tremec/Spicer
- S61 — Tremec/Spicer
- S63 — Tremec/Spicer
- S70 — Tremec/Spicer
- S71 — Tremec/Spicer
- S73 — Tremec/Spicer
- S80 — Tremec/Spicer
- S89 — Tremec/Spicer
- T61 — Tremec
- T81 — Tremec
- T82 — Tremec
- S68 — Universal
- U57 — Universal
- U60 — Universal
- U62 — Universal
- U67 — Universal
- U68 — Universal
- X68 — Universal
- U80 — Universal
- W80 — Warner
- W96 — Warner
- Z10 — Zed F
- Z92 — Zed F
- Z93 — Zed F
- Z98 — Zed F
- Z99 — Zed F
- Kit — None

Speed Ratios
- 04 — .361:1
- 05 — .470:1
- 06 — .613:1
- 07 — .724:1
- 08 — .885:1
- 09 — .923:1
- 12 — 1.170:1
- 13 — 1.333:1
- 15 — 1.500:1
- 18 — 1.720:1

Special Features
- X — None
- A — Inverted Air Cover
- E — U60 w/Standard Gasket Pack
- F — Clearance Idler Cap
- G — Greaseable Shaft (K, P, & V Only)
- H — High Torque (12, 13, 15, & 18 Only) Std.
- I — Dual Terminal Indicator
- J — High Torque–Pressure Lube (12, 13, 15, & 18 Only)
- M — Clearance Idler Cap
- P — Pressure Lube (Optional)
- Q — Clearance Idler Cap–High Torque
- V — U60 w/Std. Gasket Pack, Milled Idler Cap
- 7 — Remote Pressure Switch

Output Types
- B — 1¼ Round Keyed Shaft
- C — 1410 Companion Flange
- F — Special
- G — Special
- I — DIN 5462
- K — SAE "B" ⅞"-13T, SAE "B" 2- & 4-Bolt
- L — Low Box Mount
- M — SAE "A" ⅝"-9T, SAE "A" 2- & 6-Bolt
- P — SAE "BB" 1"-15T, SAE "B" 2- & 4-Bolt
- Q — SAE "B" ⅞"-13T, SAE "A" 2-Bolt
- R — SAE "A" ⅝"-9T, SAE "A" 2-Bolt
- S — SAE "B" ⅞"-13T, SAE "B" 2-Bolt
- T — ¾"-11T SAE "A" 2-Bolt
- X — 1.25 -20T Spline For Companion Flange
- Z — SAE "C" 1¼"-14T, SAE "B" 2- & 4-Bolt
- 2 — DIN 100 Companion Flange

Assembly Arrangements
- 1 — Right Side Shaft Low
- 2 — Right Side Shaft Low, Gear to Rear
- 3 — Left Side Shaft Low
- 4 — Left Side Shaft Low, Gear to Rear

Shift Types
- A — 12 V Manual Air
- C — Cable
- E — 12 V Elect. Air
- F — 24 V Elect. Air
- H — 12 V Hydraulic Shift
- J — 24 V Hydraulic Shift
- K — 24 V Manual Air
- M — Constant Mesh (U6004)
- N — Special Electric Air (N56)*
- P — Manual Air (Less Installation Kit)
- S — Lectra Shift
- T — E-Hydra
- Z — Cable (A69)
- 4 — 12 V Manual Air (A69)
- 5 — 12 V Electric Air (A69)
- 6 — Lectra Shift (A69)
- 9 — 12 V Hydraulic Shift (A69 Only)

Note:
* Requires Special Kit

MODEL NUMBER CONSTRUCTION CHART

A20-A10 07-HX 3 BB PX XX

PTO Types
A20 — Medium Duty Clutch Shift 10-Bolt

Transmission Input Gear Option
A10 — Allison 3000/4000 Series

Speed Ratios
05 — .54:1
06 — .63:1
07 — .73:1
08 — .84:1
09 — .90:1
10 — .97:1
11 — 1.11:1
12 — 1.19:1
15 — 1.48:1

Shift Types
HX — Elec/Hyd 12 V
HR — Elec/Hyd 12 V Remote Mount
JX — Elec/Hyd 24 V
JR — Elec/Hyd 24 V Remote Mount
XX — Elec/Hyd w/o Activation Components
RX — Reduced Harness 12 V (Wiring Pigtails Only)
SX — **Muncie Start®** 12 V Integral
SR — **Muncie Start®** 12 V Remote Mount
HH — Elec/Hyd 12V Hino 2020 & Older
H2 — Elec/Hyd 12V Hino 2021 & Newer
J2 — Elec/Hyd 24V Hino 2021 & Newer
S2 — **Muncie Start®** 12 V Hino 2021 & Newer

Assembly Arrangements
1 — Right Side Shaft Low
3 — Left Side Shaft Low
5 — No Offset (Straight Out From Opening)

Flange Position Codes**
A1–T3 — Custom Flange Position
XX — Flange Shipped Loose
Blank — Default Position

Special Features
PX — Standard Hose Kit
PW — Wet Spline w/ Standard Hose Kit***
BX — Top Opening Hose Kit
BW — Top Opening Hose Kit Wet Spline
US — Pulse Generator & SPD-1001
UX — Pulse Generator & Standard Hose Kit
UB — Pulse Generator & Top Opening Hose Kit
XX — Delete Hose Kit

Output Types
1X — 1¼" Round Keyed Shaft
2I — DIN 5462 Euro
AA — SAE “A” ⅝"-9T, SAE “A” 2-Bolt
BA — SAE “B” ⅞"-13T, SAE “A” 2-Bolt
BB* — SAE “B” ⅞"-13T, SAE “B” 2- & 4-Bolt
BS* — SAE “B” ⅞"-13T, SAE “B” 2-Bolt
CB* — SAE “C” 1¼"-14T, SAE “B”***
CC* — SAE “C” 1¼"-14T, SAE “C” 2- & 4-Bolt
II — DIN 5462
PB* — SAE “BB” 1"-15T, SAE “B” 2- & 4-Bolt
PS* — SAE “BB” 1"-15,T SAE “B” 2-Bolt
TA — ¾"-11T, SAE “A” 2-Bolt
X2 — 1½"-10T, DIN 100 Companion Flange
X4 — 1½"-10T Male, 1410 Companion Flange
XX — 1½"-10T Male, For Companion Flange
ZB — SAE “C” 1¼"-14T, SAE “B” 2- & 4-Bolt

Notes:
* Wet Spline Option Available
** Special Flange Arrangement Example: A1 or T3: for proper code selection adjust flange to the ideal position and note the letter that aligns centered with the marked dots.
*** Use with Shaft Extension

MODEL NUMBER CONSTRUCTION CHART

F20-F13 12 GX 5 TN PX

PTO Series
F20 — Ford

Transmission Input Gear Option
F13 — Ford 10R140

Speed Ratio
12 — 1.18:1

Shift Types
GX — Gas Engine Standard
GS — **Muncie Start®** Gas Engine
DX — Diesel Engine Standard
DS — **Muncie Start®** Diesel Engine
RX — Reduced Harness (Wiring Pigtails Only)
RS — Reduced Harness **Muncie Start®**

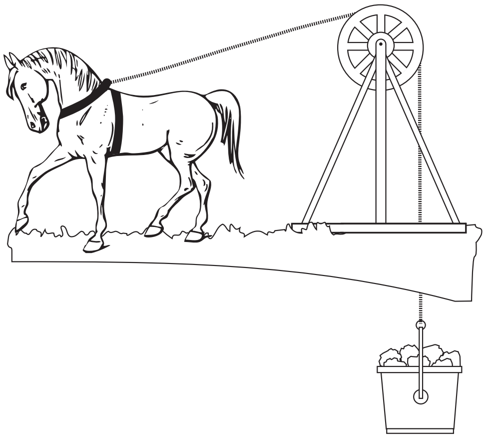
Special Features
PX — Single Mode (Either Stationary **OR** Mobile)
PB — Dual Mode (Both Stationary **AND** Mobile)

Output Types
1X — 1¼" Round Keyed Shaft
BA — SAE “B” ⅞"-13T, SAE-“A” 2-Bolt
TN — ¾"-11T, MPP “N” Pump Mount
TA — ¾"-11T, SAE-“A” 2-Bolt
UU— IS0 14 25mm-8T Shaft,
21 UNI 222 3-Bolt Flange

Assembly Arrangement
5 — No Offset (Straight Out From Opening)

SECTION 7:

PTO TORQUE AND HORSEPOWER REQUIREMENTS



***Horsepower —** The amount of force required to lift 550 pounds one foot in one second.*

Besides meeting the speed and rotational requirements of the driven component, the PTO must also meet the **torque (T)** and **horsepower (HP)** requirements of the application. This information can usually be found in the operator's manual of the equipment or by contacting the manufacturer or distributor. There are also mathematical formulas that can be used to calculate these requirements.

The most common application for a PTO is to provide power to a hydraulic pump. If the flow and pressure requirements of the hydraulic system are known, the horsepower requirement can be calculated by the formula:

HP = GPM × PSI ÷ 1,714

Example: 25 GPM × 2,000 PSI ÷ 1,714 = 29 HP

The torque load placed on the PTO can then be determined by the following formula:

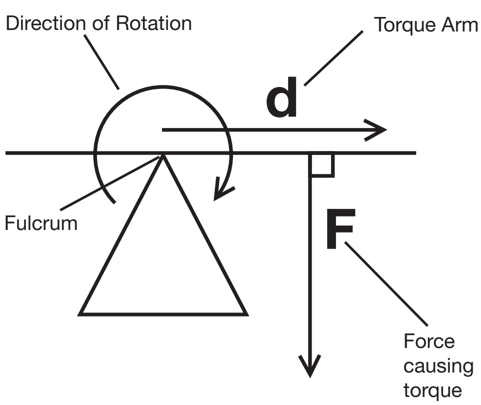
T = HP × 5,252 ÷ RPM

Note: In the above formula the RPM figure is the PTO shaft speed, not the engine speed.

So, the torque load on the PTO in the example, if the PTO shaft speed were 1,200 RPM, would be:

29 × 5252 ÷ 1,200 = 127 lb.ft.

In mechanical applications, where the PTO is supplying power directly to a driven component, the RPM and horsepower requirements must be obtained from an operator's manual, specification sheet, or by contacting the manufacturer or distributor of the component.



***Torque —** The magnitude of force multiplied by the distance from its point of application to an axis of rotation.*

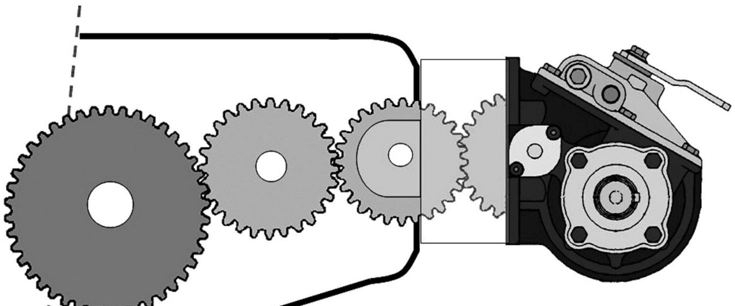
All PTOs have torque and horsepower limitations and these are shown on the application pages in the Muncie PTO QR Catalog. It is important to remember two things about the published torque and horsepower ratings:

1. Horsepower is directly proportional to PTO output shaft speed and the published ratings are at 1,000 RPM. A PTO rated at 40 HP at 1,000 RPM, therefore, can deliver 80 HP at a shaft speed of 2,000 RPM but only 20 HP at a shaft speed of 500 RPM.
2. Torque is constant. The torque rating shown is the maximum at any shaft speed. The published torque rating is calculated to provide a minimum of 300 hours life, at continuous service, at that torque level.

SECTION 8:
ADAPTER GEAR ASSEMBLIES

Adapter gear assemblies are used to reach PTO drive gears in transmissions with nonstandard mounting depths, to reverse PTO shaft rotation, or, in some instances, to angle a PTO to avoid a mounting obstruction. Muncie Power makes adapter gear assemblies to fit most transmissions and in various body styles—solid body, vertical offset, and angular offset.

Gear Adapter



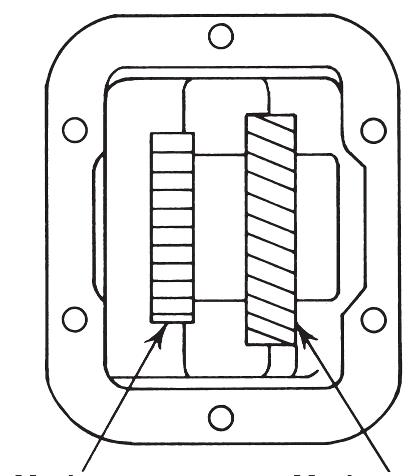
Adapter gear used to reach nonstandard depth drive gear

Most adapter gears are made with the same diameter gear as the PTO input gear and do not affect the PTO speed. Some, which utilize a cluster gear, will affect speed. Refer to the footnotes in the Muncie PTO QR Catalog for specific applications.

When utilizing an adapter, the following three things must be considered:

- **Adapter gears will always reverse the rotation of the PTO output shaft.** In the PTO application catalog if an adapter is shown in the "ADAPTER" column, the rotation shown is with the adapter. If none is indicated in the "ADAPTER" column but one is shown in the "ADAPTER TO CHANGE ROTATION" area, the PTO rotation shown is without the adapter.
- **Many adapter gears require reducing the PTO's torque and horsepower rating by 30% and many cannot be used in continuous duty applications.** Always check the footnotes in the Muncie Power PTO QR Catalog to determine if an adapter assembly can be used in your application.
- **Adapter gears often move the PTO outward, closer to frames, exhaust, etc. The exception is the angular offset models.** This can sometimes result in interference issues. Always check for proper clearance before specifying an adapter.

SPEED INCREASING ADAPTER



SECTION 9:

INTERMITTENT AND CONTINUOUS DUTY CYCLES

PTO **torque** and **horsepower ratings** are based on an intermittent duty cycle, which is defined as five minutes or less at maximum horsepower or torque within a 15-minute operating period. Operating more than five minutes at maximum horsepower or torque must be considered continuous service.

PTOs used for continuous service must be considered to have reduced horsepower and torque capacity. In most cases, the published rating must be reduced by 30%.

Example: 200 lb.ft. minus 30% = 140 lb.ft.

Example: 50 HP minus 30% = 35 HP

Fire pump applications are calculated differently and should be derated by a factor of 20%.

Any application with a PTO shaft speed above 2,000 RPM, regardless of duration, should be considered continuous duty and the PTO rating reduced by 30%.

COMMON PTO APPLICATIONS

INTERMITTENT DUTY	CONTINUOUS DUTY
Dump Truck	Pneumatic Blower
Refuse Collection	Liquid Transfer Pump
Aerial Bucket	Live Floor Trailer
Wrecker	Air Compressor
Crane	Vacuum Pump
	Generator Drive

Continuous duty applications require de-rating of the PTO torque and horsepower values by 30%.

SECTION 10:
TYPES OF POWER TAKE-OFFS

There are two broad types, or families, of PTOs: mechanical shift and clutch shift.

Mechanical

Mechanical PTOs are those which are engaged when gears slide into mesh with each other. Since a PTO is essentially a non-synchronized gearbox, it is important that the operator make certain that the transmission gears stop turning before engaging the PTO. Engaging a mechanical PTO with the transmission gears turning will result in PTO and or transmission damage.

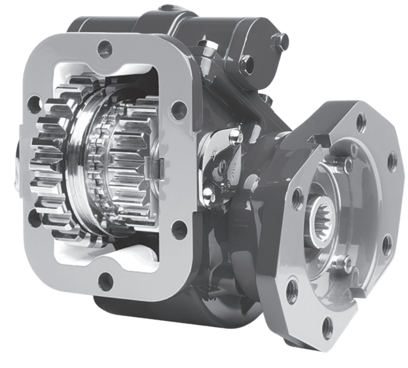
Mechanical PTOs are commonly engaged by means of a lever, cable, or air pressure. This type is typically found on manual transmissions. The Muncie Power TG Series is the most popular mechanical shift PTO. Other Muncie Power model series of this type are SH, RL, and 82.

Clutch shift

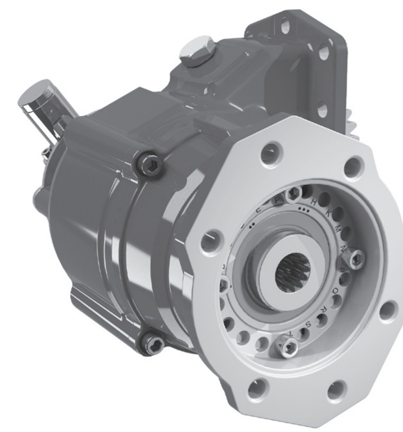
The most common PTO found on an automatic transmission is the **clutch shift** type. Rather than engaging by means of a sliding gear, the clutch shift PTO utilizes friction and spacer discs to engage. When hydraulic or air pressure is applied to an internal piston, the friction and spacer discs are forced together, engaging the PTO. Since there is no possibility of gear clash, this type of PTO can even be engaged with the vehicle in motion (as long as the truck engine speed remains under 1,000 RPM). Muncie Power clutch-type PTO series include the A20 CS6/8, CS10/11, CS41, and FR models.

Shiftable input and constant mesh

Two other terms are used to describe PTOs: **shiftable input** and **constant mesh**. A shiftable input style PTO is one which has an input gear that slides in and out of mesh with the transmission gear to engage—not a common PTO anymore. Muncie Power's SG Series PTO would be an example. The SG Series PTO is now obsolete. A constant mesh style is always in mesh with the transmission gear and engagement occurs internally, within the PTO. The Muncie Power TG and CS Series PTOs are examples of constant mesh PTOs. Constant mesh PTOs are less likely to negatively affect the transmission if operators are careless in their PTO shifting practices.



Mechanical Shift PTO



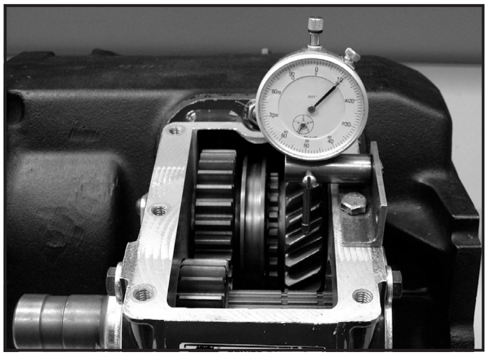
Clutch Type PTO

Constant Mesh Type PTO

SECTION 11:
POWER TAKE-OFF INSTALLATION

Backlash

The single most important aspect of PTO installation is the establishment of the proper backlash, or spacing, between the transmission and PTO gears. Backlash between mating gears serves several purposes: it allows for gear expansion, it maintains an oil film to reduce friction and noise, and it allows for easier PTO engagement.



Dial Indicator

Power take-offs that are mounted with insufficient backlash (too tight) will often produce a whining noise while those mounted with excessive backlash (too loose) will produce a clattering noise. Other symptoms of insufficient backlash are cracked mounting flanges, damaged gears, and, in some models, difficult shifting.

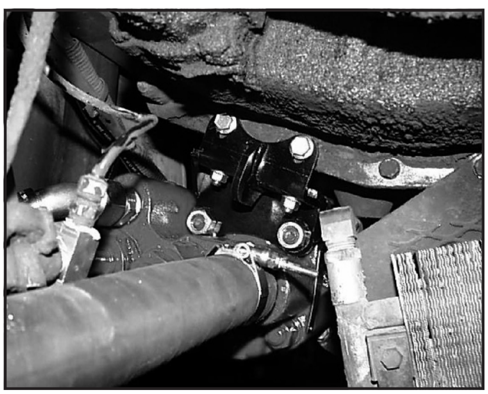
For manual transmissions, establishing backlash is the responsibility of the installer. Gaskets supplied with the PTO are added or removed to adjust the backlash to a range of .006 to .012 inches. New PTOs are supplied with gaskets in two thicknesses, .010 inches and .020 inches. Muncie Power recommends the use of a dial indicator to ensure that the PTO backlash is properly established.

SHAFT LIMITS	
SHAFT	**STL**
⅝" - 9T	≤ 5,490
¾" - 11T	≤ 10,114
⅞" - 13T	≤ 16,500
1.0" - 15T	≤ 25,650
1¼" - 14T	≤ 33,300

Most PTOs for automatic transmissions are supplied with a single "no guesswork" gasket and do not require the installer to adjust the fit, although it is still a good practice to measure the backlash upon installation.

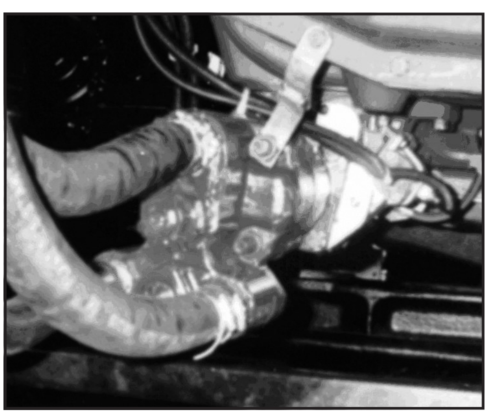
Direct-coupled hydraulic pumps

Direct-coupling a hydraulic pump to the PTO is a common practice as it eliminates the requirement for a driveline assembly which must be periodically serviced. When direct coupling a PTO and pump, it is necessary to specify a PTO output shaft and mounting flange that match those of the pump and, under certain conditions, provide a rear pump bracket to support the weight of the pump.



Proper Bracket Installation

As previously stated, there are standard pump mounting configurations established by SAE and designated by letter codes. These are based on the shaft diameter, number of splines, the mounting bolt circle, and the pilot diameter of the mounting face. The pilot of the pump refers to the raised area on the mounting face that serves to center the pump onto the PTO flange. The most common pump mount, for truck-mounted hydraulic systems, is the SAE B, which typically incorporates a ⅞ inch diameter shaft with 13 splines.

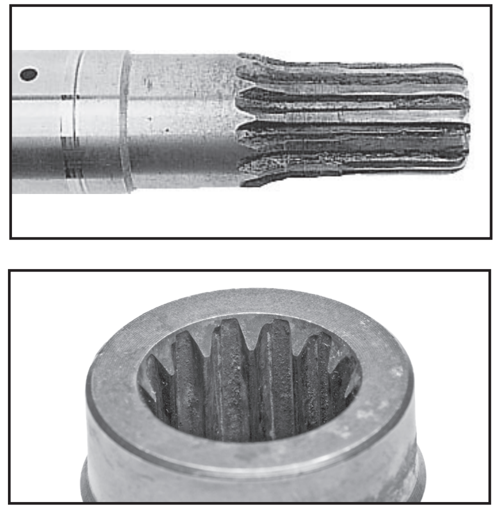


Improper Bracket Installation

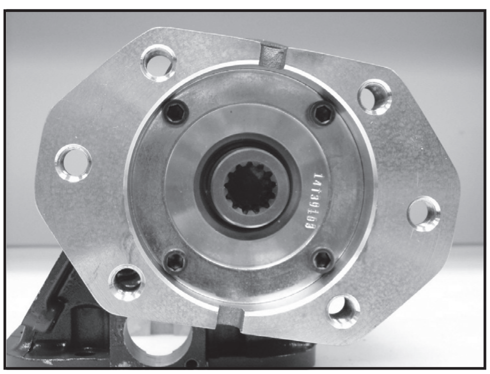
Correct PTO and pump shaft size are determined by selecting that which will withstand the torque load up to the designed **shaft torque limit (STL)**. The STL is calculated by multiplying the pump's cubic displacement by the operating pressure. The resulting figure is the STL. If the pump is a tandem or triple section, the STL for the pump is the sum of those for each section. For maximum component life always choose the largest shaft available.

Any time the combined weight of the pump, oil, hose, and fittings exceeds 40 lbs. and or the length of the pump is greater than 12 inches, it is necessary for the installer to provide a bracket at the back of the pump to support its weight. It is important that this bracket mount to two points on the pump and two on the transmission case. This provides protection from excessive vibration as well as up and down motion. Pump manufacturers often provide extended assembly studs for this purpose. This weight limitation is the same for both aluminum and cast iron bodied PTOs. **Failure to install a properly designed support bracket will result in damage to the PTO housing and possible transmission failure if lubricant is lost.**

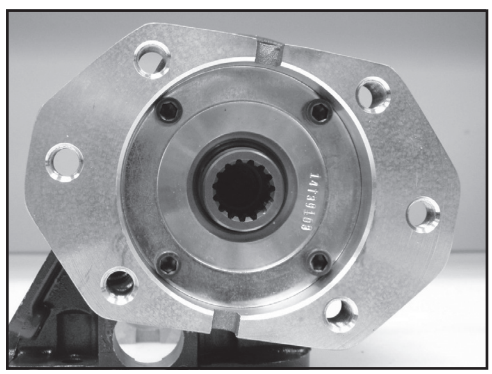
Another concern when direct-coupling the PTO and hydraulic pump is a condition called **shaft fretting**. Shaft fretting causes rapid spline wear of the PTO and hydraulic pump shafts. The wear is evident where two metal surfaces are in contact with each other and micro-movement of the two surfaces against each other wears the surfaces. Typically, this leaves a brownish residue when the surfaces are left dry. Spline failure from fretting has increased with the advent of electronically controlled diesel engines. Based upon our own findings and industry reports, it is evident that failures due to fretting corrosion are caused by conditions (harmonic vibrations originating in the engine) that are beyond the control of the PTO and pump manufacturer. There are some measures, however, that can be taken to minimize the effects of these vibrations on the PTO and pump shafts. Muncie Power has taken the lead in this area by developing and promoting a PTO with a greaseable spline feature that allows for introduction of grease into the spline area without removing the pump. This is offered as an option on several PTO models. Muncie Power also ships all direct mount style PTOs with a long lasting, high quality lubricant pre-applied to the female shaft splines. Another common response to this problem is to specify PTOs and pumps with larger diameter shafts and more splines. *See examples—SAE B and SAE BB Flanges—below:*



Shaft Fretting Damage



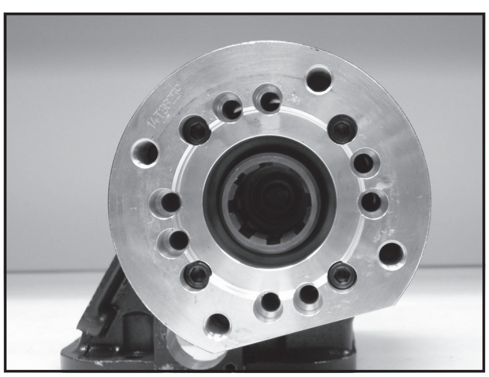
SAE B Flange



SAE BB Flange

SAE B AND SAE BB FLANGE EXAMPLES

The standard SAE class B assembly, which incorporates a 7/8" diameter, 13 spline shaft, is replaced with an SAE BB assembly which, while having the same pilot and bolt circle dimensions, utilizes a 1" diameter, 15 spline shaft.



DIN Flange

Another shaft option is the DIN 5462, a European standard which features larger, flat splines and is available on many pumps. While none of these measures is a cure for spline fretting they can mitigate its effects and extend spline life.

CRITICAL SPEEDS FOR SOLID SHIFTING

	SHAFT DIAMETER			
Length	¾"	⅞"	1.0"	1¼"
24	4,650	5,425	6,200	7,750
36	2,050	2,400	2,750	3,450
48	1,150	1,350	1,550	1,925
60	750	850	1,000	1,250
72	500	600	675	850

Shaft driven equipment
Sometimes it is not possible to direct-couple a hydraulic pump, requiring the pump to be remote mounted and powered from the PTO by means of a driveshaft assembly.

In other applications, the driven equipment is designed to be driven mechanically by the PTO rather than by hydraulics. These are **remote mount** applications. In either case, certain specification, installation, and maintenance requirements must be met.

First and foremost, the correct type and series of driveshaft must be selected. Solid shafting is not recommended but is frequently utilized in low speed/low horsepower applications to save cost. Solid shafts cannot be balanced and can vibrate, damaging PTO and pump shaft seals, causing leaks.

TORQUE RATINGS FOR REMOTE SHAFTS

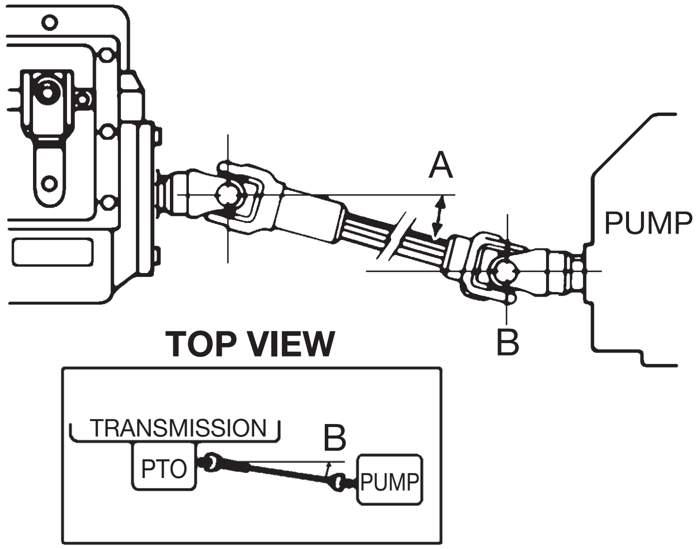
SHAFT	DUTY CYCLE		
PTO SHAFT (Round, Keyed or External Spline)	INTERMITTENT (lb.ft.)	CONTINUOUS (lb.ft.)	SEVERE (lb.ft.)
⅞" with ¼" Key	130	90	35
1.0" with ¼" Key	130	90	60
1¼" with 5⁄16" Key	300	210	200
1.3" 21T Spl. w/ Comp. Flange	300	210	200
1½" 10T Spl. w/ Comp. Flange	600	420	390

Also, solid shafts, especially those longer than 48 inches, can have critical speeds below the PTO operating RPM. The critical speed of a shaft is the maximum speed at which the shaft can rotate before it begins to bow in the center, like a jump rope. Critical speed can be increased by placing a hanger bearing in the center, effectively making two shorter shafts out of one long one: e.g., a 72-inch shaft with a bearing placed in the center becomes two 36-inch shafts for the purpose of determining critical speed.

A far better choice is a balanced, tubular assembly designed to meet the speed, torque, and horsepower requirements of the application. The Spicer™ 1000 Series components are often referred to as a PTO series. For higher horsepower applications, the 1310 Series is recommended. Consult Muncie Power or your local driveline professional for recommendations if you are unsure of your requirements.

DRIVELINE ANGLES

Max. Speed (RPM)	Max. Angle TJA "A"
3,500	5°
3,000	6°
2,500	7°
2,000	8°
1,500	11°
1,000	12°



For speeds over 2,500 RPM, contact Muncie Power for approval.

For installation with angels in the top and side views, use this formula to compute the TJA.

$$TJA = \sqrt{A^2 + B^2}$$

The operating angle must also be considered in driveshaft applications. The operating angle or **true joint angle (TJA)** is a combined angle, calculated from the known vertical and horizontal angles of the shaft. As shaft speed is increased, the acceptable TJA decreases.

Round, keyed PTO output shafts are susceptible to failure by high **cyclic loading**. Applications requiring round, keyed output shafts should be limited to the severe duty rating shown in the chart below.

Whenever a driveshaft is utilized, it is important that it be **in phase** and that it incorporate a slip yoke at one end. A shaft is in phase when the ears of its two yokes are aligned as in the drawing to the left, labeled Driveline Angles. An out of phase shaft will vibrate and damage PTO and pump shaft seals. A functioning slip yoke will allow the shaft to adjust for flexing of the truck chassis.

The bearings and slip yoke of the driveshaft must be lubricated as part of a regularly scheduled preventative maintenance plan. A driveshaft failure often results in damage to other vehicle components in proximity to the shaft. Serious personal injury is an ever-present possibility.

Shaft failure due to cyclic loading

SECTION 12:
OVERSPEED PROTECTION DEVICES

SPD-1001

PTO Switch

One advantage that clutch shifted PTOs offer over mechanically shifted models is the ability to protect the PTO, as well as other hydraulic system components, from damage caused by excessive operating speeds. Overspeed damage shows up as burnt PTO clutch packs, twisted driveshafts, overheated hydraulic systems, failed hoses, and damaged hydraulic cylinders.

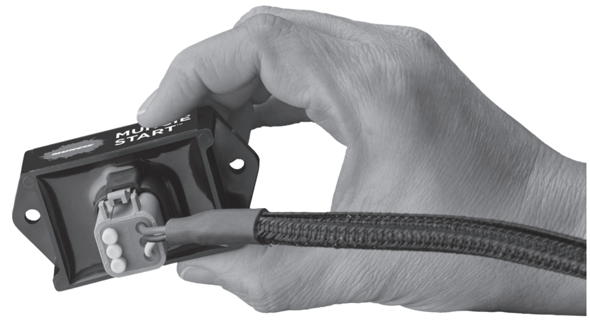
Overspeed protection is accomplished by incorporating an overspeed protection device in the system. Muncie Power has been a leader in this area, first with the EOS-110 Electronic Overspeed Switch and, more recently, with the introduction of the **SPD-1001 System Protection Device**. Both models are capable of sensing excessive engine RPM and, at a pre-programmed maximum speed, automatically disengaging the PTO.

The newest model, the SPD-1001, also allows for inputs from other vehicle sensors to ensure that safe operating parameters are met for PTO operation. These might include neutral safety switches, speedometer inputs, pressure switches, and open door sensors, for example.

It must be remembered that these devices can only be used with clutch type PTOs, which can safely be engaged and disengaged without engaging the vehicle's clutch. While not a requirement, they tend to be found on vehicles with automatic transmissions.

SECTION 13:
MUNCIE START®

A new electronically controlled, modulated clutch engagement system from Muncie Power eliminates torque spikes through the PTO, truck drivetrain, and mounted auxiliary equipment upon start up for high-inertia loads. Allowing for a smooth engagement of the PTO, the Muncie Start increases the life of the PTO and driven mechanical components.



APPLICABLE PTOS

A20 SERIES

Muncie Start
Shift code:
SX (12 VDC Integral) or
SR (12 VDC Remote Mount)

F20 SERIES

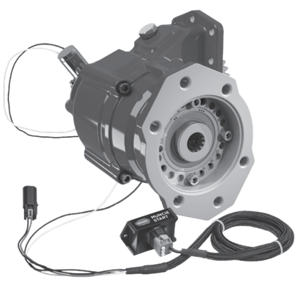
Muncie Start
Shift code:
GS (Gas Engine) or
DS (Diesel Engine)

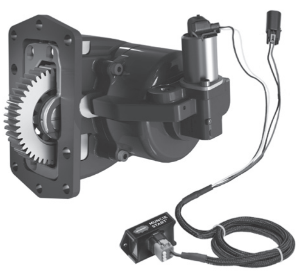
FR6Q SERIES

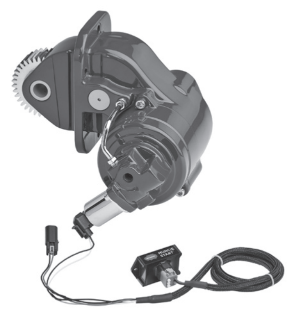
Muncie Start
Special feature option:
6 (Stationary or Mobile) or
Special feature option:
7 (Stationary and Mobile, only available on 6, F and D shift types)

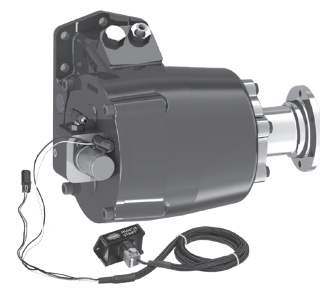
CS40/41 SERIES

Muncie Start
Special feature option:
6 (Stationary or Mobile)









SECTION 14:
WHERE TO FIND IT

BODY BUILDERS

Dodge Ram Trucks
www.rambodybuilder.com/year.pdf

Ford
www.fleet.ford.com/truckbbas/

Freightliner
www.accessfreightliner.com/newsinformation/m2bodybuilder/default.asp

GM
www.gmupfitter.com

International Truck
www.internationaltrucks.com/support/tem-body-builder-resources

Isuzu
www.isuzutruckservice.com

Kenworth
www.kenworth.com/media/4281/t470bodybuildermanual.pdf

Mack Trucks
www.macktrucksemedia.com/

Mitsubishi - Fuso
https://bb-portal.mitsubishi-fuso.com/en/

Nissan (UD Trucks)
www.udtrucksna.com

Peterbilt Motors
www.peterbilt.com/resources/

Volvo Trucks
www.volvotrucks.us/parts-and-services/services/body-builder-support/

TRANSMISSION MANUFACTURERS

Allison Transmission
www.allisontransmission.com

Caterpillar Transmission
www.cat.com/en_US/products/new/power-systems/oil-and-gas/transmissions.html

Eaton/Roadranger
www.roadranger.com/rr/ProductsServices/ProductsbyCategory/Transmissions/index.htm

Mercedes Transmissions (Freightliner)
www.freightliner.com/demand-detroit/detroit-dt12-transmission/

TTC (Spicer and Tremec)
www.ttcautomotive.com

ZF/Meritor Transmissions
www.meritor.com/products/transmissions

SECTION 15:
CONVERSION CHARTS, ABBREVIATIONS, AND FORMULAS

CONVERSION CHART

From English Units (U.S.) to Système International (Metric)

From	To	Multiply By	or	Divide By
cu.in. (in^3)	cc (cm^3)	16.39		0.06102
cu.in. (in^3)	Liters	0.01639		61.02
Pounds Feet	Newton meters (Nm)	1.356		0.7376
Gallons (U.S.)	Liters	3.785		0.2642
Gallons (U.S.)	cu.in. (in^3)	231		0.00433
Horsepower	BTU	2545.0		0.00039
Horsepower	WATTS	745.7		0.001341
Horsepower	kW	0.7457		1.341
PSI (pounds/in^2)	BAR	0.06895		14.5
PSI (pounds/in^2)	Kilopascal (KPa)	6.895		0.000145
Pound	Kilogram	0.4536		2.2046
Inch	Millimeter (mm)	25.4		0.03937
Mile	Kilometer (km)	1.6093		0.6214

ABBREVIATION EQUIVALENTS

A = Area of circle (sq.in.)	Ext = Extension	kW = Kilowatts	r = Radius
BAR = Unit of pressure	F = Fahrenheit	lbs.ft. = Force to produce torque	RPM = Revolutions per minute
β = Beta ratio	ft.lb. = A unit of work	Li = Length (inches)	sq.in. = square inches
cc. = Cubic centimeters	F = Force	L = Liters	STL = Shaft torque limitation
C = Celsius	gal. = Gallons	μm = Micrometers	Ta = Torque accelerating
CID = Cubic inch displacement	GPM = Gallons per minute	μ = Microns	Tc = Torque continuous
CIR = Cubic inches/revolution	HP = Horsepower	ml = Milliliter	T = Torque
cu.in. = Cubic inches	Hyd = Hydraulic	mm = Millimeters	TJA = True joint angle
Cyl. = Cylinder	in. = Inches	Min. = Minutes	Ts = Torque starting
Δ = Delta (change)	in.lb. = Inches per pound	Nm = Newton meters	V = Velocity
ΔP = Delta-P or parasitic pressure	in.Hg. = Inches of mercury	OA = Operating	Vol. = Volume
d = Diameter	K = HP per foot of PLV	π = 3.1416 (pi)	VE = Volumetric efficiency
Di = Depth (inches)	Kg. = Kilograms	PPM = Parts Per Million	Wi = Width (inches)
E or EFF = Efficiency	km = Kilometer	PLV = Pitch Line Velocity	

FORMULAS FOR CALCULATOR USE

The following formulas will assist in calculating specific requirements to help determine the appropriate products to pair for a successful hydraulic system. Formulas include those to solve horsepower, torque, engine speed, and so forth.

To Solve For	Calculator Entry
PTO Output Speed (RPM)	PTO RPM = Engine RPM × PTO%
Required Engine Speed (RPM)	Engine RPM = Desired PTO RPM ÷ PTO%
Horsepower (HP)	HP = T (ft.lb.) × RPM ÷ 5252
Torque (ft.lb.)	T = HP × 5252 ÷ RPM
Area of a Circle	$A = \pi r^2$ or $A = d^2 \times .7854$
Volume of a Cylinder (gal.)	$V = \pi r^2 \times Li \div 231$ OR $d^2 \times .7854 \times Li \div 231$
Force of a Cylinder (lb.)	F = A (sq.in.) × PSI
Cylinder Extension (inches/second)	Ext. Rate = GPM × 4.9 ÷ d^2 (in.)
Cylinder Extension (seconds to extend)	Ext. Time = Cyl. Volume (cu.in.) × .26 ÷ GPM
Volume of a Reservoir (rectangular, gal.)	Vol. = Li × Wi × Di ÷ 231
Volume of a Reservoir (round, gal.)	Vol = $\pi r^2 \times Li \div 231$ OR $d^2 \times .7854 \times Li \div 231$
Pump Output Horsepower (HP)	HP = GPM × PSI ÷ 1714
Pump Input Horsepower (HP)	HP = GPM × PSI ÷ 1714 ÷ E
Pump Input Torque (ft.lbs.)	T = CID × PSI ÷ 24π
Pump Output Flow (GPM)	GPM = CIR × RPM ÷ 231 × E
Pump Input Speed (RPM)	RPM = GPM × 231 ÷ CIR ÷ E
Displacement of Pump (CIR)	CIR = GPM × 231 ÷ RPM ÷ E
Flow in GPM Using PTO	GPM = Engine RPM × PTO% × CIR ÷ 231 × E
Velocity of Oil (ft./sec)	V = GPM × .3208 ÷ A (sq.in.)
Pressure Drop Through an Orifice (PSI)	$\Delta P = .025 \times GPM^2 \div d^5$ (in.)
Heat Rise in Degrees F	ΔF ° = HP × 746 × Inefficiency × Min. ÷ Gal. in System ÷ 60

NOTE: The following hydraulic motor formulas are calculated in inch pounds (in.lbs.), rather than foot pounds (ft.lbs.). To convert to ft.lbs., divide by 12.

MOTOR OUTPUT TORQUE	
Continuous	Tc = GPM x PSI × 36.77 ÷ RPM OR Tc = CID × PSI ÷ 2 π OR Tc = HP × 63025 ÷ RPM
Starting	Ts = Tc × 1.3
Accelerating	Ta = Tc × 1.1
Motor Working Pressure	PSI = T × 2 π ÷ CIR ÷ E
Motor RPM	RPM = GPM × 231 ÷ CIR

CALL MUNCIE POWER AT 800-367-7867

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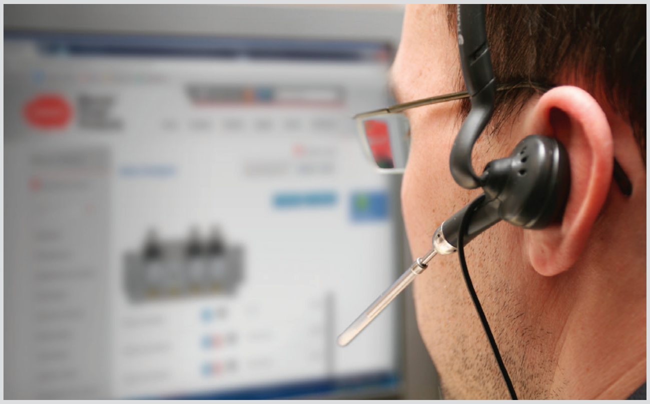
NOTES

WE BUILD TRUST.

At Muncie Power Products, it's more than building hydraulic components—it's building trust.



NEED HELP?

Please contact our customer service team for product related questions, or visit online for additional product information, literature, stocking locations, and more.

800-367-7867 www.munciepower.com

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