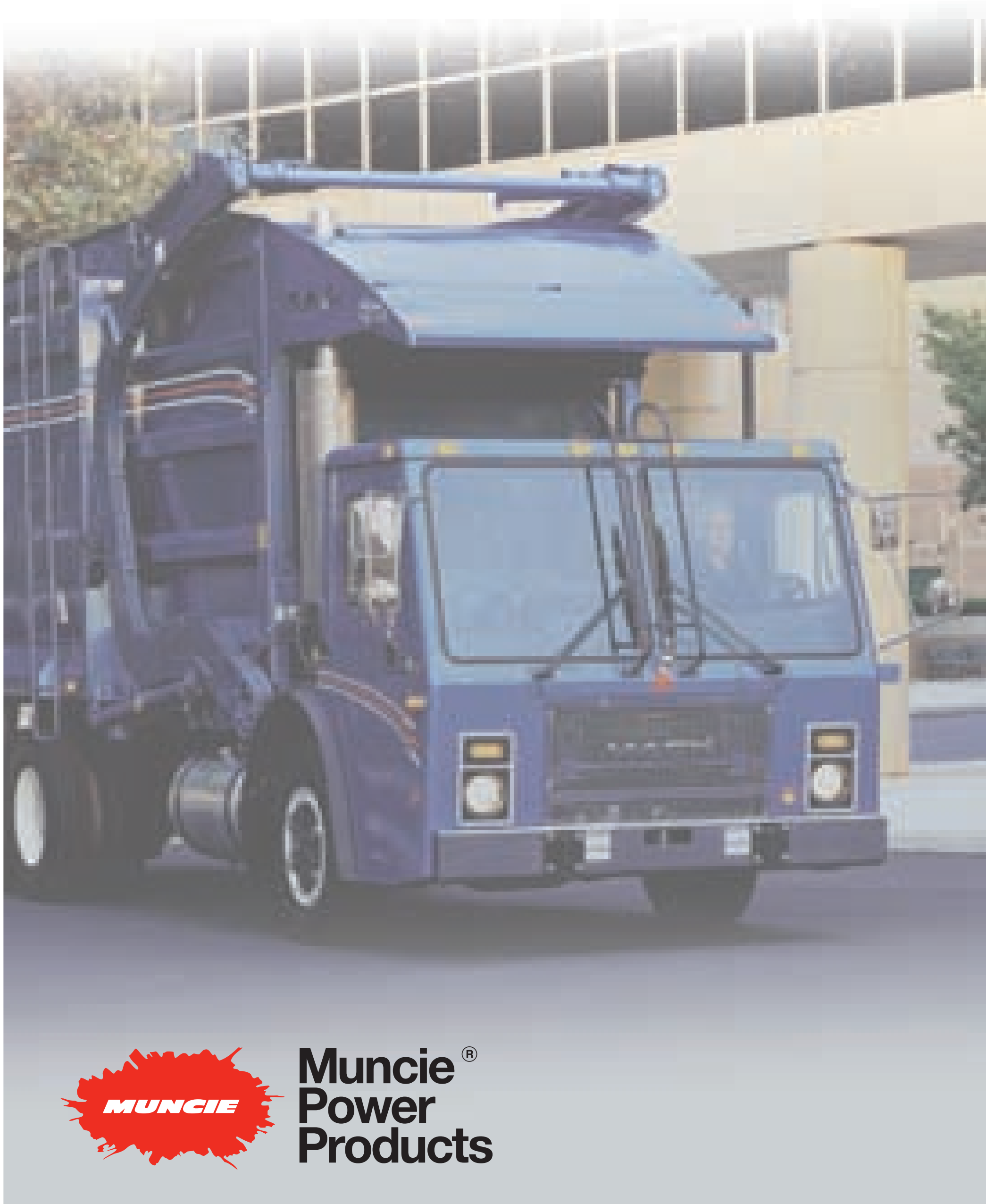
Understanding POWER TAKE-OFF SYSTEMS

SIXTH EDITION



Muncie® Power Products

Welcome to the sixth edition of Muncie Power Products' UNDERSTANDING POWER TAKE-OFF SYSTEMS, the companion piece to our UNDERSTANDING TRUCK MOUNTED HYDRAULIC SYSTEMS booklet. Together these contain a body of valuable information on providing dependable auxiliary power on today's work trucks.

Many sources are called upon to produce an accurate and useful technical/training publication. We thank the officers, employees, and customers of Muncie Power Products for their many contributions. Special appreciation goes to Rick Wallace, Power Take-Off Product Manager, and Muncie's engineering team in Tulsa, OK for developing the quality PTO products that make Muncie Power Products, Inc. the leader in the industry.

The illustrations, design, and graphics for this booklet, as well as all of Muncie's sales and support literature, were contributed by Tony Jeroski and Mark Sherfick.

We encourage anyone wishing to become more familiar with Muncie Power Products, Inc. to visit our web site, www.munciepower.com, to learn more about our company and products. While there be sure to click on the link to our M-POWER Customer Assistance Software for assistance in selecting the right Muncie PTO or hydraulic product for your application.

David L. Douglass
Director of Training

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.

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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 power take-off 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” although, in truth, many side-mounted PTOs are also driven by gears on the transmission’s countershaft and so are also “countershaft” PTOs. You may hear people refer to “side countershaft” and “rear countershaft” power take-offs 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, although 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 power take-off may be engaged by means of a cable, lever, air pressure, or hydraulic pressure. The latest PTO shifting design incorporates a small electric motor and hydraulic pump within the shift cover assembly to provide hydraulic force to engage the PTO.

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 (S.A.E.) 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 S.A.E. A, B, D, E and F.

Truck Classification By GVWR

(Gross Vehicle Weight Rating)

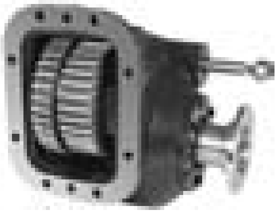
Class 1	*Less than 6,000 lb.*
Class 2	*6,001-10,000 lb.*
Class 3	*10,001-14,000 lb.*
Class 4	*14,001-16,000 lb.*
Class 5	*16,001-19,500 lb.*
Class 6	*19,501-26,000 lb.*
Class 7	*26,001-33,000 lb.*
Class 8	*33,000 lb. and up*

Transmission with PTO and hydraulic pump installed.

Air Shift Cover

Cable Shift Cover

Lectra Shift Cover



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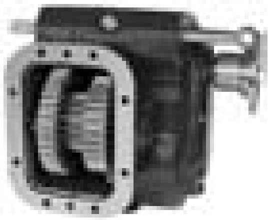

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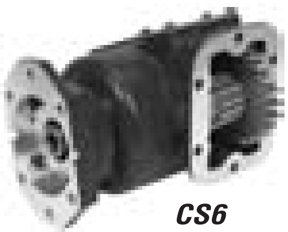
CD10

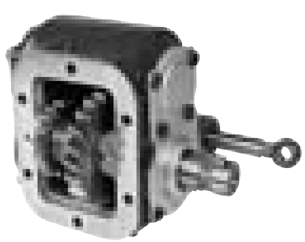


CS6

CS10

CS20

FR



RG

POWER TAKE-OFFS—A BRIEF HISTORY

The earliest documented use we have of a power take-off 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 power take-offs 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 power take-offs and by the 1960s began an expansion that would make Muncie the largest PTO distributor in North America. The company name changed to Muncie Power Products, Inc. in 1979. In 1981 Muncie Power, until then a distributor for Dana's Chelsea line, entered into a partnership with the Tulsa Winch Company and began manufacture of new PTO designs under the Muncie name. In 1986 Muncie purchased the Tulsa manufacturing facility from its parent company. In 1999 Muncie joined the Interpump Group to become, along with two other Interpump Group PTO manufacturers, PZB and Hydrocar, a part of the worlds largest PTO power take-off manufacturing entity.

The original power take-off 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 is greatly diminished. 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, like the Muncie 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.

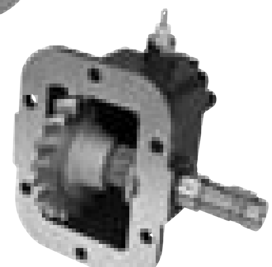
Reversible PTOs are another type that is experiencing decreasing popularity. Traditionally, reversible PTOs were used to provide power in two directions to mechanical winches and liquid transfer pumps. As hydraulic drives replace mechanical in these applications there is less need for the reversible power take-off. 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, however, not to exceed the PTO's torque capacity, which, in its reverse gear, is often similar to that of the single gear PTO.

8-Bolt power take-offs are the largest PTOs, 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 both single speed and reversible models. Hydraulic pumps can be direct coupled and the PTO can be air actuated.

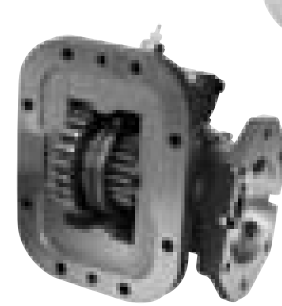
The newest design power take-offs are the **clutch type.** Commonly called "Clutch Shift", "Power Shift ", or "Hot Shift" PTOs, these models engage by means of friction disks rather than sliding gears. Used for many years on Allison automatic transmissions, this type of PTO can also be fitted to many 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 does much to prevent accidental PTO and transmission damage from improper shifting practices. While clutch type power take-offs cost more than multiple 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.

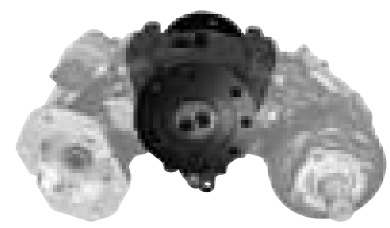
RS



SG



TG



SS66

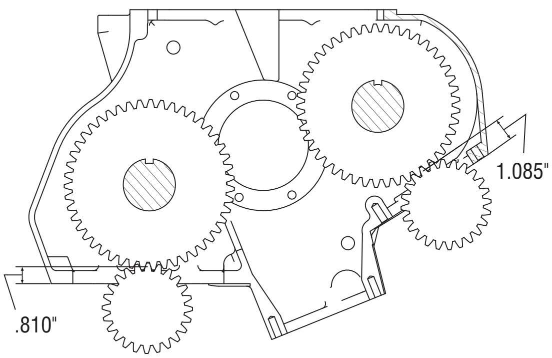
SH

SSV

SSH2

THE TRANSMISSION APERTURE

TYPICAL FULLER TRANSMISSION



The transmission's PTO aperture may be of the six-bolt, eight-bolt, or ten-bolt type, referring to the number of fasteners used to attach the PTO to the transmission. The six and eight-bolt openings are S.A.E. standard sizes. The ten-bolt opening is exclusive to automatic transmissions manufactured by Allison and Caterpillar. The PTO apertures of foreign transmissions, or U.S.–made transmissions with metric bolts, are referred to as "non-standard" openings.

S.A.E. Standards Pertaining to Transmission Mounted Power Take-Offs

J704 - Openings for Six and Eight-Bolt Truck Transmission Mounted Power Take-Offs

J722 - Clearance Envelopes for Six-Bolt, Eight-Bolt, and Rear Truck Transmission Mounted Power Take-Offs

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 S.A.E. standard gear mounting depth, referred to as the "pitch line to mounting face" (P.L.M.F.) dimension. This is 1.085 inches for a standard six-bolt opening and .810 inch for a standard eight-bolt. Muncie Power Products designs PTOs to these mounting dimensions and allows for non-standard 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 S.A.E. specification PTOs to imported transmissions with non-S.A.E. bolt patterns.

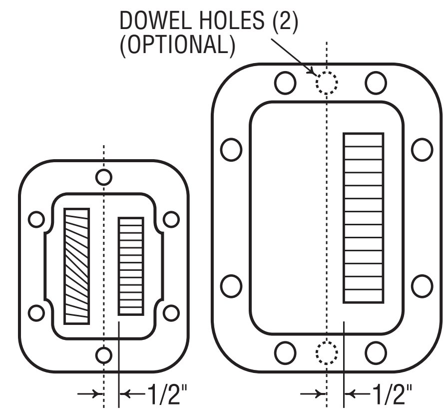
The pitch line of a gear is a reference line which represents the point on a gear tooth where load is transferred to a meshing gear during operation. While this is not a visually identifiable point, it is typically at about the mid-point of a gear tooth depending on the specific design profile of the 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", a linear representation of the gear's speed used to calculate available horsepower. The higher the pitch line velocity, the more horsepower is available to the PTO. Pitch Line Velocity is measured in feet per minute (FPM) rather than revolutions per minute (RPM). 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 pitch line velocity is required.

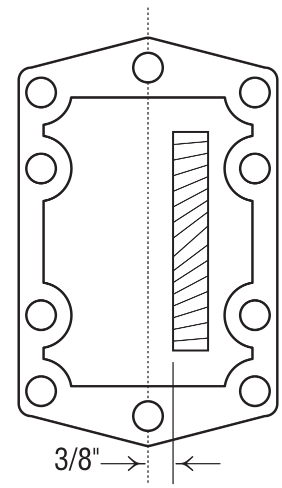
Pitch line velocity is a function of the internal gearing of the transmission and the diameter of the transmission's PTO drive gear. Horsepower available at the PTO drive gear can be calculated by the formula:

HP = PLV × Engine RPM × "K" ÷ 1000

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 six-bolt apertures, .085 hp/ft for eight-bolt, and .049 hp/ft for ten-bolt.

The standard location of the PTO drive gear in an S.A.E. six- or eight-bolt opening is ½ inch to the front or rear of the vertical centerline of the aperture. (On ten-bolt openings it is ⅜ inch.) S.A.E. standard openings with standard gear locations allow for power take-off models that are easily interchanged from one transmission to another. Non-standard openings often require transmission-specific PTOs.





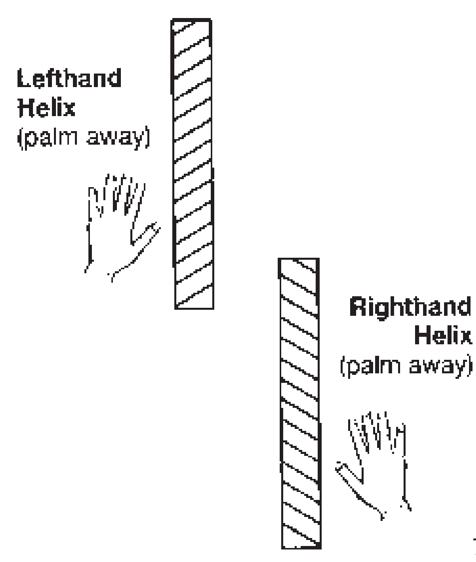
THE POWER TAKE-OFF INPUT GEAR

Power Take-Off input gears are designed to mesh with the transmission's PTO drive gear and transmit power to the PTO output shaft. Muncie 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 Gear ***Helical Gear***

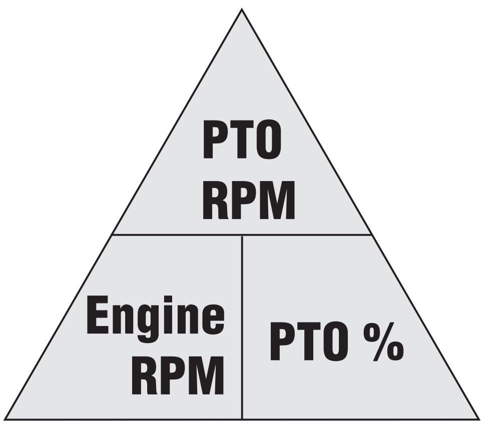
There are two gear designs in use in truck transmissions: spur and helical. Spur gears are those which have teeth cut parallel to their shaft bore. While more common they are not as quiet as helical gears, which have teeth cut at an angle to their shaft bore. A negative consequence of utilizing helical 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.

Helical gears are further identified as being either "left hand" or "right hand" gears. The drawings 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 three inch area of its circumference. If you count six teeth it is a six pitch gear, ten teeth and it is a ten pitch gear. Gears with high pitch counts will be quieter and can carry more torque than low pitch gears. The most common gear design we see in truck transmissions is the six 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 more torque and quieter operation.

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.

ie: **85% = .85, 125% = 1.25, etc**

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

ENGINE SPEED × PTO % = PTO SHAFT SPEED

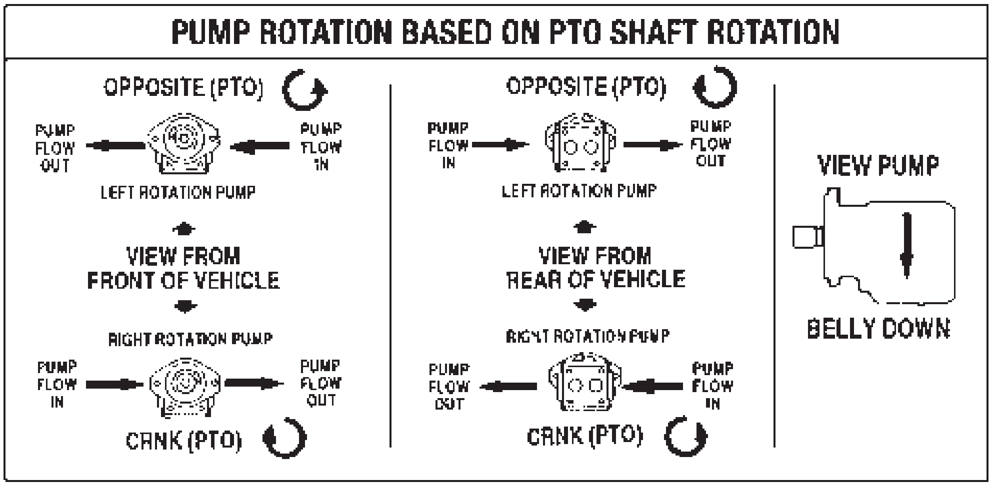
All PTO driven components have an operating speed range and the power take-off is selected which will properly match the desired engine operating speed to the required component input speed. This can be determined by referring to the written specifications of the driven component or consulting with your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

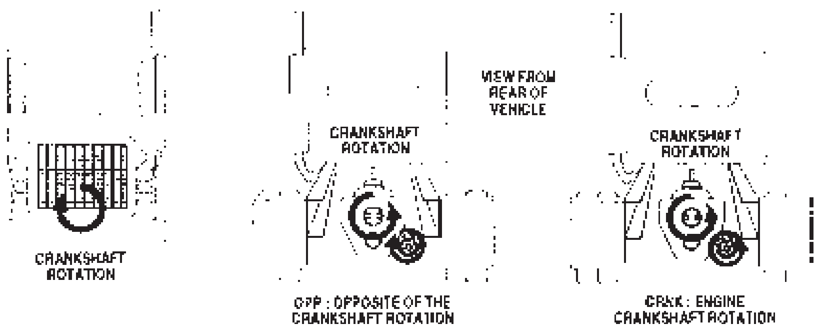
PTO SHAFT SPEED ÷ ENGINE SPEED = PTO %

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.

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 power take-off?

1. Transmission make and model number. This can be found on the manufacturer's tag on the transmission itself or, with a new vehicle, on the build sheet. The local 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, the PTO envelope space. Note the presence of exhaust pipes, spring hangers, air tanks, etc.

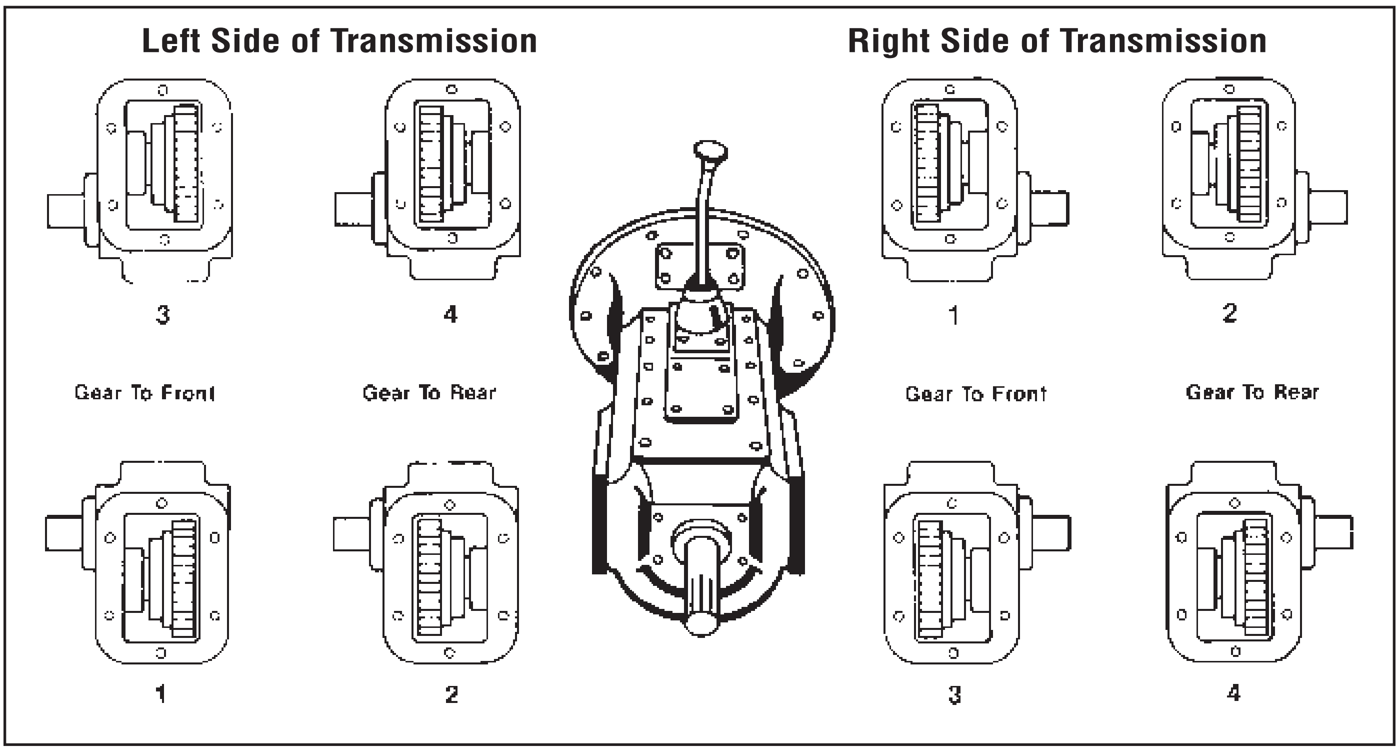
3. The speed requirement of the driven component and/or the desired PTO percentage.

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.

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.



MUNCIE POWER-TAKE-OFF ASSEMBLY ARRANGEMENTS

THE MUNCIE PTO MODEL NUMBER

Muncie Power Products uses a 13 character model number, divided into three segments, to describe the power take-off.

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.

A sample model number 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), Constant Drive (CD), Super Heavy Duty (SH), and Reversible (RG or RL).

6S– These characters identify the mounting pad as being a 6-bolt, S.A.E. standard. 8S is 8-bolt S.A.E. standard, and 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 the sample PTO above, 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 $\frac{9}{10}$ 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, 1-2-3-4, 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.

CONSTRUCTION CHART

TG 6S – U68 07 – C 1 B X

PTO TYPE

Single Speed, Single Gear	SG
Single Speed, Double Gear	HC, PZ, SH, TG
Single Speed, Double Gear, Constant Drive	CD
Clutch Shift	CS
1 & 1 Reversible	RG
1 & 1 Reversible, Low Speed	RL
2 & 1 Reversible	RX
SAE 8 Bolt Double Gear, Single Speed	82
SAE 8 Bolt 1 & 1 Reversible	83
Ford Automatic	FA, FR
Allison Automatic	GA, GM
Rear Countershaft	RS

MOUNTING

ISO 4 Bolt Standard	4S
SAE 6 Bolt Standard Mount	6S
SAE 6 Bolt Deep Mount	6D
SAE 6 Bolt Non-Standard	6N
SAE 6 Bolt w/29TK3863 (for N56)	6A
SAE 6 Bolt Standard, Metric Stud Kit	6B
SAE 6 Bolt Deep Mount, Metric Stud Kit	6C
SAE 6 Bolt Standard, Less Drag Brake (CS6 only)	6G
SAE/ISO 6 Bolt Standard, w/Dowel Holes	6F
SAE 8 Bolt Standard, Less Drag Brake (CS8 only)	8G
SAE 8 Bolt Standard Mount	8S
SAE 8 Bolt Deep Mount	8D
SAE 8 Bolt Standard, Metric Stud Kit	8B
SAE 8 Bolt Deep Mount, Metric Stud Kit	8C
SAE 8 Bolt Extra Deep Mount	8M
Allison 10 Bolt, Heavy Duty	10 or 11
Allison 10 Bolt	20 or 21
Ford 4x2	62
Ford 4x4	64

TRANSMISSION GEAR

Aisin	8.46P 20° PA Spur	I84
Allison	10.16P LH	A10
Allison	6.86P 20° PA Spur	A68
Caterpillar	9.55P 20° PA 19.73° LH	C95
Clark	5.7P 25° PA 37.7° RH	C57
Clark	6.10P 25° PA 18.68 LH	C60
Clark	6.10P 25° PA 32.28 RH	C61
Clark	7P 25° PA 30.78 RH	C70
Clark	7.61P 18.49 PA, 23.22 RH	C76
Ford	14.2P 15.9° PA 18° RH	F14
Fuller	10.1P 20° PA Spur	F10
Fuller	10.1P 21.5° PA Spur	F11
Fuller	6.1P 20.5° PA 29° RH	F61
Fuller	6.27P 22.5° PA Spur	F62
Fuller	6.35P 20° PA 22° RH	F63
Fuller	6.5P 20° PA 23° RH	F65
Fuller	6.65P 20° PA 21.5° RH	F66
Fuller	6.7P 25° PA 30.14° LH	F67
Fuller	6.0P 20° PA Spur	F68
Fuller	7.0P 23° PA 26° RH	F70
Fuller	7.5P 22° PA 15° RH	F75
Fuller	8.38P 18° PA 33.1° RH	F84
Fuller	8.5P 21° PA Spur	F85
G.M.C.	7P 20° PA 30° RH	G70*
G.M.C.	7.34P 20° PA 24° RH	G73
G.M.C.	7.93P 22.49° PA 30° RH	G79
G.M.C.	9.23P 20° PA 36° RH	G92
Getrag	8.46P 17.5° PA RH	G85
I.H.C.	6.54P 18.47 PA 23.45 RH	H65
Isuzu	8P 20° PA 15° RH	I80
Isuzu	8.46P 20° PA Spur	I85
Mack	6.48P 17.65° PA Spur	M65
Daimler/Mercedes	8.04P 17.5° PA 26.97° RH	M80
Daimler/Mercedes	8.38P 17.5° PA 24.97° RH	M83
Daimler/Mercedes	9.41P 18° PA 26.47° RH	D94
Mitsubishi	7.58P 20° PA 28.17° RH	M76
Mitsubishi	7.58P 20° PA 30° RH	M78
Mitsubishi	8.67P 22.5° PA 11.65° LH	M89
New Process	6P 20° PA 17.68 RH	N60
New Process	7P 20° PA 30.49 LH	N70
New Process	7.19P 16.88 PA 33.15 RH	N71*
New Process	7P 20° RH	N72*
New Process	8.11P 20° PA 33.5 RH	N81
New Venture	10.40P 20° PA 34.5° RH	N10
New Venture	7.94P 22.5° PA 30° LH	N78
New Venture	7.94P 22.5° PA 30° RH	N79
New Venture	7.99P 22.19° PA 29° RH	N80
Nissan	5.64P 20° PA Spur	N56
Nissan	9.27P 20° PA 25° LH	N92
Renault	6.77P 22.5° PA 23.87° RH	R68
Renault	8.47P 22.5° PA 28.46° RH	R85
Spicer	5.85P 20° PA Spur	S58
Spicer	6P 17.5° PA 26.17 RH	S60
Spicer	6P 17.5° PA 22.25° RH	S61
Spicer	6P 17.5° PA 26.06° LH	S62
Spicer	6.2P 20° PA 23.15° RH	S63
Spicer	6P or 6/8P 20° PA Spur Deep Reach	S68
Spicer	7P 17.5° PA 28.07 RH	S70
Spicer	7P 17.5° PA 18° RH	S71
Spicer	7P 20° PA 20° LH	S72*
Spicer	7P 22.5° PA 19° RH	S73
Spicer	8.10P 20° PA Spur	S80
Spicer	8.99P 20° PA Spur	S89

* Transmissions to which these gear pitches apply are obsolete. Contact Muncie for application information.

SPECIAL FEATURES

A — Reversed Shift Cover
B — Special Lube Kit (CD10)
C — Pressure Lube, Pulse Generator, EOS-111
D — Pulse Generator with EOS-111
E — U60 Input Gear w/Standard Mounting Gasket Pack
F — Special Idler Plate (G85)
G — Special Lube Shaft
H — High Torque
I — Dual Terminator Indicator Switch
J — High Torque & Pressure Lube
M — Special Idler Plate
P — Pressure Lubrication
Q — Special Idler Plate & High Torque
R — PTO Pulse Generator (CS, SH), No Pressure Lube
S — PTO Pulse Generator (CS, SH), Pressure Lube
T — High Torque with PTO Pulse Generator (TG)
U — Standard with PTO Pulse Generator (TG)
V — U60 w/Standard Gasket & Special Idler Plate (TG)
X — None
3 — Special Lube Kit (CS, CD)

OUTPUT SHAFT

A — 7/8" Round, 1/4" key (SG)
A — SAE “D” 1-1/4" 14 Spline (82)
B — 1-1/4" Round, 5/16" Key (TG, CS, SH, CD, FA, FR, RG, RL, RX)
C — 1-1/2" 10 Spline (CD, CS, SH, 82, 83)
D — SAE “B” Hydraulic Pump Flange (CD, CS, SH, TG, 82)
E — SAE “C” Hydraulic Pump Flange (CS, SH, 82)
F — SAE “A” Hydraulic Pump Flange (TG)
G — Special Dana Mount (CS, SH, TG)
H — 7/8" Round, 1/4" key, 5-3/4" long (SG)
I — 1" Round (GB10)
I — DIN 5462 (CS, SH, CD, TG, 82)
J — 7/8" Round, 1/4" key, 3-1/4" long (SG)
K — SAE “B” Hydraulic Pump Flange (CS, SH, TG)
L — SAE “B” with Round Shaft (TG)
M — SAE “A” (TG)
N — 6 Bolt Round (TG), Special (FR64)
P — SAE “B-B” 1" 15 Spline (CS, SH, TG, 82)
Q — SAE “A” Hydraulic Pump Flange (CS, SH, TG, FR)
R — SAE “A” Hydraulic Pump Flange (CD, TG)
S — SAE “B” Hydraulic Pump Flange (CS, SH, TG)
T — SAE “A” 3/4" 11 Spline (TG, FA, FR, GA, GM)
T — SAE “B” Hydraulic Pump Flange (one end) (82)
SAE “C” Hydraulic Pump Flange (opp. end) (82)
U — SAE “C” Hydraulic Pump Flange (dual output) (82)
V — SAE “B” Hydraulic Pump Flange (CS, SH, TG)
W — SAE “A” 3/4" 11 Spline (FA, FR)
X — 1-1/2" 10 Spline (CD, CS10, 82, 83)
X — 1.3 - 10 Spline 21T (TG, CS20, CS6/8, SH)
Y — SAE “C” Hydraulic Pump Flange (CD)
Z — SAE “B” Hydraulic Pump Flange 1-1/4" 14 Spline (82, CD)
2 — DIN 100 Companion Flange (TG, CS, SH, CD, 82, 83)
6 — SAE “B” 2-Bolt Special (CS)

ASSEMBLY ARRANGEMENTS

1, 2, 3, 4 *(See pages 14-15)*

SHIFTER TYPES

A — Manual Air (12 Volt Light)
B — Special Electric/Air (TG-N56)
C — Cable
D — Double Acting Air – 82 Series
E — 12 Volt Elect/Air – All TG
F — 24 Volt Elect/Air – All TG
G — Spcl Elect/Air (TG-N56) (1995-98)
H — 12 Volt Elect/Hyd – All CS-U60
J — 24 Volt Elect/Hyd – All CS-U60
K — Manual Air (24 Volt Light)
L — Lever
M — Constant Mesh – Non-Shiftable
N — Spcl Elect/Air (TG-N56) (1999-01)
P — Air Shift Less Activation Kit
Q — Double Acting Air – 82 Ser
R — Lever – Light Spring (RG)
S — Lectra Shift
T — E-Hydra Shift
U — Obsolete
V — Double Acting Elect/Air
X — None
Z — Special Rocker Switch (FA)
Z — Special Cable Shift (TG)
4 — Special Air Shift (TG)
5 — Special Elect/Air Shift (TG)
6 — Special Lectra Shift (TG)

SPEED RATIO (RANGE)

03 — 0.25 - 0.34:1	09 — 0.85 - 0.94:1	15 — 1.45 - 1.54:1
04 — 0.35 - 0.44:1	10 — 0.95 - 1.04:1	16 — 1.55 - 1.64:1
05 — 0.45 - 0.54:1	11 — 1.05 - 1.14:1	17 — 1.65 - 1.74:1
06 — 0.55 - 0.64:1	12 — 1.15 - 1.24:1	18 — 1.75 - 1.84:1
07 — 0.65 - 0.74:1	13 — 1.25 - 1.34:1	19 — 1.85 - 1.94:1
08 — 0.75 - 0.84:1	14 — 1.35 - 1.44:1	

TRANSMISSION GEAR *(cont.)*

Tremec	6.1P 25° PA 30.4° RH	T61
Tremec	8.1P 20° PA 29.47° LH	T81
Tremec	8.19P 20° PA 29.9° RH	T82
Universal	5 or 5/7P 20° Spur	U57
Universal	6P 20° Spur, Full Addendum	U60
Universal	6P 25° PA Spur	U62
Universal	6P 17.50° PA Spur	U67
Universal	6P or 6/8P 20° Spur	U68
Universal	6P or 6/8P 20° Spur, Full Dedendum	X68
Universal	8P 20° PA Spur	U80
Warner	8.08P 20° PA 30° RH	W80
Warner	9.60P 20° PA 21.6° LH	W96
Warner	9.60P 20° PA 21.6° RH	W97
Zed F	10.36P 20° PA 28° RH	Z10
Zed F	9.24P 23° PA 36.05° RH	Z90
Zed F	9.24P 23° PA 36.05° LH	Z91
Zed F	9.23P 20° PA 36° RH	Z92
Zed F	9.23P 20° PA 36° LH	Z93
Zed F	9.96P 20° PA 28.5° RH	Z98
Zed F	9.96P 20° PA 28.5° RH	Z99
None	Less Input Gear	Kit

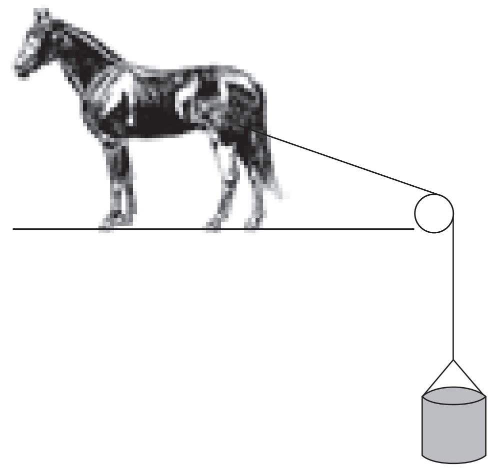
PTO TORQUE AND HORSEPOWER REQUIREMENTS

Besides meeting the speed and rotational requirements of the driven component, the power take-off must also meet the torque and horsepower requirements of the application. This information can usually be found in the owner's manual of the equipment or by contacting the manufacturer or distributor. There are also mathematical formulae that can be used to calculate these requirements.

The most common application for a power take-off 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 ÷ 1714

Example: 25 GPM × 2000 PSI ÷ 1714 = 29 HP



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

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

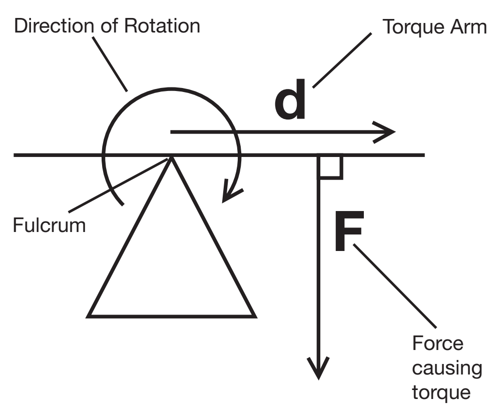
T = HP × 5252 ÷ RPM

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 1200 RPM, would be:

29 × 5252 ÷ 1200 = 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 owner's manual, specification sheet, or by contacting the manufacturer or distributor of the component.



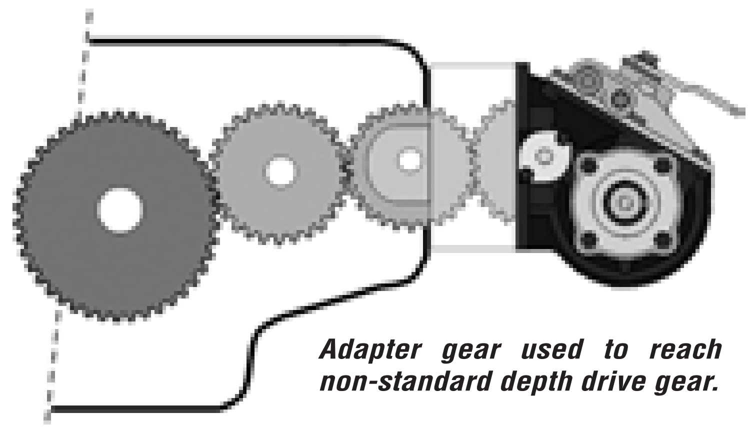
Torque— *The magnitude of force multiplied by the distance from its point of application to an axis of rotation.*

All PTOs have torque and horsepower limitations and these are shown on the application pages in the Quick Reference 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 1000 RPM. A PTO rated at 40 HP@ 1000 RPM, therefore, can deliver 80 HP at a shaft speed of 2000 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.

ADAPTER GEAR ASSEMBLIES

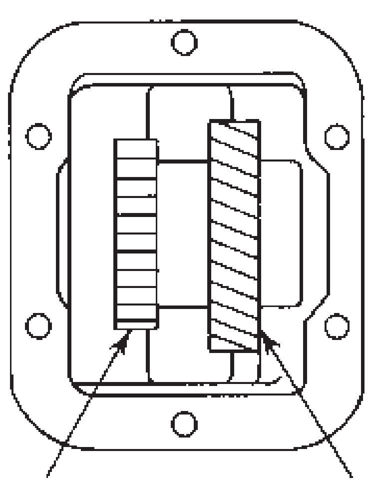
Adapter gear assemblies are used to reach PTO drive gears in transmissions with non-standard mounting depths; to reverse PTO shaft rotation; or, in some instances, to angle a PTO to avoid a mounting obstruction. Muncie makes adapter gear assemblies to fit most transmissions and in various body styles—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



Adapter gear used to reach non-standard 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 PTO Quick Reference catalog for specific applications.

SPEED INCREASING ADAPTER



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 PTO Quick Reference 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.

INTERMITTENT AND CONTINUOUS DUTY CYCLES

Power Take-Off 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 de-rated by a factor of 20%.

Any application with a PTO shaft speed above 2000 RPM, regardless of duration, should be considered continuous duty and the PTO rating reduced by 30%.

COMMON POWER TAKE-OFF APPLICATIONS

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

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

PTO TORQUE & HORSEPOWER RATINGS

Intermittent service refers to an On-Off operation under load. If maximum HP and/or torque is used for extended periods of time, (5 min. or more every 15 min.) this is considered "Continuous Service" and HP rating of PTO should be reduced by multiplying intermittent value below by .70. Applications with PTO output shaft speeds above 2000 RPM, regardless of duration, are to be considered "Continuous" duty. MAX rated output shaft speed for all Muncie PTOs is 2500 RPM.

Fire Pump applications are calculated within a different category listed on page 3 and are derated by multiplying intermittent value below by .80.

Below is a chart showing the Intermittent and calculated continuous Torque rating of the PTOs included in this catalog. The Application pages may have lower ratings for these PTOs listed. The Application page rating may be adjusted to limit the PTO output to a rating which will not exceed the transmission manufacturers rating. The transmission manufacturer does not differentiate between Intermittent and Continuous; therefore, the Application page rating is never to be exceeded. Refer to this page when there is a question of the rating (Intermittent or Continuous) for the PTO as it is manufactured.

PTO SERIES	SPEED RATIO	INTERMITTENT HP@1000 RPM	INTERMITTENT TORQUE LBS. FT.	CONTINUOUS TORQUE LBS. FT.	INTERMITTENT [KW]@1000 RPM	INTERMITTENT TORQUE [NM]	CONTINUOUS TORQUE [NM]
SG	10	25	130	91	[19]	[176]	[123]
TG	04	54	285	200	[40]	[386]	[270]
	05	51	270	189	[38]	[366]	[256]
	06	47	245	172	[35]	[332]	[232]
	07	44	230	161	[33]	[312]	[218]
	08	44	230	161	[33]	[312]	[218]
	09	39	205	144	[29]	[278]	[195]
	12H	40	180	126	[30]	[244]	[171]
	13H	40	180	126	[30]	[244]	[171]
	15H	37	195	137	[28]	[264]	[185]
	18H	33	175	123	[25]	[237]	[166]
CS6/8	03	57	300	210	[43]	[407]	[285]
	04	57	300	210	[43]	[407]	[285]
	05	57	300	210	[43]	[407]	[285]
	06	57	300	210	[43]	[407]	[285]
	07	57	300	210	[43]	[407]	[285]
	09	52	275	193	[39]	[373]	[261]
	12	52	275	193	[39]	[373]	[261]
	14	52	275	193	[39]	[373]	[261]
SH6/8	05	76	400	280	[57]	[542]	[379]
	07	76	400	280	[57]	[542]	[379]
	09	71	375	263	[53]	[508]	[356]
	12	62	325	228	[46]	[441]	[309]
	13	62	325	228	[46]	[441]	[309]
RG	13	26	140	N/A	[19]	[190]	N/A
RL	03	38	200	N/A	[28]	[271]	N/A
	05	38	200	N/A	[28]	[271]	N/A
82	05	95	500	350	[71]	[678]	[475]
	08	85	450	315	[63]	[610]	[427]
	10	78	410	287	[58]	[556]	[389]
	12	71	375	263	[53]	[508]	[356]
	13	71	375	263	[53]	[508]	[356]
	15	67	350	245	[50]	[475]	[332]
	19	57	300	210	[43]	[407]	[285]

PTO SERIES	SPEED RATIO	INTERMITTENT HP@1000 RPM	INTERMITTENT TORQUE LBS. FT.	CONTINUOUS TORQUE LBS. FT.	INTERMITTENT [KW]@1000 RPM	INTERMITTENT TORQUE [NM]	CONTINUOUS TORQUE [NM]
83	05	95	500	N/A	[71]	[678]	N/A
	06	95	500	N/A	[71]	[678]	N/A
	12	71	375	N/A	[53]	[508]	N/A
FR62	06	29	150	105	[22]	[203]	[142]
FR63	06	36	190	133	[27]	[258]	[181]
FR64	06	36	190	133	[27]	[258]	[181]
GA6B	05	30	158	111	[22]	[214]	[150]
GM6B	05	30	158	111	[22]	[214]	[150]
GB10	06	42	220	154	[31]	[298]	[209]
	07	36	190	133	[27]	[258]	[181]
	09	29	150	105	[22]	[203]	[142]
CD10	05	76	400	280	[57]	[542]	[379]
	06	73	385	270	[54]	[522]	[365]
	07	68	360	252	[51]	[488]	[342]
	08	64	336	235	[48]	[456]	[319]
	10	59	310	217	[44]	[420]	[294]
	12	50	260	182	[37]	[352]	[246]
	15	43	225	158	[32]	[305]	[214]
CD40	07	114	600	420	[85]	[813]	[569]
	12	93	490	343	[70]	[664]	[465]
CS10 /11	05	95	500	350	[71]	[678]	[475]
	06	91	480	336	[68]	[651]	[456]
	07	86	450	315	[64]	[610]	[427]
	08	80	420	294	[60]	[569]	[398]
	10	73	385	270	[54]	[522]	[365]
CS20 /21	06	62	325	228	[46]	[440]	[308]
	07	58	305	214	[43]	[414]	[290]
	08	56	295	207	[42]	[400]	[280]
	10	55	290	203	[41]	[393]	[275]
	12	48	250	175	[36]	[338]	[237]
	15	38	200	140	[28]	[271]	[190]
CS41	07	114	600	420	[85]	[813]	[569]
	10	103	545	382	[76]	[739]	[517]
	12	93	490	343	[70]	[664]	[465]

The HC, PZ, and RS Series PTOs vary in their torque and horsepower ratings and are based on the transmission on which they are mounted. The torque rating of these PTOs are shown on their respective application pages or you may contact Muncie Power Products, Inc. Product Engineering Dept. for this information.

TYPES OF POWER TAKE-OFFS

There are two broad types, or families, of power take-offs: mechanical shift and clutch shift.

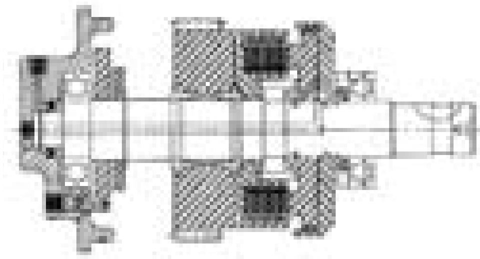
Mechanical PTOs are those which are engaged when gears slide into mesh with each other. Since a power take-off is essentially a non-synchronized gearbox, it is important that the operator make certain that the transmission gears stop turning before engaging the PTO. Engaging a mechanical PTO with the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

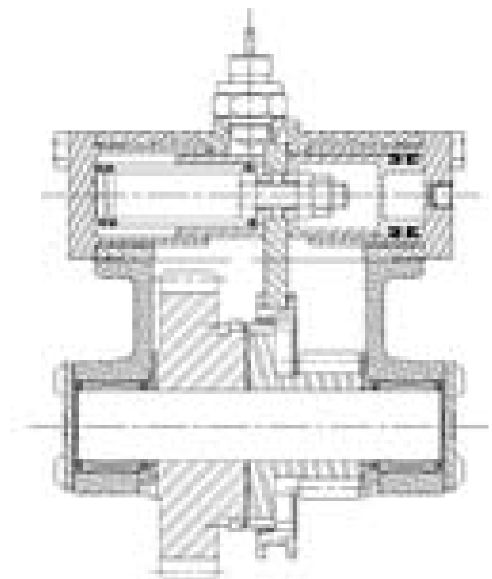
Mechanical power take-offs are commonly engaged by means of a lever, cable, or air pressure. This type is typically found on manual transmissions. The Muncie TG Series is the most popular mechanical shift PTO. Other Muncie model series of this type are SH, SG, RG, RL, 82, and 83.

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 clutch disks and friction plates to engage. When hydraulic or air pressure is applied to an internal piston, the clutch disks and friction plates are forced together, engaging the PTO. Since there is no possibility of gear clash, this type of power take-off can even be engaged with the vehicle in motion (as long as the truck engine speed remains under 1000 RPM). Muncie clutch-type PTO series include the CS6/8, CS20/21, CS10/11, CS41, FR, GA, and GM models.

Two other terms are used to describe power take-offs: “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. Muncie’s SG series PTO would be an example. A constant mesh style is always in mesh with the transmission gear and engagement is done internally, within the PTO. The Muncie TG and CS series PTOs are examples of constant mesh power take-offs. Constant mesh PTOs are less likely to negatively affect the transmission if operators are careless in their PTO shifting practices.

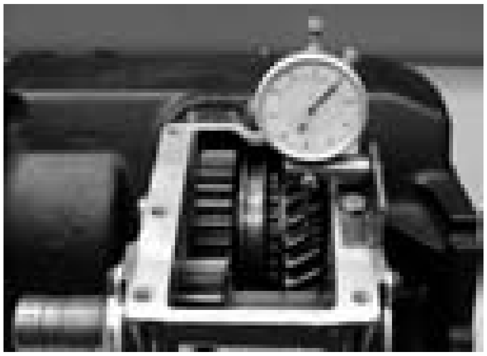
CLUTCH TYPE PTO





MECHANICAL SHIFT PTO

POWER TAKE-OFF INSTALLATION—BACKLASH



Dial Indicator

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.

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”. New power take-offs are supplied with gaskets in two thicknesses, .010” and .020”. Muncie recommends the use of a dial indicator to ensure that the PTO backlash is properly established.

Most power take-offs 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.

POWER TAKE-OFF INSTALLATION DIRECT COUPLED HYDRAULIC PUMPS

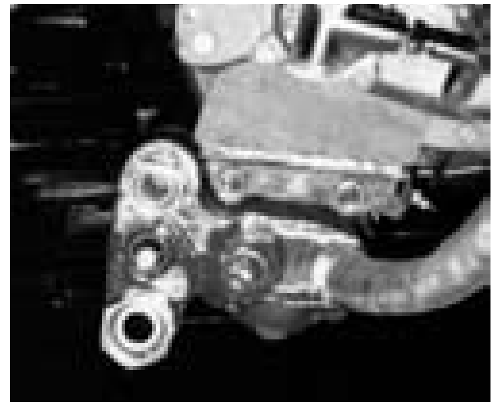
SHAFT LIMITS

SHAFT	STL
5/8” - 9T	≤ 5,490
3/4” - 11T	≤ 10,114
7/8” - 13T	≤ 16,500
1.0” - 15T	≤ 25,650
1-1/4” - 11T	≤ 33,300

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.

As previously stated, there are standard pump mounting configurations established by the Society of Automotive Engineers (S.A.E.) and designated by letter codes. These are based on the shaft diameter and 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 S.A.E. “B”, which typically incorporates a ⅞" diameter shaft with 13 splines.

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.

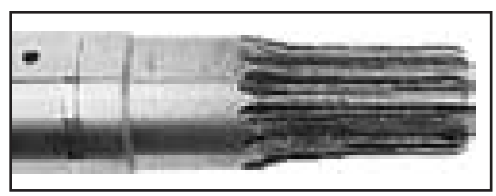


Proper Bracket Installation

Any time the combined weight of the pump and its fittings and hoses exceeds 40 lbs. and/or the length of the pump is greater than 14 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 body 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.**

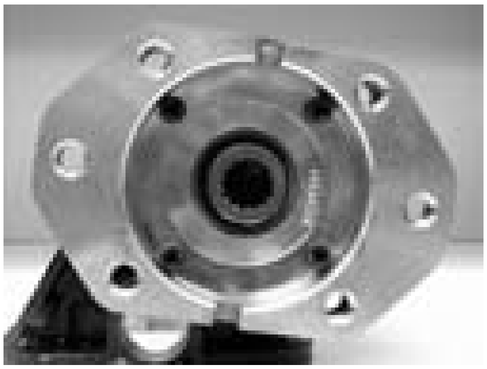
Improper Bracket Installation

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 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 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 power take-offs and pumps with larger diameter shafts and more splines. For example, the standard S.A.E. class "B" assembly, which incorporates a ⅞" diameter, 13 spline shaft, is replaced with an S.A.E. "B-B" assembly which, while having the same pilot and bolt circle dimensions, uti-



Shaft Fretting Damage

DIN Flange



SAE B Flange

SAE BB Flange

Critical Speeds for Solid Shifting

SHAFT DIAMETER				
Lgth.	34"	7/8"	1.0"	1-1/4"
24	4650	5425	6200	7750
36	2050	2400	2750	3450
48	1150	1350	1550	1925
60	750	850	1000	1250
72	500	600	675	850

lizes a 1” diameter, 15 spline shaft.

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.

POWER TAKE-OFF INSTALLATION 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 power take-off 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.

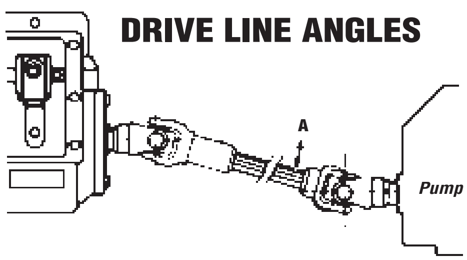
First and foremost, the correct type and series of driveshaft must be selected. Solid shafting is not recommended but is frequently utilized in low speed/ low horsepower applications to save cost. Solid shafts cannot be balanced and can vibrate, damaging PTO and pump shaft seals, causing leaks.

Also, solid shafts, especially those longer than 48 inches, can easily 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: ie, a 72” shaft with a bearing placed in the center becomes two 36” 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 or your local driveline professional for recommendations if you are unsure of your requirements.

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

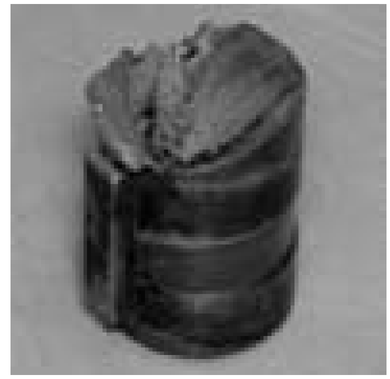
Max Speed (RPM)	Max. TJA "A"
3500º	5º
3000º	5º
2500º	7º
2000º	8º
1500º	11º
1000º	12º



** For speeds over 2500 RPM, contact Muncie for approval.*

For installations with angles in the top and side views, use this formula to compute the true joint angle (TJA):

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



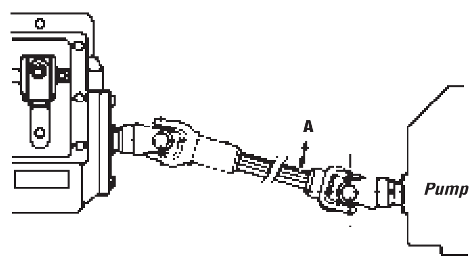
Shaft failure due to Cyclic Loading

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.

TORQUE RATINGS FOR REMOTE SHAFTS

	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

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. 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.

SPD1000A

PTO Switch

OVERSPEED PROTECTION DEVICES

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 Products has been a leader in this area, first with the EOS-110 Electronic Overspeed Switch and, more recently, with the introduction of the SPD-1000A System Protection Device. Both models are capable of sensing excessive engine RPM and, at a pre-programmed maximum speed, automatically disengaging the power take-off. The newest model, the SPD-1000A, 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.

BODY BUILDERS

Dodge Ram Trucks
www.dodgebodybuilder.com

Ford
www.fleet.ford.com/truckbbas/

Freightliner
http://www.accessfreightliner.com/newsinformation/m2body-builder/default.asp

GM
www.gmupfitter.com

International Truck
https://evalue.internationaldelivers.com/service/bodybuilder/general/

Isuzu
www.isuzutruckservice.com/bodybuilder.php

Kenworth
www.kenworth.com/6500_arc_pre_mor.asp?file=1980

Mack Trucks
http://smrpprod.macktrucks.com/spubs/internet/bbtoc.htm

Nissan (UD Trucks)
www.udtrucks.com/bbb.htm

Peterbilt Motors
www.peterbilt.com/

Sterling
http://216.45.19.226/vocrefguide/

Toyota
www.toyotaupfitter.com

Volvo Trucks
http://www.volvo.com/trucks/na/en-us/products/bodybuilder/

TRANSMISSION MANUFACTURERS

Allison Transmission
www.allisontransmission.com

Caterpillar Transmission
www.cat.com/cda/layout?m=85740&x=7

Eaton/Roadranger
http://www.roadranger.com/Roadranger/productssolutions/transmissions/index.htm

Mercedes Transmissions (Freightliner)
http://www.freightlinertrucks.com/trucks/featured-components/transmissions.aspx

TTC (Spicer and Tremec)
http://www.ttcautomotive.com/English/home/home.asp

ZF/Meritor Transmissions
http://www.meritorhvs.com/Product.aspx?product_id=26

FORMULAS FOR CALCULATOR USE

TO SOLVE FOR:	CALCULATOR ENTRY:
PTO OUTPUT SPEED	PTO RPM = ENGINE RPM x PTO%
REQUIRED ENGINE SPEED	ENGINE RPM = DESIRED PTO RPM ÷ PTO%
HORSEPOWER	HP = T X RPM ÷ 5252
TORQUE	T = HP X 5252 ÷ RPM
AREA OF A CIRCLE	$A = \pi r^2$ or $A = d^2 \times .7854$
VOLUME OF A CYLINDER	$V = \pi r^2 \times Li \div 231$
or	$d^2 \times .7854 \times Li \div 231$
FORCE OF A CYLINDER	F = A × PSI
CYLINDER EXTENSION (inches/second)	EXT. RATE = GPM × 4.9 ÷ d^2
CYLINDER EXTENSION (time to extend)	EXT. TIME = CYL. VOLUME × .26 ÷ GPM
VOLUME OF A RESERVOIR (rectangular)	VOL = Li × Wi × Di ÷ 231
VOLUME OF A RESERVOIR (round)	VOL = $\pi r^2 \times Li \div 231$
or	$d^2 \times .7854 \times Li \div 231$
PUMP OUTPUT HORSEPOWER	HP = GPM × PSI ÷ 1714
PUMP INPUT HORSEPOWER	HP = GPM × PSI ÷ 1714 ÷ E
PUMP INPUT TORQUE (ft.lb.)	T = CID × PSI ÷ 24π
PUMP OUTPUT FLOW	GPM = CIR × RPM ÷ 231 × E
PUMP INPUT SPEED	RPM = GPM × 231 ÷ CIR ÷ E
DISPLACEMENT OF PUMP	CIR = GPM × 231 ÷ RPM ÷ E
FLOW IN GPM USING PTO	GPM = ENGINE RPM × PTO% × CIR ÷ 231 × E
VELOCITY OF OIL	V = GPM × .3208 ÷ A
PRESSURE DROP THRU AN ORIFICE	ΔP = .025 × GPM2 ÷ d^5
HEAT RISE IN DEGREES F	ΔF° = HP × 746 × Inefficiency × Minutes ÷ Gallons in system ÷ 60

NOTES:

T =	Torque (ft. lb.)
A =	Area of circle (sq.in.)
F =	Force
d =	diameter
r =	radius
π =	3.1416 (pi)
Li =	Length (inches)
Wi =	Width (inches)
Di =	Depth (inches)
VOL =	Volume
E =	Efficiency
CIR =	Cubic Inches/Revolution
V =	Velocity
1 GAL =	231 cu in

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

MOTOR OUTPUT TORQUE:

CONTINUOUS	Tc = GPM × 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	T × 2 π ÷ CIR ÷ E
MOTOR RPM	RPM = GPM × 231 ÷ CIR

CONVERSION CHART

From English Units (US) 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
HORSEPOWER	BTU	2545.0	0.00093
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)	6895.0	0.000145
POUND	KILOGRAM	0.4536	2.2046
INCH	MILLIMETER (MM)	25.4	0.03937
MILE	KILOMETER (KM)	1.6093	0.6214

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Corporate Headquarters • *Muncie, Indiana*

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