Technical Information

Oil Recommendations

HYDRAULIC OIL RECOMMENDATIONS

All parts, with the exception of a few items, are lubricated by the hydraulic oil in the circuit. Particular attention must be paid to keep the oil in the circuit clean. Whenever there is a hydraulic component failure (cylinder, pump, valve), and there is a reason to feel that metal particles may be in the system, the oil must be drained, the entire system flushed clean, and any filter screens thoroughly cleaned or replaced. New oil should be supplied for the entire system. Oil suitable and recommended for use in circuits involving pumps, motors and cylinders should meet the following specifications:

Viscosity Index: 90 minimum
Aniline Point: 175 maximum
Recommended Additives: Foam depressant, rust and oxidation inhibitors.
Filtration: 10 micron recommended for maximum pump life.

Normal Temperatures:	**Minimum**	**Maximum**
Ambient:	O° F (-18° C.)	100° F. (37.8° C.)
System:	100° F. (37.8° C.)	180° F.(82.2° C.)

Other Desirable Characteristics:
- Stability of physical and chemical characteristics.
- High demulsibility (low emulsibility) for separation of water, air and contaminants.
- Resistant to the formation of gums, sludges, acids, tars and varnishes.
- High lubricity and film strength.

General Recommendations:
A good quality hydraulic oil conforming to the characteristics listed above is essential to the satisfactory performance and long life of any hydraulic system.

Oil should be changed on regular schedules in accordance with the manufacturers recommendations and the system periodically flushed.

Oil operating temperature should not exceed 200° F. (93° C.) with a maximum of 180° F. (82° C.) generally recommended. 120° F to 140° F. (50° C. to 60° C.) is generally considered the optimum system operating temperatures. High temperatures result in rapid oil deterioration and may point out a need for an oil cooler or a larger reservoir. The nearer to optimum temperature, the longer the service life of the oil and the hydraulic components.

The system reservoir capacity should equal, in gallons, the pump output in gpm or the total gpm of all pumps where there is more than one in the system.

Oil poured into the reservoir should pass through a 100 mesh screen. Pour only clean oil from clean containers into the reservoir.

PHYSICAL PROPERTIES

TEST	REQUIREMENT	METHOD
Viscosity @ 100 deg. F.	150 SSU Minimum	D88
Viscosity @ 210 deg. F.	42 SSU Minimum	D88
Viscosity index	95-125	D2270
Gravity, API	28.9-31.0	D287
Zinc	.08% Minimum	By Weight
Corrosion at 212 deg. F. Maximum	1	D130
Emulsion at 130 deg. F.	30	D1401
Flash point deg. F. Minimum	380	D92
Foam Test:		
Tendency @ 75 deg. F., M1, Maximum	75	D892-IP146
Stability @ 75 deg. F., M1, Maximum	0	
Pour Point deg. F., Minimum*	-20	D97
Rust Test	Pass	D665
Minimum Hours to reach Acid No. 2	2,000	D943

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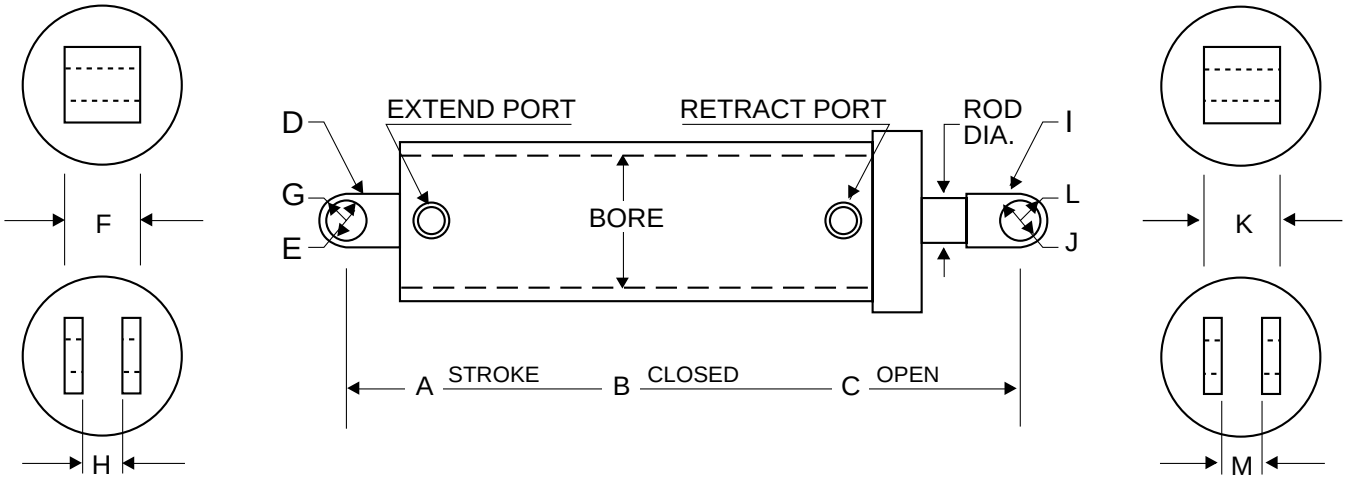
Cylinder Technical Information

ROD CYLINDER SPECIFICATION DATA FORM



Type of Equipment _____ Manufacturers Name _____

Cylinder Application _____ Quantity _____

Bore _____ Rod Diameter _____ Single or Double Acting _____

System Operating P.S.I. Normal _____ Max _____

System G.P.M. Min _____ Max _____

System Operating Temp. Normal _____ Max _____

Cushions _____

If all information is not available, please complete items in shaded boxes.

A: Total Stroke _____ Extend Port Size & Type _____

B: Closed Length _____ Extend Port Location _____

C: Open Length _____ Retract Port Size & Type _____

D: Base Mount Type/Code _____ Retract Port Location _____

E: Base Pin Diameter _____

F: Base Mount Width _____

G: Base Mount Radius _____

H: Base Clevis Gap _____

I: Rod Mount Type/Code _____

J: Rod Pin Diameter _____

K: Rod Mount Width _____

L: Rod Mount Radius _____

M: Rod Clevis Gap _____

Special Mounts (If applicable) _____

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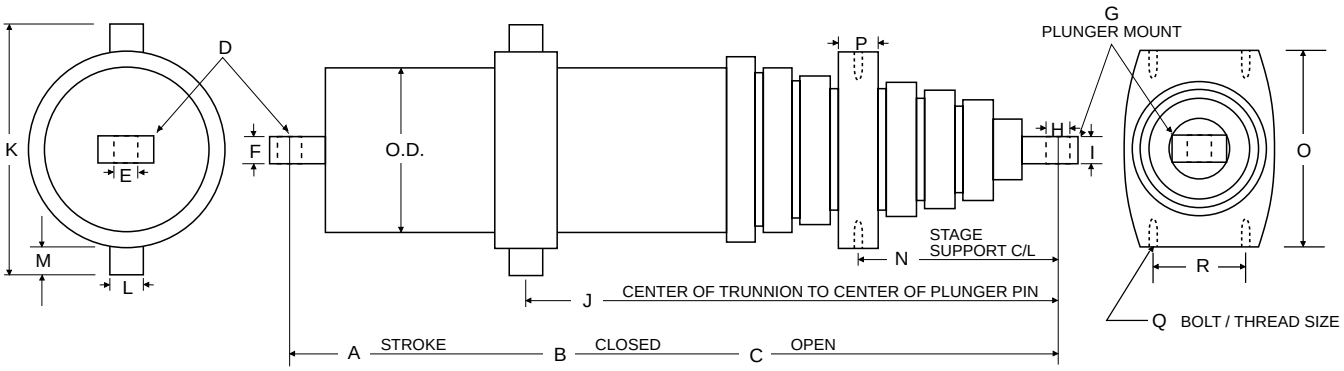
TELESCOPIC CYLINDER SPECIFICATION DATA FORM



Type of Equipment _____ Manufacturers Name _____

Cylinder Application _____ Quantity _____

O.D. of All Moving Stages _____

Number of Moving Stages _____

Single or Double Acting _____ Chrome or Non-Chrome Stages _____

System Operating P.S.I. Normal _____ Max _____

System G.P.M. Min _____ Max _____

System Operating Temp. Normal _____ Max _____

A: Total Stroke _____ N: Pin to Support C/L _____

B: Closed Length _____ O: Stage Support Width _____

C: Open Length _____ P: Stage Support Thickness _____

D: Base Mount Type/Code _____ Q: Support Bolt / Thread Size _____

E: Base Pin Diameter _____ R: Support Bolt Location & C/L's _____

F: Base Mount Width _____

G: Plunger Mount Type/Code _____

H: Plunger Pin Diameter _____ Extend Port Size & Type _____

I: Plunger Mount Width _____ Extend Port Location _____

J: Pin to Trunnion C/L (If applicable) _____ Retract Port Size & Type _____

K: Trunnion Overall Width _____ Retract Port Location _____

L: Trunnion Lug Diameters _____

M: Trunnion Lug Lengths _____

Special Mounts (If applicable) _____

If all information is not available, please complete items in shaded boxes.

TELESCOPIC CYLINDERS

NORMAL MAINTENANCE ITEMS

Packing, wipers and bushings are considered normal maintenance or service items. These items are subject to contamination from external and internal foreign materials, many of which are abrasive in nature, causing abnormal wear or damage to the parts, to the extent that replacements are required.

Cylinders may be subject to leaking oil past the seals for various reasons requiring adjustment of head/packing nuts. This adjustment is considered normal maintenance.

WARNING!!
Before working on a telescopic cylinder mounted on a truck or trailer unit, use supports or holding devices that will absolutely prevent the body from accidentally lowering. Place control valve in the "Lower" position to assure that all pressure has been relieved from the cylinder.

Procedure for Adjusting Telescopic Cylinder Head Nuts.

1. Loosen set screw (or set screws) in head nut that holds in packing of leaking stage.
2. Lightly tap head nut around circumference with a hammer.
3. Back head nut off 1/2 to 1 full turn using a spanner or chain wrench.
   (Note: If stage rotates when head nut is turned, hold stage with strap wrench.)
4. Cycle cylinder 2 to 3 times to reset chevron vee packing.
5. Retighten head nut approximately 1/2 turn further than it was when it loosened.
6. Tighten set screws.

Procedure for Mis-Staging of Mis-Sequencing Cylinder.

1. Loosen set screws in head nut that holds in packing that fits over stage that is sticking.
2. Lightly tap head nut around circumference with a hammer.
3. Back head nut off 1/2 turn using a spanner or chain wrench.
4. Cycle cylinder, if cylinder still mis-stages back head nut off another 1/2 turn.
5. Cycle cylinder, if cylinder still mis-stages tighten the head nut of the next stage that is extending.
6. Tighten set screws.

Bleeding Air from Single-Acting Telescopic Cylinders.

For smooth operation on these cylinders, it is advisable to bleed the air from the cylinder weekly.
Manual bleeding is accomplished by:

1. Empty the dump body of any material.
2. Remove the cover plate from the dog house of the dump body to access the bleeder valve.
3. Fully extend the cylinder, raising the EMPTY dump bed.
4. Lower the dump to within 1 foot from resting on the frame.
5. With the fingers turn the bleeder valve in a counterclockwise direction. This opens the valve and allows the air to escape from the cylinder.
6. When a steady stream of oil comes from the bleeder, turn the valve in a clockwise direction until it is closed.

If these procedures fail to correct the problem, please contact our Component Sales Team for Instructions.

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WAYS TO EXTEND THE LIFE OF YOUR CYLINDERS

WARNING!!
Before working on a telescopic cylinder mounted on a truck or trailer unit, use supports or holding devices that will absolutely prevent the body from accidentally lowering. Place control valve in the "LOWER" position to assure that all pressure has been relieved from the cylinder.

Single-Acting Telescopic Dump Cylinders

Cylinders are not to be used as a stabilizer on a dump body or dump trailer. The cylinder is strictly a lifting device and is not a structural member of the dumping unit.

The cylinder should float in the pin mountings. It should be installed with 1/8" to 3/16" of clearance between the pin and the pin hole if the mounting eye is wider than 5", or with 1/16" to 1/8" clearance if the mounting eye is less than 5" wide. There should be a clearance of 1/4" per side on eyes less than 5" to 1/2" clearance per side on eyes in excess of 5" wide. This is to allow the body to sway slightly while dumping, without putting a side load on the cylinder. The cylinder end mounts should be lubricated regularly.

Cylinders cannot withstand side pressures from a dump unit leaning. A tractor trailer unit must be in a straight line when dumping, not jackknifed. All dump units must be on firm, level ground and not operated during heavy crosswinds. Failure to do so may cause the unit to upset.

Do not overload the dump unit. The load must be evenly distributed during loading and unloading.
Do not jerk or slingshot dump unit in an attempt to free a sticking or frozen load. Pulling forward (or backing up) and hitting the brakes or lowering the body part way and then quickly engaging the valve in the "HOLD" or "RAISE" position will cause a tremendous pressure spike. This pressure spike may bulge or split one of the larger stages of the cylinder.

When lowering a load that is sticking, the dump unit must be feathered down slowly to avoid a high pressure build up in the cylinder.

Do not operate cylinder at pressures above factory recommended operating pressures (Normally 2,000 P.S.I. unless otherwise approved).

The driver should stay at the controls during the entire dumping operation. If the body starts to lean to one side, the driver should immediately lower the body. It is important to feather the control valve into the hold position to avoid a pressure spike in the cylinder.

Do not operate cylinder with personnel or equipment alongside.
The dump unit must be lowered completely before moving unit.

Do not drive with P.T.O. or Hydraulic Pump engaged.

Hydraulic hoses should be inspected regularly and replaced if worn out or damaged.

Hydraulic oil should be inspected or changed regularly and whenever a new cylinder is installed.

A damp to light film of oil on each plunger or stage of a telescopic cylinder indicates good cylinder operation. After many cycles of the cylinder, a small accumulation of oil may be noticed on the plungers or sleeves at the head nuts. This should not be mistaken for packing leakage.

Cylinder should be free of entrapped air. It is advisable to bleed air from cylinder weekly for a smooth operation.

TELESCOPIC CYLINDERS

WAYS TO EXTEND THE LIFE OF YOUR CYLINDERS

WARNING!!
Before working on a telescopic cylinder mounted on a truck or trailer unit, use supports or holding devices that will absolutely prevent the body from accidentally lowering. Place control valve in the "LOWER" position to assure that all pressure has been relieved from the cylinder.

Double-Acting Telescopic Cylinders

A double-acting telescopic cylinder should be fully retracted when not in use.

A double-acting telescopic cylinder should not be extended until it has been fully retracted. A partially extended cylinder with pressure relieved may drift out of position. This can happen if a cylinder experiences vibration, such as an ejector or push out cylinder does in a refuse body. If this happens and the cylinder is then extended, the out of position plunger or sleeves will rapidly reposition themselves and possibly cause high pressure oil to be trapped on the retract side of the cylinder. This could cause a stage / sleeve to bulge and or the packing and bearings to be blown out from under a head nut.

Do not operate a packer / ejector cylinder with a misaligned blade. If the packer / ejector blade is bent, damaged, or if blade slide shoes or guide track assembly are worn out, this can cause excessive side loading to the cylinder damaging it internally or bending a plunger or sleeve.

If the hydraulic system uses quick disconnects (such as on a transfer trailer) or holding / lock type valves, make sure they are properly connected. If not, oil may become trapped in the cylinder causing an excessive pressure build up and damage to the cylinder. This is particularly true if there is a blockage on the retract side of the cylinder and the cylinder is then extended. This could internally intensify the pressure 10 times or more inside the cylinder. (Example: The pump develops 2,000 P.S.I. trying to extend cylinder, oil pressure trapped on the retract side of the cylinder could see 20,000 P.S.I.)

Do not operate a cylinder at pressures above factory recommended operating pressures (Normally 2,000 P.S.I. unless otherwise approved.) Make sure hydraulic pump is developing required G.P.M., Double-acting telescopic cylinders normally require 15 G.P.M. to retract properly.

Most double-acting telescopic cylinders will self bleed themselves of air. Upon installation of a new cylinder this will require cycling the cylinder approximately 10 times to the complete extend and retract positions with no load against it. Check to make sure stages are sequencing properly. When extending, the largest stage should move first then the next largest, etc. and when retracting the smallest should move first then the next smallest, etc.

On Roll Off units, if the Lift Cylinders are not completely extended when a container is being pulled onto the hoist, the lift cylinders may be pulled open by the weight of the load. Then as the container is pulled over center, the cylinders will be forced closed until they hit the column of oil inside the cylinders causing a sudden pressure surge. If the lift cylinders are pulled open by the load, they should be extended with the control valve to fill them with oil before pulling the container on the rest of the way. Care should be taken if moving a Roll Off unit with tilt cylinders extended, avoiding sudden stops or jolts.

On Roll Off units dropping off a loaded container, feather control valve to avoid any pressure surges in the reeving / cable cylinders as gravity pulls the container to the ground.

On Roll Off units, if the container is not evenly loaded and is heavy on one side, the lift cylinders may misstage. When the plunger / sleeves attempt to correct themselves, there may be a sudden pressure surge, possibly damaging the cylinder.

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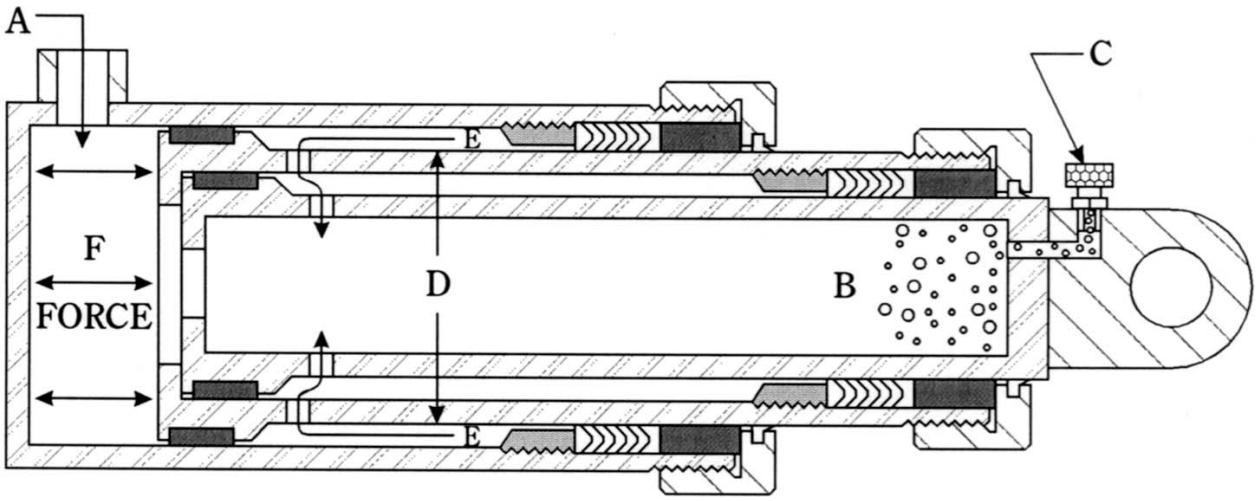
SINGLE ACTING TELESCOPIC CYLINDER OPERATION



To Extend:
High pressure oil from the pump is directed by the control valve through the port (A) to fill the cylinder. Any air in the system is trapped in the end of the cylinder (B) and may be bled off through the bleeder valve (C). Generally, bleeding is only necessary on initial start up or if air has been allowed to enter the system.

Oil pushes on the bottom of the sleeve or plunger forcing (F) it to move out. The outside diameter or sealing area of the sleeve or plunger (D) determines the effective area.

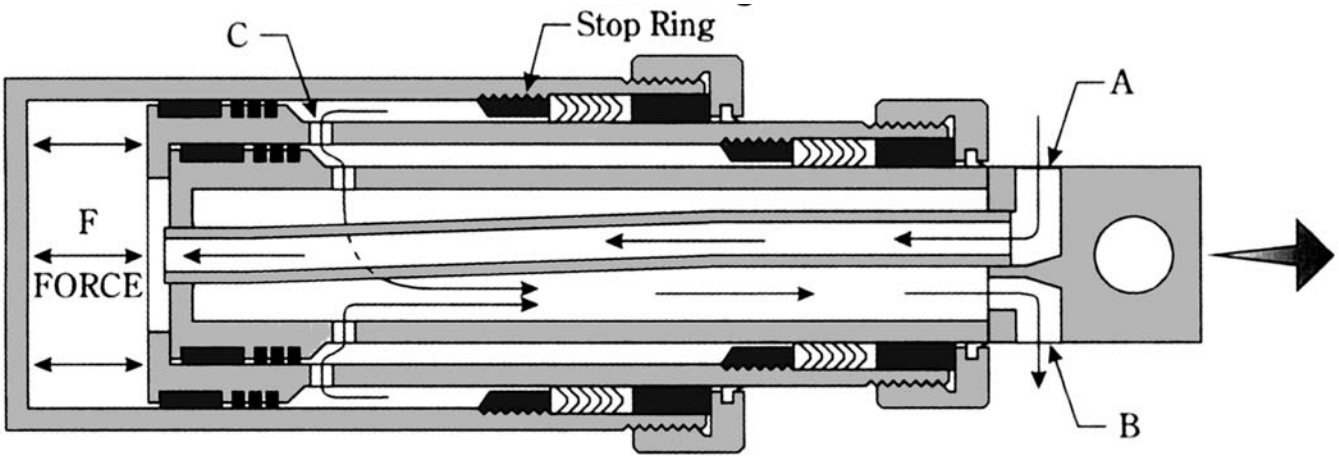
As the sleeve or plunger moves out, the oil trapped between (E) the sleeve or plunger wall is released through holes in the sleeve or plunger.

To Retract:
A single acting cylinder must be retracted by gravity or mechanical means.

TELESCOPIC CYLINDERS

DOUBLE ACTING TELESCOPIC CYLINDER OPERATION

EXTENDING

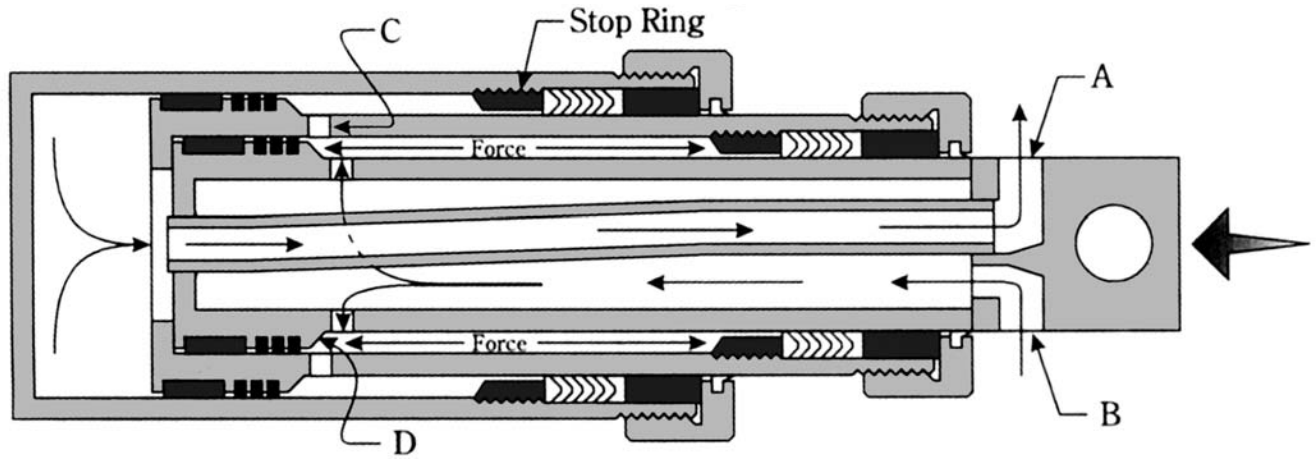


To Extend:
High pressure oil is directed by the control valve into port A. The oil passes through the transfer tube in the rod to the base of the cylinder. The pressure acts on the effective area (area of the largest piston) and extends all stages to the first stop ring.

The next stage then begins to extend. The effective area of each stage is figured from the inside diameter of the next largest stage. Each stage extends in its turn to the stop ring.

Oil trapped between the sleeves escapes through holes (c) in each sleeve and returns to tank through port B.

RETRACTING



To Retract:
High pressure oil is directed by the control valve in port B. The pressure is applied to the effective area (d) of the plunger which retracts first. Each stage from the smallest to the largest retracts in its turn, however, THE EFFECTIVE AREA FOR RETRACTING EACH STAGE IS THE AREA (D) OF THE PLUNGER.

Oil inside the cylinder is forced out of port A. Because of the area differential the flow into port B must be multiplied by this differential to determine the flow out of port A. It may be necessary to install a dump-to-tank valve to speed up the retracting cycle.

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Stroke & Lifting Calculations Mounting

Note: This guide is for use to determine approximate stroke and lifting requirements for a front mount dump body. Final dimensions should be determined by an engineering drawing.

Formula for Calculating Initial Required Cylinder Force to Lift a Load

$$\frac{\text{Load (lbs) X "A"}}{\text{"B"}} = \text{Initial required cylinder force}$$

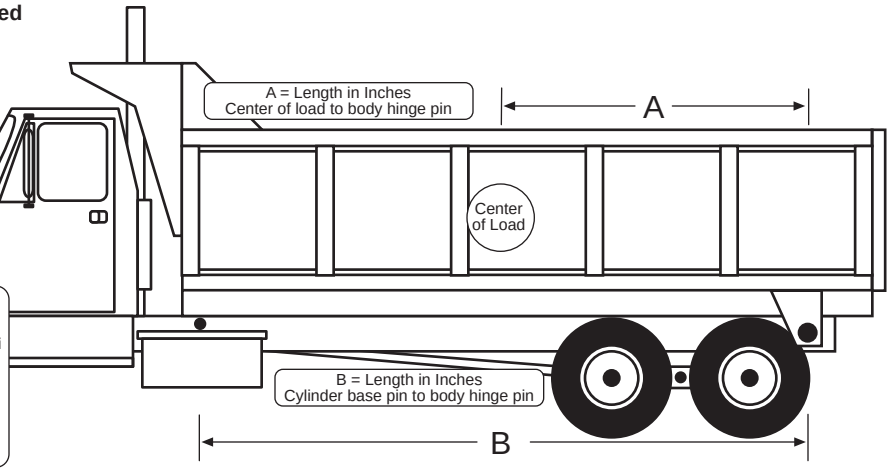
Example

$$\frac{\text{50,000\# X 85"}}{\text{166"}} = \text{25,603\# of force to start the lift}$$

Note: For a good design, initial pressure should not exceed 800 psi at start of lift

Telescopic Lifting Capabilites

Stage O.D. in inches	800 psi	System operating pressure 1000 psi	1500 psi	2000 psi
2.75"	4752	5940	8909	11879
3.75"	8836	11045	16567	22089
4.75"	14176	17721	26581	35441
5.75"	20774	25967	38951	51935
6.75"	28628	35785	53677	71570
7.90"	39213	49017	73525	98034
9.37"	55165	68956	103434	137911



Formula for Calculating the Required Cylinder Stroke for a Dump Angle

"B" X "D" = Approximate Stroke

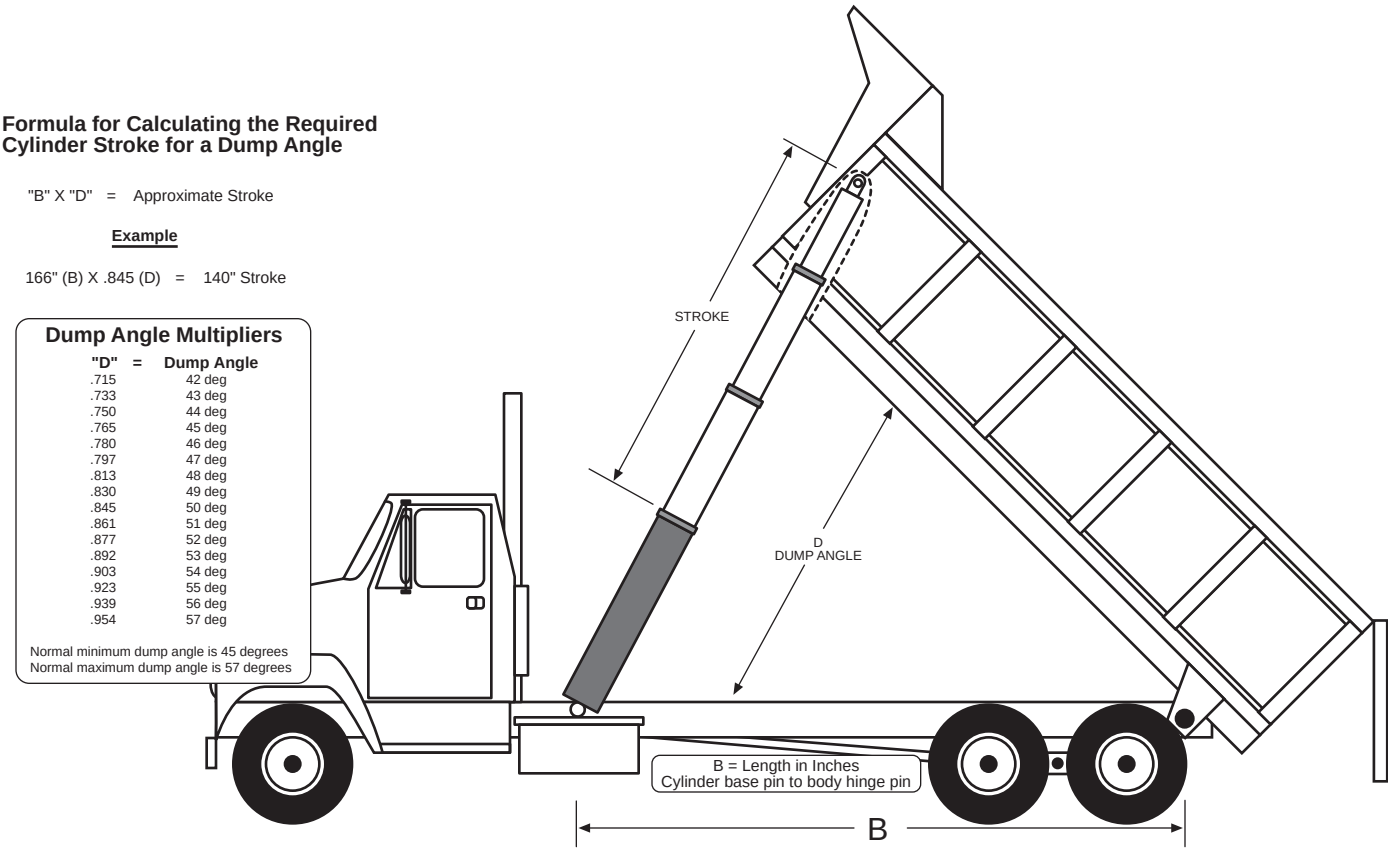
Example

166" (B) X .845 (D) = 140" Stroke

Dump Angle Multipliers

"D" =	Dump Angle
.715	42 deg
.733	43 deg
.750	44 deg
.765	45 deg
.780	46 deg
.797	47 deg
.813	48 deg
.830	49 deg
.845	50 deg
.861	51 deg
.877	52 deg
.892	53 deg
.903	54 deg
.923	55 deg
.939	56 deg
.954	57 deg

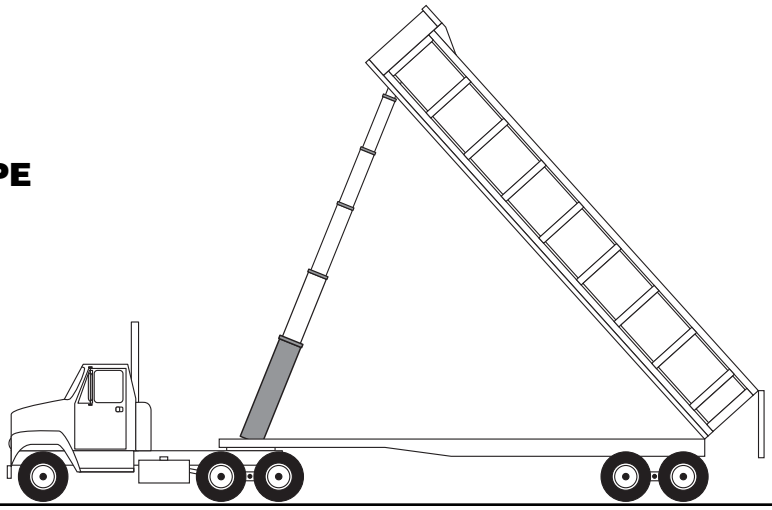
Normal minimum dump angle is 45 degrees
Normal maximum dump angle is 57 degrees



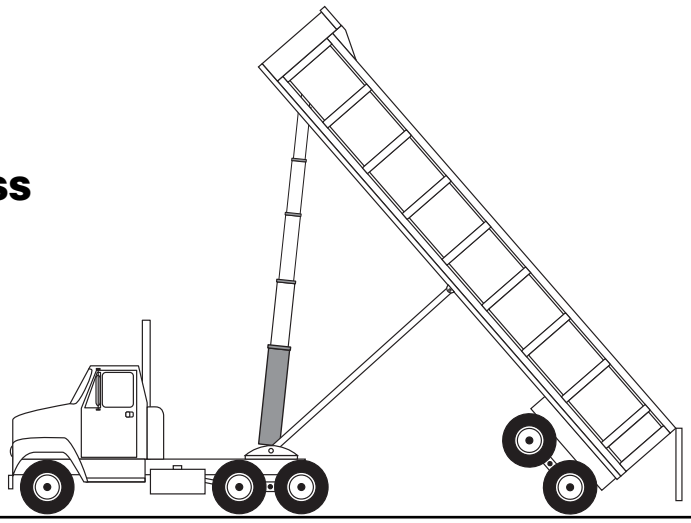
DUMP TRAILER TYPES

Identification Chart

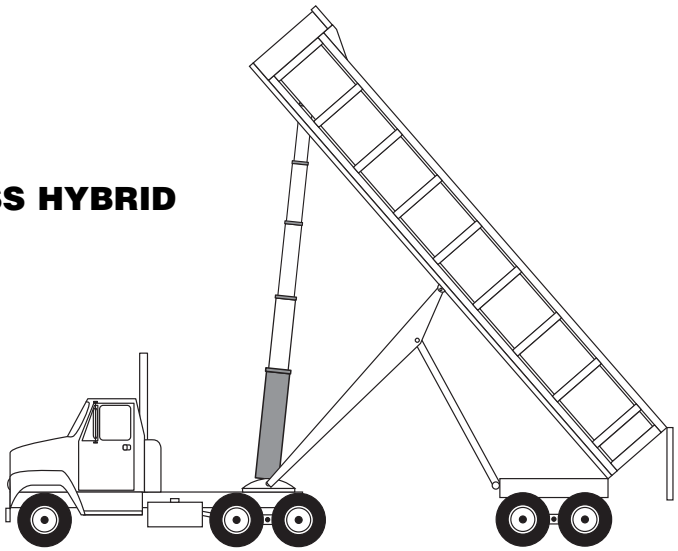
FRAME TYPE



FRAMELESS



FRAMELESS HYBRID



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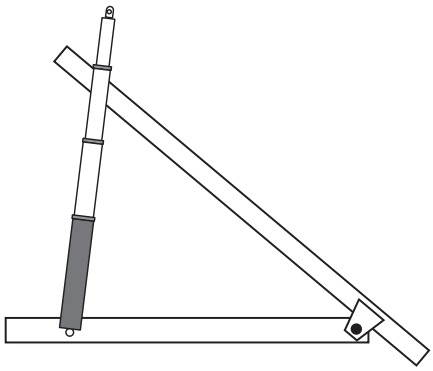
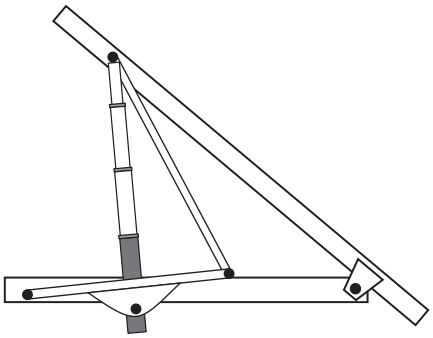
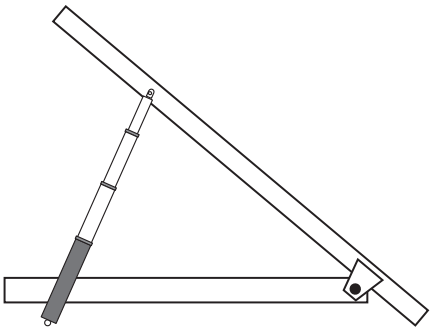
Identification Chart



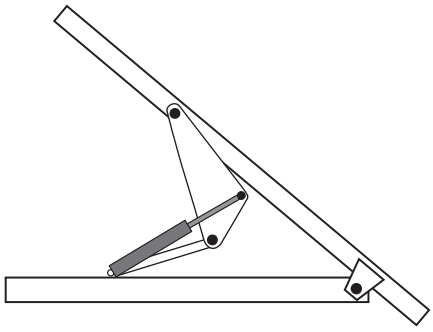
FRONT MOUNT TELESCOPIC
HEAD LIFT OR BOTTOM LIFT



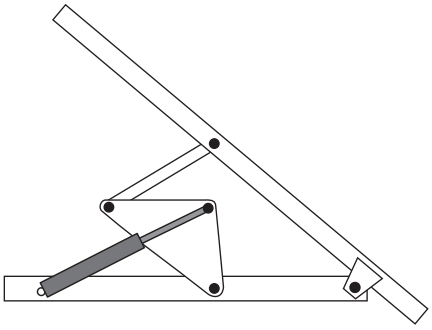
TELESCOPIC SCISSOR
HINGE FORWARD OR REARWARD



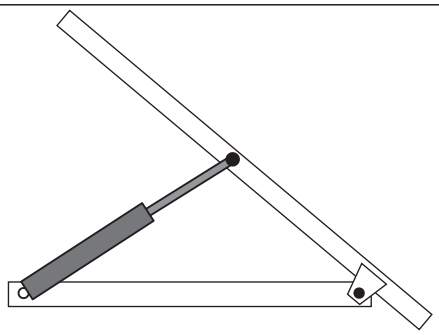
UNDERBODY TELESCOPIC
SLANT FORWARD OR SLANT REARWARD



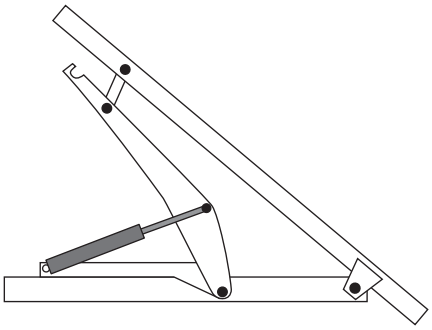
SINGLE STAGE SCISSOR



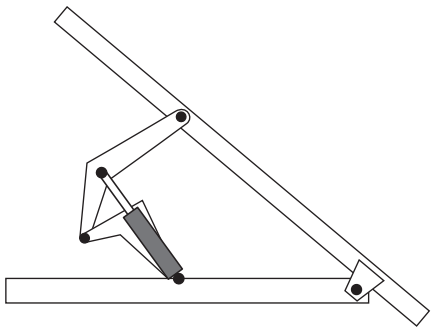
UNDER BODY ARM HOIST



UNDER BODY DIRECT LIFT



UNDER BODY ARM - SCISSOR

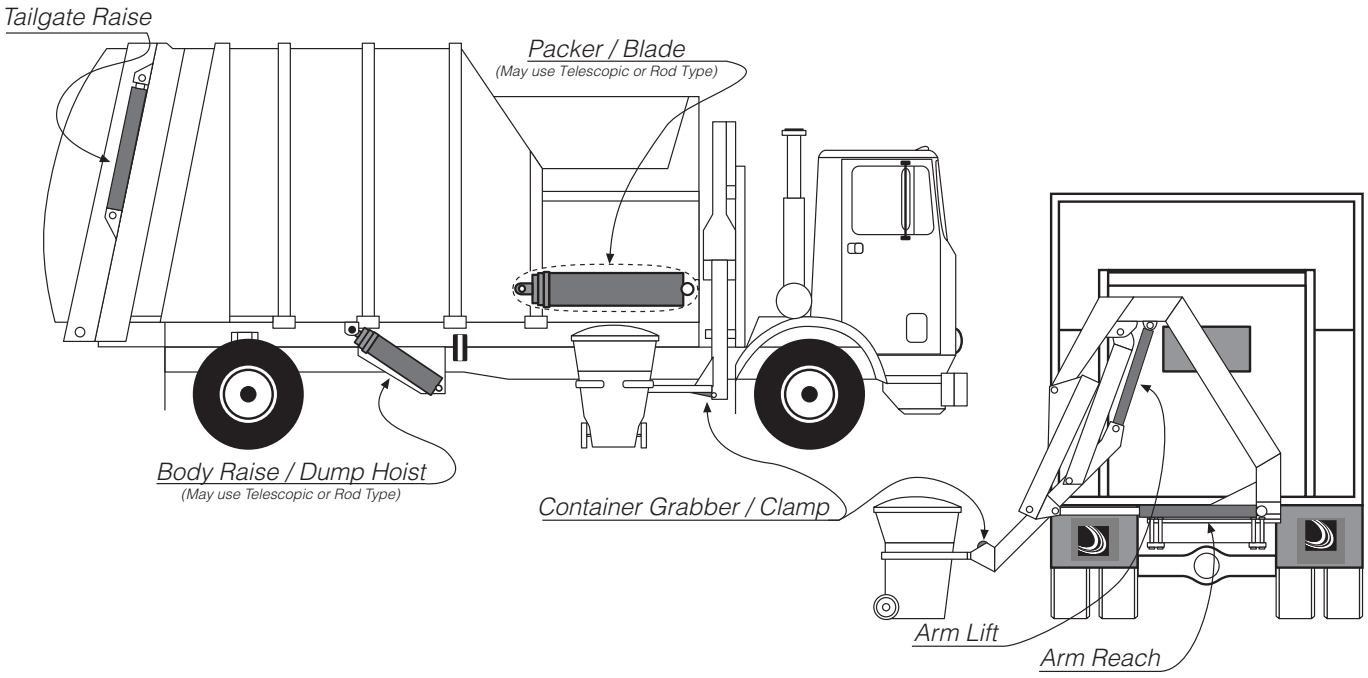


LOST MOTION SCISSOR

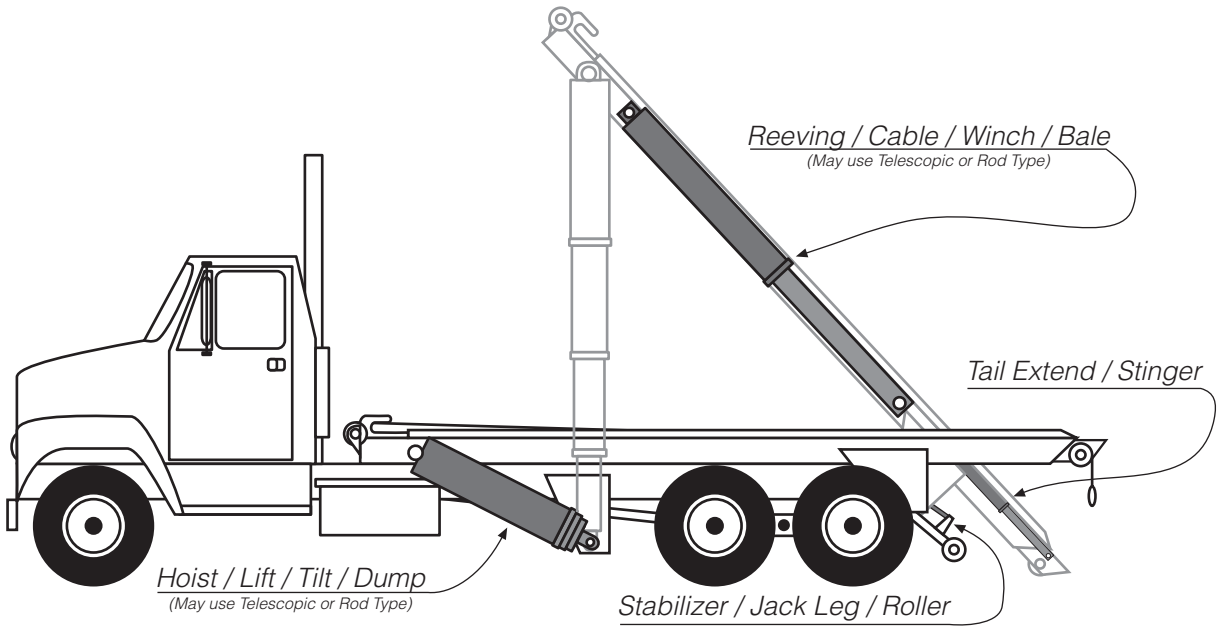
REFUSE BODY CYLINDER APPLICATIONS

Application Guide

Side Loader Refuse Bodies



Roll Off & Tilt Frame Hoists



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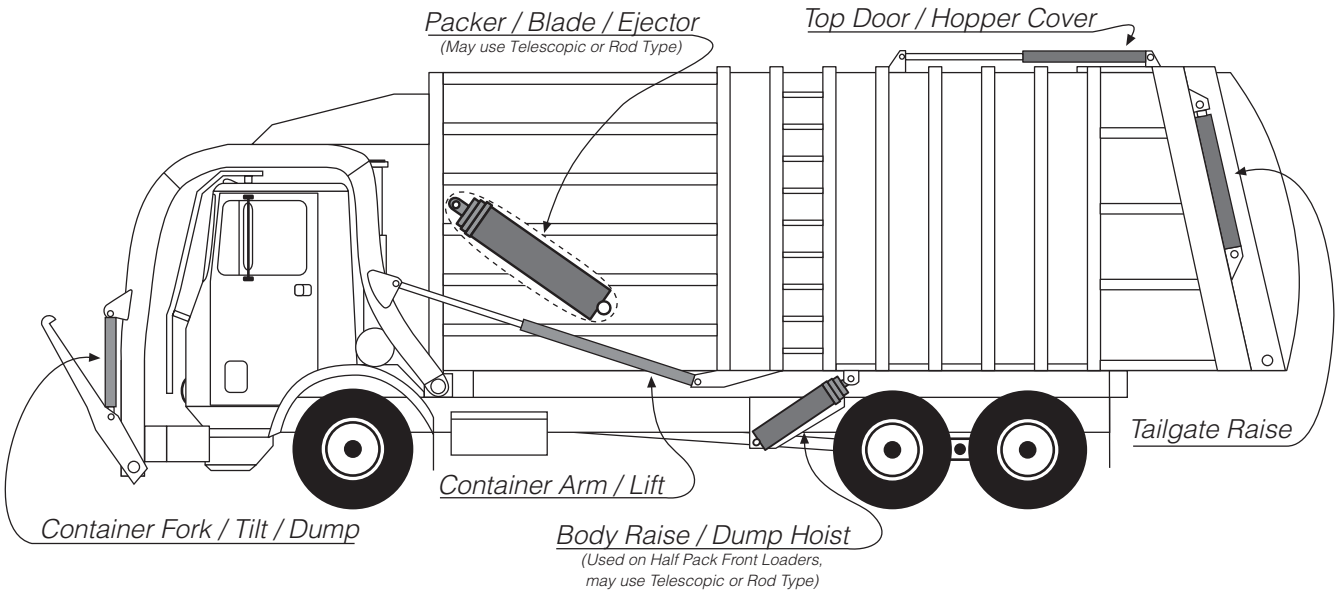
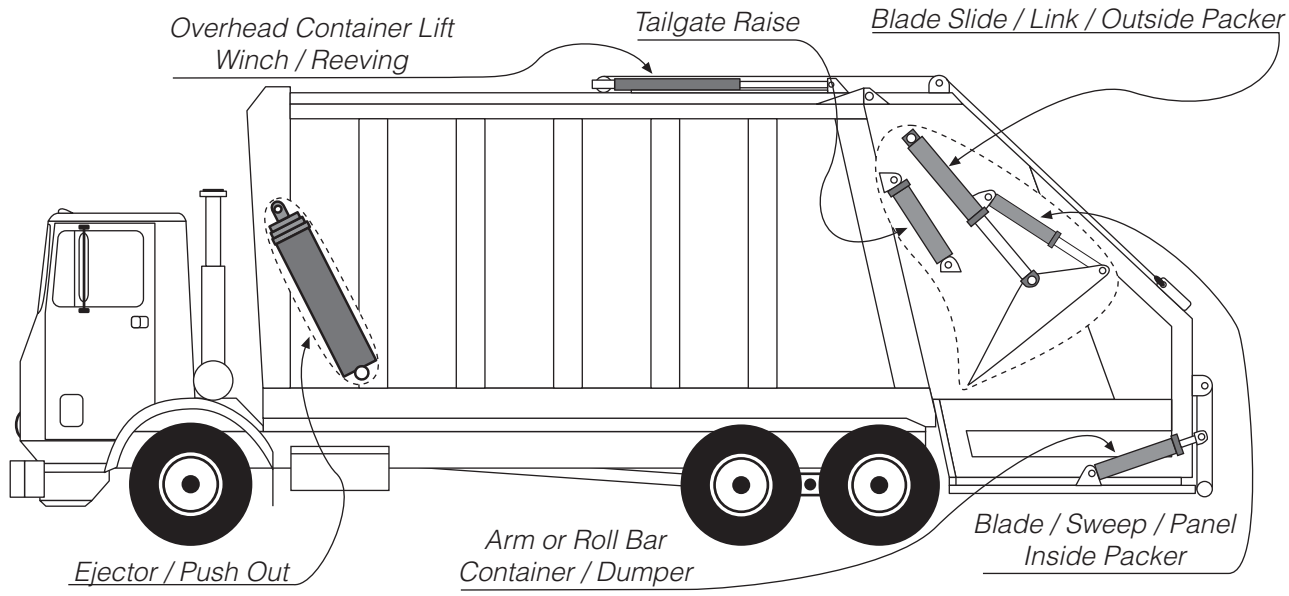
Application Guide

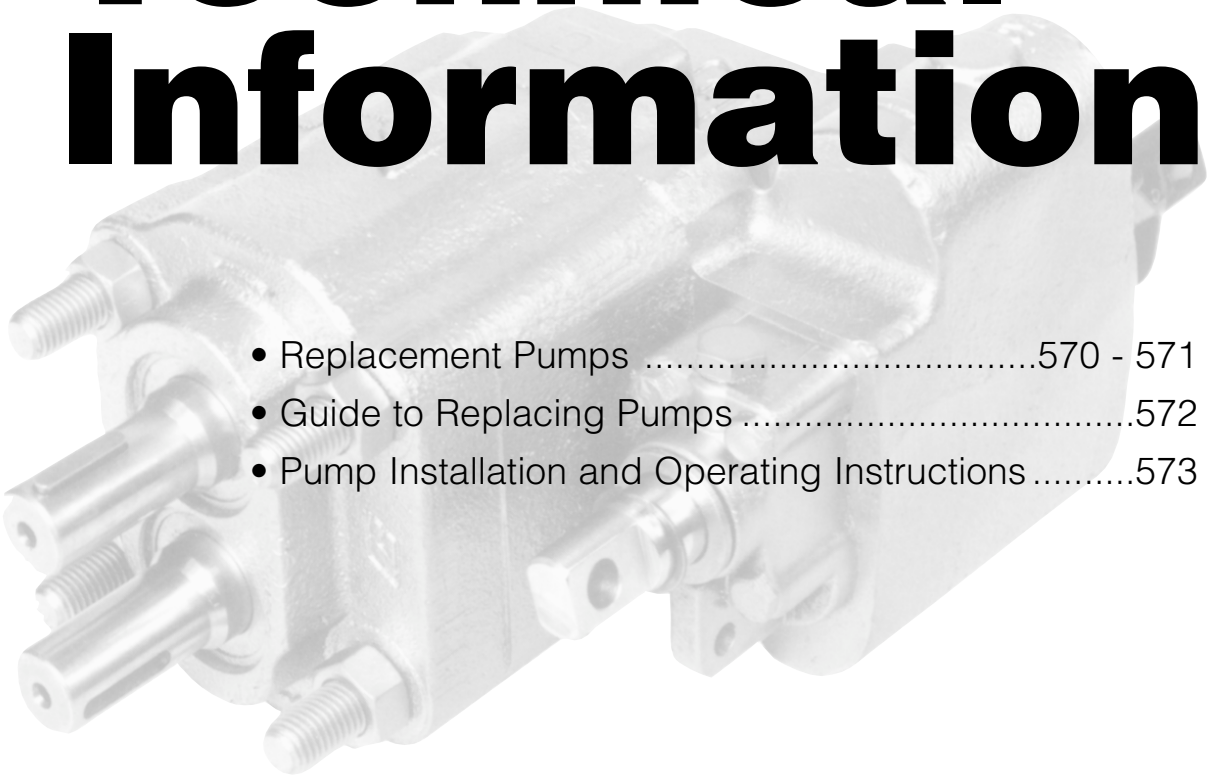
Front Loader Refuse Bodies



Rear Loader Refuse Bodies



Pump Technical Information



REPLACEMENT PUMPS

HERCULES CARRIES REPLACEMENT PUMPS FOR THE FOLLOWING POPULAR OEM PUMP NUMBERS.

CHELSEA

1431-0007-E1RPX
1431-0007-E3RPX
1431-0007-01RPX
1431-0007-03RPX
1431-0010-E1RPX
1431-0010-E3RPX
1431-0010-01RPX
1431-0010-03RPX
1431-0012-E1RPX
1431-0012-E3RPX
1431-0012-01RPX
1432-1007-E3RPX
1433-0007-E1RPX
1433-0007-E3RPX
1433-0007-01RPX
1433-0007-03RPX
1433-0010-E1RPX
1433-0010-E3RPX
1433-0010-01RPX
1433-0010-03PRX
1433-0012-E1RPX
1433-0012-E2RPX
1433-0012-E3RPX
1433-0012-01RPX
1433-0012-02RPX
1433-0012-03RPX
1433-0015-E2RPX
1433-0015-02RPX
1433-0017-E1RPX
1433-0017-E2PRX
1433-0017-E8RPX
1433-0017-01RPX
1433-0017-02RPX
1433-0017-03RPX
1433-0017-08RPX
1434-0012-E3RPX
1436-0007-E1RPX
1436-0007-E3RPX
1436-0007-01RPX
1436-0007-03RPX
1436-0010-E1RPX
1436-0010-E3RPX
1436-0010-01RPX
1436-0010-03RPX
1436-0012-E1RPX
1436-0012-E2RPX
1436-0012-E3RPX
1436-0012-01RPX
1436-0012-02RPX
1436-0012-03RPX
1436-0015-E1RPX
1436-0015-E2RPX
1436-0015-E3RPX
1436-0015-01RPX
1436-0015-02RPX
1436-0015-03RPX
1436-0017-E1RPX
1436-0017-E2RPX
1436-0017-E3RPX
1436-0017-01RPX
1436-0017-02RPX
1436-0017-03RPX
1437-0007-01RPX

CHELSEA CONTINUED

1437-0007-03RPX
1437-0007-E1RPX
1437-0007-E3RPX
1437-0010-01RPX
1437-0010-03RPX
1437-0010-E1RPX
1437-0010-E3RPX
1437-0012-01RPX
1437-0012-02RPX
1437-0012-03RPX
1437-0012-E1RPX
1437-0012-E2RPX
1437-0012-E3RPX
1437-0017-01RPX
1437-0017-02RPX
1437-0017-03RPX
1437-0017-E1RPX
1437-0017-E2RPX
1437-0017-E3RPX
1438-0015-E3RPX

1504-0022-B2RPC
(V103-05-3-25-1-4)

1504-0022-B2RPD
(V106-05-3-25-1-4)

1504-0022-B8RPCSD

1504-0025-B2RPC
(V103-05-3-25-1-4)

1504-0025-B2RPD
(V106-05-3-25-1-4)

1532-0022-E2RPX
1533-0020-E3RPX
1533-0020-E4RPX
1533-0020-E8RPX
1533-0020-03RPX
1533-0020-04RPX
1533-0020-08RPX
1533-0022-E3RPX
1533-0022-E4RPX
1533-0022-E8RPX
1533-0022-03RPX
1533-0022-04RPX
1533-0022-08RPX
1533-0025-E3RPX
1533-0025-E4RPX
1533-0025-E8RPX
1533-0025-03RPX
1533-0025-04RPX
1533-0025-08RPX
1533-0030-E3RPX
1533-0030-E4RPX
1533-0030-E8RPX
1533-0030-03RPX
1533-0030-04RPX
1533-0030-08RPX
1534-0030-E3RPX
1534-0030-04RPX

CHELSEA CONTINUED

3504-0045-B8RMX
4539-0020-04SPX
4539-0022-04SPX
4539-0025-04SPX
4539-0030-04SPX
A146661LR
DD80017E3RPX
DD8001703RPX

P007SC301-3
A146660(LR)

P015RR101-3
CHELSEA 575

P021RR209-3
300-029-205
10RR101-3

CLARK

156368
225995-40
228997
228998
45011
450012
450063
450140
450145
450230
450245
450263
455286
539618
543042
549319
553415
564653
652966
942395
1565083
1566233
1902981
1919511
1929207
1930086

DEMPSTER

BB1653
AB655
CB2190
20-35448

DROTT

34507
34552
36814
38003
39993
201616
201993
205756
205757
223317
230733
404965
500108
500124
500128
500129
501438
502013
502120
504916
505360
33350N1
33530H1
33567H1
201616M2
205757M1
295756
550707
608014
213301
213304
216793
31774
33956
36300
27228M1
39359
223317
220448
502095
502852
503234
503272
504038
F608013

FMC

36J1769X
36J1809X
36J1835X
36J2166A
305-E-50
305-E-34
305-E-33

GROVE

B24-308LAAD
7-632-000004
7-722-000012
7-722-000001
7-722-000007
7-722-000009
7-722-000013
7-722-000045
7-722-000054
7-722-000067
7-722-000102
7-722-000103
7-722-000120
7-722-000143
7-722-000153

HEIL

A219-404
A219-A351
A219-A399
A219-A400
A219-A443
A219-A732
A219-A544
A219-A744
A219-A745
A219-D363
A219-0119
A219-0920
A219-192
A219-932
A219-1045
TB82466
AA402-1

IF YOU DON'T SEE THE PUMP YOU NEED, CALL FOR MORE INFORMATION.

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FAX 1-800-759-6391

REPLACEMENT PUMPS

HERCULES CARRIES REPLACEMENT PUMPS FOR THE FOLLOWING POPULAR OEM PUMP NUMBERS.

HYDRECO

2015A14C4BR
2015A19E2AL
2015F2B1
2015F2B2
2017A19E2AL
2020A1D2A1
2020A1D8F29
20201D2AL
2020F2F1
2020G5B1
2020H3C1
2025A1A10AL
2025A19E2AL
2025A1D2AL
2025A5N9AB
2025C19L1LAL
2025G2B6
2025H361
3015A1A4A
3015H11B2
3017A1A1AR
22PR220046
3025A1B1AL
3025A1A5AL
3025C1A1AL
3035K20J2
3117A1A1AL
3117A6A2AL
3122A1A1AR
3615(89)K2AL
3125A2A1AR
2025A10E5AB
1517E1B5N8L
5015-15AFZE2D2AL
1409C2A1CL
42PL240504
3120A1A1AL
3130A1A1AL
2025A1A1AL
1512A1A1EL
3015A1A1AL
30M210A2A5A
19PR190502
2025SA7E1AL
2025A1A3AL
2020H31
1414A1A1CR
1711C3B1AR
2020H281
2025A5A3AR
3125A2A1AR
22PR220046

INTERNATIONAL HARVESTER

610730C91
328114R91
531271R92
610730C91
619800C91
627136C91
702751C91
889766C91
610728C91
627463C91
65780C91
1140037C91
531271R92
547563R91
610728C91
610730C91
619800C91
619800L92
927135C91
662178C91
702751C91
889766C91
627045C91
656911C91
931993C92

JOHN DEERE

AU40816
AT31216
AT38800
AT36103
AT34194
AT36103T
AT39949

J.I.CASE

1150
W13950
L15047
A19032
A22010
A22014
L23326
D2534
L26379
L26895
D29449
D30402
D31206
D31254
D39047
R38214
D41390
D48950
L51862
L71667
45184
72397
74838
241390
S502120
72-12-51/XL55

KOEHRING

1066C
28131
297B1107
853011036
853111017
853111038
674-288D1002
853111047
863111048
43964

LOADMASTER

150020
150023
150059
150085

LORAIN

F230-16A
E75330AX
E81202AX
E84089X
E85895X
F230-16-8
E88382X

PRENTICE

142021
142022
142023
142025
142026
142027
142028
142031
142032
142037
142038
142055
142064
142071
142087
142103
142104
142109
142121
142122
146510
146531

TEREX

9003384
9005552
90081183
9008120
9040196
9074989
9186096
9194739
9196031
9196032
9196481
9196482
9202035
9203506
9205144
9205145
9205146
9205147
9206102
9208753
9208754
9212804
9215510
9229805
9232173
9236364
9236488
9241448
9242401
9242539
9251808
9266150
9261602
9274098
9373358
9373355
1570949

TROJAN

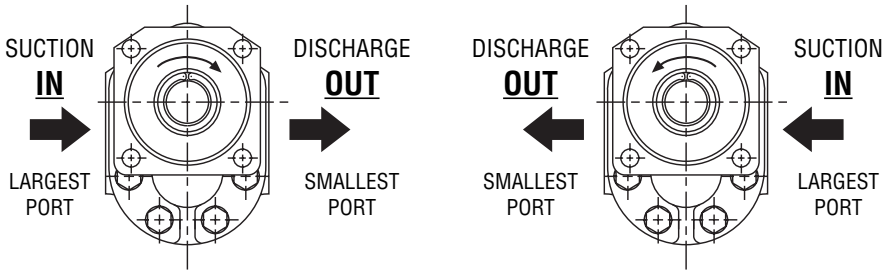
A224-5
2046639
2058053
2060163
2060835
2075222
2075711
2076109
6901388
20300A1D2
2550A-1E3

IF YOU DON'T SEE THE PUMP YOU NEED, CALL FOR MORE INFORMATION.

GUIDE TO REPLACING PUMPS

How to determine direction of rotation and location of inlet and discharge port

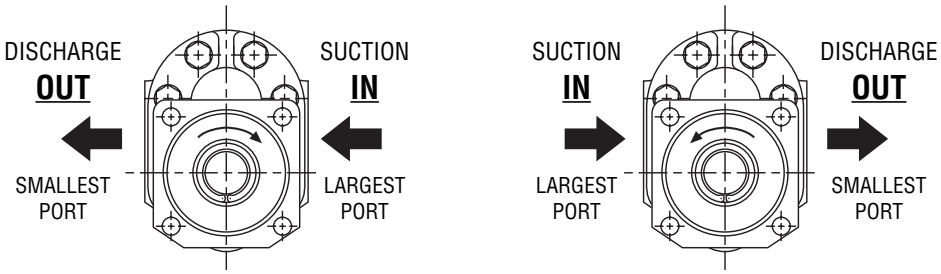
Drive Shaft in Higher Position and Belly of Pump DOWN



CLOCKWISE
"C"
VIEWED FROM DRIVE SHAFT END

COUNTER-CLOCKWISE
"A"
VIEWED FROM DRIVE SHAFT END

Drive Shaft in Lower Position and Belly of Pump UP



CLOCKWISE
"C"
VIEWED FROM DRIVE SHAFT END

COUNTER-CLOCKWISE
"A"
VIEWED FROM DRIVE SHAFT END

MANY ARE IDENTICAL

In many cases, OEM's have used pumps from several different manufacturers for the same model of equipment and are, for all practical purposes, identical.

USE THIS HELPFUL GUIDE

If you have a pump that needs replacing, the following information would be helpful:

Number (if any) stamped on pump _____
Direction of rotation _____
Shaft size & type _____
Type of mounting flange _____
Port size & type _____
Gear diameter & width _____
Other information _____

LET US HELP YOU

Using the above information, our trained personnel will select the proper replacement pump. Some pumps, however, have been out of production for a number of years and certain modifications may have to be made.

COPY FOR SHOP & COUNTER USE

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PUMP INSTALLATION AND OPERATING INSTRUCTIONS

1. Pump rotation is designated by looking at the pump shaft end (see diagram at top). Rotating the pump in the wrong direction of rotation will damage the pump.

2. Exceeding the pump's performance capabilities will result in reduced pump life. Call our sales department for specifics.

3. Use clean S.A.E. #10 anti-wear hydraulic oil.

NOTE: Pump inlet oil temperature should not exceed +225° F.

4. Start with a clean hydraulic system and then use a 10 micron return line filter to keep it clean.

5. Line size to the pump inlet (suction line) should not be smaller than the pump port size. Increase inlet line size (diameter) 1/4" for each 2' of length.

NOTE: Pump inlet vacuum should not exceed 5" of mercury at operating temperature.

CAUTION: WHEN INSTALLING PUMPS AND VALVES, SECURE TRUCK BED OR OTHER EQUIPMENT TO AVOID SERIOUS INJURY IF EQUIPMENT SHOULD DROP.

6. After installing a pump, it is desirable to run pump at lowest possible RPM and zero pressure for several minutes. The pump should run free and not develop leaks or build up heat. If unit operates properly, then the speed and pressure can be increased to normal operating settings.

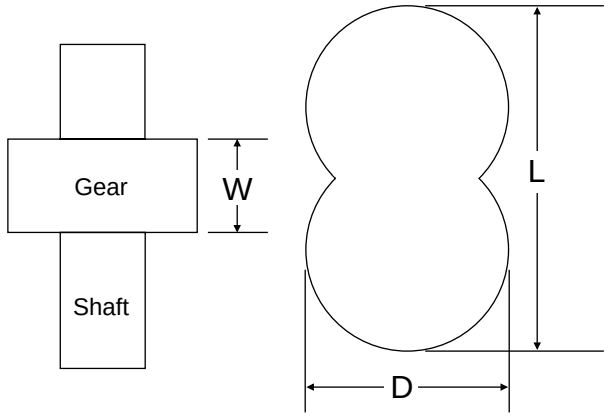
NOTE: A pressure gauge should always be used at the pump outlet port to set the system relief valve to its operating setting.

7. When driving the pump with a driveline, consult the driveline manufacturer's literature for operating angles, speeds and lengths.

8. If there is ANY problem with your pump after installation, call Hercules Hydraulics before disassembly. Any modification or disassembly of the pump or motor will void the manufacturers warranty.

When replacing a hydraulic pump or motor, it is essential that all critical parameters are taken into account. Be sure you know the required system pressure, RPM range, direction of rotation, shaft size and type, port size and type, and mounting information. If you have any questions regarding replacement pumps, don't hesitate to call our component group at 1-800-333-5617.

Figuring Gear Pump G.P.M



GPM @ 1000 RPM = $26 \times W \times (2D - L) \times \frac{(L - D)}{2}$

GPM @ 1200 RPM = $31 \times W \times (2D - L) \times \frac{(L - D)}{2}$

GPM @ 1800 RPM = $47 \times W \times (2D - L) \times \frac{(L - D)}{2}$

EXAMPLE: GPM @ 1000 RPM

D = 1.990
W = 1.738
L = 3.705

GPM $= 26 \times W \times (2D - L) \times \frac{(L - D)}{2}$

$= 26 \times 1.738 \times (2 \bullet 1.990 - 3.705) \times \frac{(3.705 - 1.990)}{2}$

$= 45.188 \times .275 \times .8575$

$= 10.656 \approx 11$ GPM @ 1000 RPM

Handy Formulas

CYLINDER PUSH AND PULL FORCES
SQUARE HEAD "HIGH PRESSURE" CYLINDERS

Working Pressure of Hydraulic Fluid P.S.I.

BORE	AREA	ROD	SIZE	50	100	250	500	1000	1500	2000	3000	5000
	PUSH	—		88	177	443	885	1,770	2,655	3.540	5,310	8,850
1-1/2	PULL	STD	5/8	73	146	365	730	1,460	2,190	2,920	4,380	7,300
	PULL	2:1	1	49	98	245	490	980	1,470	1,960	2,940	4,900
	PUSH	—		157	314	785	1,570	3,140	4,710	6,280	9,420	15,700
2	PULL	STD	1	118	236	590	1,180	2,360	3,540	4,720	7,080	11,800
	PULL	2:1	1-3/8	83	166	415	830	1,660	2,490	3,320	4,980	8,300
	PUSH	—		246	491	1,228	2,455	4,910	7,265	9,820	14,730	24,550
2-1/2	PULL	STD	1	206	412	1,030	2,060	4,120	6,180	8,240	12,360	20,600
	PULL	2:1	1-3/4	125	250	625	1,250	2,500	3,750	5,000	7,500	12,500
	PUSH	—		415	830	2,075	4,150	8,300	12,450	16,600	24,900	41,500
3-1/2	PULL	STD	1-3/8	341	681	1,703	3,405	6,810	10,215	13,620	20,430	34,050
	PULL	2:1	2	258	515	1,288	2,575	5,150	7,725	10,300	15,450	25,750
	PUSH	—		628	1,257	3,143	6,285	12,570	18,855	25,140	37,710	62,850
4	PULL	STD	1-3/4	508	1,016	2,540	5,080	10,160	15,240	20,320	30,480	50,800
	PULL	2:1	2-1/2	383	766	1,916	3,830	7,660	11,490	15,320	22,980	38,300
	PUSH	—		982	1,964	4,910	9,820	19,640	29,460	39,280	58,920	98,200
5	PULL	STD	2	825	1,649	4,123	8,245	16,490	24,735	32,980	49,470	82,450
	PULL	2:1	3-1/2	500	1,001	2,503	5,005	10,010	15,015	20,020	30,030	50,050
	PUSH	—		1,413	2,827	7,068	14,135	28,270	42,405	56,540	84,810	141,350
6	PULL	STD	2-1/2	1,168	2,336	5,840	11,680	23,360	35,040	46,720	70,080	116,800
	PULL	2:1	4	786	1,571	3,928	7,855	15,710	23,565	31,420	47,130	78,550
	PUSH	—		1,924	3,849	9,623	19,245	38,490	57,735	76,980	115,470	192,450
7	PULL	STD	3	1,571	3,142	7,855	15,710	31,420	47,130	62,840	94,260	157,100
	PULL	2:1	5	942	1,885	4,713	9,425	18,850	28,275	37,700	56,550	94,250
	PUSH	—		2,514	5,027	12,568	25,135	50,270	75,405	100,540	150,810	251,350
8	PULL	STD	3-1/2	2,032	4,064	10,160	20,320	40,640	60,960	81,280	121,920	203,200
	PULL	2:1	5-1/2	1,326	2,651	6,628	13,255	26,510	39,765	53,020	79,530	132,550
	PUSH	—		3,927	7,854	19,635	39,270	78,540	117,810	157,080	235,620	392,700
10	PULL	STD	4-1/2	3,132	6,264	15,660	31,320	62,640	93,960	125,280	187,920	313,200
	PULL	2:1	7	2,003	4,006	10,015	20,030	40,060	60,090	80,120	120,180	200,300

This table is a ready reference of forces available from either end from various cylinder and rod sizes at a range of pressures. For pressures intermediate between those shown, add force values from two or more pressures whose sum equals the given operating pressure.

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FLUID MOTOR TORQUE

Figures shown are inch pounds

RPM	1	2	Horse Power 3	4	5	6	7	8	9	10	15	20	25
1	63,025	126,050	189,076	252,100	315,125	378,150	441,175	504,200	567,225	630,250	945,375	105,042	131,302
2	31,512	63,025	94,538	126,050	157,563	189,075	220,588	252,100	283,613	315,125	472,688	630,250	787,813
3	21,009	42,017	63,025	84,036	105,042	126,050	147,058	168,067	189,075	210,083	315,125	420,167	525,208
4	15,756	31,512	47,269	63,025	78,781	94,538	110,294	126,050	141,806	157,563	236,344	315,125	393,906
5	12,605	25,210	37,815	50,420	63,025	75,630	88,236	100,840	113,445	126,050	189,076	252,100	315,125
6	10,506	21,009	31,513	42,017	52,521	63,025	73,529	84,033	94,538	105,040	157,563	210,083	262,604
7	9,004	18,007	27,011	36,016	45,018	54,021	63,025	72,029	81,032	90,036	135,054	180,071	225,089
8	7,878	15,756	23,634	31,512	39,391	47,269	55,147	63,025	70,903	78,780	118,172	157,563	196,953
9	7,003	14,006	21,010	28,011	35,014	42,017	49,019	56,022	63,025	70,030	105,042	140,056	175,069
10	6,303	12,605	18,908	25,210	31,512	37,815	44,118	50,420	56,723	63,025	94,538	126,050	157,563
20	3,151	6,303	9,454	12,605	15,756	18,908	22,059	25,210	28,316	31,512	47,269	63,025	78,781
25	2,521	5,042	7,563	10,084	12,605	15,126	17,647	20,168	22,689	25,210	37,815	50,420	63,025
30	2,101	4,202	6,303	8,403	10,504	12,605	14,705	16,807	18,908	21,009	31,513	42,017	52,521
40	1,576	3,151	4,727	6,303	7,878	9,454	11,029	12,605	14,181	15,756	23,634	31,513	39,391
50	1,261	2,521	3,782	5,042	6,303	7,563	8,824	10,084	11,345	12,605	18,908	25,210	31,513
60	1,050	2,101	3,151	4,202	5,252	6,303	7,353	8,403	9,454	10,504	15,756	21,009	26,260
70	900	1,801	2,701	3,601	4,502	5,402	6,303	7,203	8,103	9,004	13,506	18,007	22,509
75	840	1,681	2,521	3,361	4,202	5,042	5,882	6,723	7,563	8,403	12,605	16,806	21,008
80	788	1,576	2,363	3,151	3,939	4,727	5,515	6,303	7,090	7,878	11,817	15,756	19,695
90	700	1,400	2,101	2,801	3,501	4,202	4,902	5,602	6,303	7,003	10,504	14,006	17,507
100	630	1,261	1,891	2,521	3,151	3,782	4,412	5,042	5,672	6,303	9,453	12,605	15,758
150	420	840	1,261	1,681	2,101	2,251	2,941	3,361	3,781	4,202	6,303	8,403	10,504
200	315	630	945	1,261	1,575	1,891	2,206	2,521	2,836	3,151	4,727	6,303	7,878
250	252	504	756	1,008	1,260	1,531	1,765	2,017	2,269	2,521	3,782	5,042	6,303
300	210	420	630	840	1,050	1,261	1,471	1,681	1,891	2,101	3,151	4,202	5,252
350	180	360	540	720	900	1,080	1,261	1,441	1,621	1,801	2,701	3,601	4,502
400	158	315	473	630	788	945	1,104	1,261	1,418	1,576	2,364	3,151	3,939
450	141	280	420	560	700	840	980	1,120	1,261	1,401	2,101	2,801	3,501
500	126	252	378	504	630	756	882	1,008	1,134	1,261	1,891	2,521	3,151
550	115	229	344	458	573	688	802	917	1,031	1,146	1,719	2,292	2,865
600	105	210	315	420	525	630	735	840	945	1,050	1,576	2,101	2,626
650	97	194	291	388	485	582	679	776	873	970	1,454	1,939	2,424
700	90	180	270	360	450	540	630	720	810	900	1,351	1,801	2,251
750	84	168	252	336	420	504	588	672	756	840	1,261	1,681	2,101
800	79	158	236	315	393	473	551	630	709	788	1,182	1,576	1,970
850	74	148	222	297	371	445	519	593	667	741	1,112	1,483	1,854
900	70	140	210	280	350	420	490	560	630	700	1,050	1,400	1,751
950	66	133	199	265	332	398	464	531	597	663	995	1,327	1,659
1000	63	126	189	252	315	378	441	504	567	630	945	1,261	1,576
1100	57	115	172	229	286	344	401	458	516	573	860	1,146	1,432
1200	53	105	158	210	263	315	368	420	473	525	788	1,050	1,313
1300	48	97	145	194	242	291	339	388	436	485	727	970	1,212
1400	45	90	135	180	225	270	315	360	405	450	675	900	1,125
1500	42	84	126	168	210	252	294	336	378	420	630	840	1,050
1600	39	79	118	158	197	236	276	315	355	394	591	788	985
1700	37	74	111	148	185	222	260	296	334	371	556	741	927
1800	35	70	105	140	175	210	245	280	315	350	525	700	875
1900	33	66	100	133	166	199	232	265	299	332	498	663	829
2000	32	63	95	126	158	189	221	252	284	315	473	630	788
2100	30	60	90	120	150	180	210	240	270	300	450	600	750
2200	29	57	86	115	143	172	201	229	258	286	430	573	716
2300	27	55	82	110	137	164	192	219	247	274	411	548	685
2400	26	53	79	105	131	158	184	210	236	263	394	525	657
2500	25	50	76	101	126	151	176	202	227	252	378	504	630
2750	23	46	69	92	115	138	160	183	206	229	344	458	573
3000	21	42	63	84	105	126	147	168	189	210	315	420	525
3250	19	39	58	78	97	116	136	155	175	194	291	388	485
3500	18	36	54	72	90	108	126	144	162	180	270	360	450
3750	17	34	50	67	84	101	118	134	151	168	252	336	420
4000	16	32	47	63	79	95	110	126	142	158	236	315	394
4250	15	30	44	59	74	89	104	119	133	148	222	297	371
4500	14	28	42	56	70	84	98	112	126	140	210	280	350
4750	13	27	40	53	66	80	93	106	119	133	199	265	332
5000	13	25	38	50	63	76	88	101	113	126	189	252	315
6000	11	21	32	42	53	63	74	84	95	105	158	210	263
7000	9	18	27	36	45	54	63	72	81	90	135	180	225
8000	8	16	24	32	39	47	55	63	71	79	118	158	197
9000	7	14	21	28	35	42	49	56	63	70	105	140	175
10000	6	13	19	25	32	38	44	50	57	63	95	126	158

HYDRAULIC CYLINDER SPEEDS

(Inches/Minute)

PISTON DIAMETER	ROD DIAMETER	FLOW - GPM										
		1	2	3	5	10	12	15	20	25	50	75
1	—	298	596	894	1490							
	1/2	392	784	1176	1960							
1-1/2	—	130	260	392	654	1308						
	5/8	158	316	476	792	1584						
	1	235	470	706	1176	2352						
2	—	73	146	221	368	736	883	1120				
	3/4	85	170	257	428	956	1025	1283				
	1	97	184	294	490	980	1175	1465				
	1-3/8	139	278	418	697	1394	1673	2090				
2-1/2	—	47	94	141	235	470	565	675	940	1175		
	1	56	112	168	280	560	672	840	1120	1400		
	1-3/8	67	134	203	339	678	813	1015	1355	1695		
	1-3/4	92	184	277	463	926	1110	1385	1850	2310		
3	—	32	64	98	163	326	392	490	653	817		
	1	36	72	110	184	368	440	551	735	920		
	1-1/2	43	86	131	218	436	523	655	872	1090		
	2	58	116	176	294	588	705	882	1175	1470		
3-1/2	—	24	48	72	120	240	288	360	480	600	1200	
	1-1/4	27	54	82	137	274	330	411	548	685	1370	
	1-3/4	32	64	96	160	320	384	480	640	800	1600	
	2	35	70	107	178	356	428	534	712	890	1780	
4	—	18	36	55	92	184	220	276	368	460	920	
	1-1/4	20	40	61	102	204	244	306	408	510	1020	
	1-3/4	22	44	68	113	226	273	339	452	565	1130	
	2	24	48	73	122	244	294	366	488	610	1220	
	2-1/2	30	60	90	150	300	362	450	600	750	1500	
5	—	12	24	35	58	116	141	174	232	290	580	870
	1-1/2	13	26	39	64	128	155	193	258	320	640	960
	2	14	28	42	70	140	168	210	280	350	700	1050
	2-1/2	16	32	47	78	156	188	235	315	390	780	1170
	3	18	36	55	92	184	220	275	365	460	920	1380
	3-1/2	22	44	66	111	222	266	333	444	555	1110	1665
6	—	8	16	24	41	82	98	123	162	202	404	606
	1-3/4	9	18	27	45	90	107	135	180	225	450	675
	2-1/2	10	20	30	50	100	118	150	200	250	500	750
	3	11	22	33	54	108	130	165	206	270	540	810
	3-1/2	12	24	37	62	124	148	185	245	310	620	930
	4	15	30	44	73	146	176	220	295	365	730	1095
8	—	4	8	14	23	46	55	69	92	115	230	345
	3-1/2	5-1/2	11	17	28	56	68	85	115	140	280	420
	4	6	12	18	30	60	73	90	122	150	300	450
	5	7-1/2	15	22	38	76	90	114	150	185	375	555
	5-1/2	8-1/2	17	26	43	86	104	129	172	215	430	645
10	—	3	6	9	15	30	35	44	60	73	146	220
	4-1/2	3-1//2	7	11	18	36	44	55	75	92	184	275
	5	4	8	12	20	40	47	60	80	100	200	300
	5-1/2	4-1/2	9	13	21	42	50	63	84	105	210	315
	7	5-1/2	11	17	29	58	69	87	115	145	290	435

This chart is based on the formula $V = \frac{231 \times GPM}{\text{EFF. CYL. AREA (Sq. Inches)}}$

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ELECTRIC MOTOR HORSEPOWER

Required to Drive a Hydraulic Pump

	PUMP PRESSURE PSI										
GPM	**100**	**200**	**250**	**300**	**400**	**500**	**750**	**1000**	**1250**	**1500**	**2000**
1/2	.04	.07	.09	.10	.14	.17	.26	.34	.43	.52	.69
1	.07	.14	.17	.21	.28	.34	.52	.69	.86	1.03	1.37
1 1/2	.10	.21	.26	.31	.41	.52	.77	1.03	1.29	1.54	2.06
2	.14	.28	.34	.41	.55	.69	1.03	1.37	1.72	2.06	2.75
2 1/2	.17	.34	.43	.52	.69	.86	1.29	1.72	2.15	2.58	3.43
3	.21	.41	.52	.62	.83	1.03	1.54	2.06	2.57	3.09	4.12
3 1/2	.24	.48	.60	.72	.96	1.20	1.80	2.40	3.00	3.60	4.81
4	.28	.55	.69	.82	1.10	1.37	2.06	2.75	3.43	4.12	5.49
5	.34	.69	.86	1.03	1.32	1.72	2.57	3.43	4.29	5.15	6.86
6	.41	.82	1.03	1.24	1.65	2.06	3.09	4.12	5.15	6.18	8.24
7	.48	.96	1.20	1.44	1.92	2.40	3.60	4.81	6.01	7.21	9.61
8	.55	1.10	1.37	1.65	2.20	2.75	4.12	5.49	6.86	8.24	11.0
9	.62	1.24	1.55	1.85	2.47	3.09	4.63	6.18	7.72	9.27	12.4
10	.69	1.37	1.62	2.06	2.75	3.43	5.15	6.86	8.58	10.3	13.8
11	.76	1.51	1.89	2.27	3.02	3.78	5.66	7.55	9.44	11.3	15.1
12	.83	1.65	2.06	2.47	3.30	4.12	6.18	8.24	10.3	12.4	16.5
13	.89	1.79	2.23	2.68	3.57	4.46	6.69	8.92	11.2	13.4	17.8
14	.96	1.92	2.40	2.88	3.84	4.81	7.21	9.61	12.0	14.4	19.2
15	1.03	2.06	2.57	3.09	4.12	5.15	7.72	10.3	12.9	15.4	20.6
16	1.10	2.20	2.75	3.30	4.39	5.49	8.24	11.0	13.7	16.5	22.0
17	1.17	2.33	2.92	3.50	4.68	5.83	8.75	11.7	14.6	17.5	23.3
18	1.24	2.47	3.09	3.71	4.94	6.18	9.27	12.4	15.4	18.5	24.7
19	1.30	2.61	3.26	3.91	5.22	6.52	9.78	13.0	16.3	19.6	26.1
20	1.37	2.75	3.43	4.12	5.49	6.86	10.3	13.7	17.2	21.6	27.5
25	1.72	3.43	4.29	5.15	6.86	8.58	12.9	17.2	21.5	25.8	34.3
30	2.06	4.12	5.15	6.18	8.24	10.3	15.4	20.6	25.7	30.9	41.2
35	2.40	4.81	6.01	7.21	9.61	12.0	18.0	24.0	30.0	36.0	48.0
40	2.75	5.49	6.86	8.24	11.0	13.7	20.6	27.5	34.3	41.2	54.9
45	3.09	6.18	7.72	9.27	12.4	15.4	23.2	31.0	38.6	46.3	61.8
50	3.43	6.86	8.58	10.3	13.7	17.2	25.7	34.3	42.9	51.5	68.6
55	3.78	7.55	9.44	11.3	15.1	18.9	28.3	37.8	47.2	56.6	75.5
60	4.12	8.24	10.3	12.4	16.5	20.6	30.9	41.2	51.5	61.8	83.4
65	4.46	8.92	11.2	13.4	17.8	22.3	33.5	44.6	55.8	66.9	89.2
70	4.81	9.61	12.0	14.4	19.2	24.0	36.0	48.0	60.1	72.1	96.1
75	5.15	10.3	12.9	15.4	20.6	25.7	38.6	51.4	64.3	77.2	103.0
80	5.49	11.0	13.7	16.5	22.0	27.5	41.2	54.9	68.6	82.4	109.8
90	6.18	12.4	15.4	18.5	24.7	30.9	46.3	61.8	77.2	92.7	123.6
100	6.86	13.7	17.2	20.6	27.5	34.4	51.5	68.6	85.8	103.0	137.3

This chart is based on the formula $HP = \frac{GPM \times PSI}{1714 \times EFFICIENCY}$

For the purposes of this chart, pump efficiency was assumed to be 85%.

As horsepower varies directly with flow or pressure, multiply proportionately to determine values not shown. For instance, at 4000 PSI multiply 2000 PSI values by 2.

AREAS AND CIRCUMFERENCES OF CIRCLES

Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area
			1	3.1416	.7854	5	15.708	19.635	12	37.699	113.10	24	75.398	452.39
1/64	.04909	.00019	1/16	3.3379	.8866	1/8	16.101	20.629	1/4	38.485	117.86	1/4	76.184	461.86
1/32	.09818	.00077	1/8	3.5343	.9940	1/4	16.493	21.648	1/2	39.270	122.72	1/2	76.969	471.44
3/64	.14726	.00173	3/16	3.7306	1.1075	3/8	16.886	22.691	3/4	40.055	127.68	3/4	77.764	481.11
1/16	.1965	.00307	1/4	3.9270	1.2272	1/2	17.279	23.758	13	40.841	132.73	25	78.540	490.87
5/64	.24544	.00479	5/16	4.1233	1.3530	5/8	17.671	24.850	1/4	41.626	137.89	1/4	79.325	500.74
3/32	.29452	.00690	3/8	4.3197	1.4849	3/4	18.064	25.967	1/2	42.412	143.14	1/2	80.111	510.71
7/64	.34361	.00940	7/16	4.5160	1.6230	7/8	18.457	27.109	3/4	43.197	148.49	3/4	80.896	520.77
1/8	.39270	.01227	1/2	4.7124	1.7671	6	18.850	28.274	14	43.982	153.94	26	81.681	530.93
9/64	.44179	.01553	9/16	4.9087	1.9175	1/8	19.242	29.465	1/4	44.768	159.48	1/4	82.467	541.19
5/32	.49087	.01917	5/8	5.1051	2.0739	1/4	19.635	30.680	1/2	45.553	165.13	1/2	83.252	551.55
11/64	.53996	.02320	11/16	5.3014	2.2365	3/8	20.028	31.919	3/4	46.338	170.87	3/4	84.038	562.00
3/16	.58905	.02761	3/4	5.4978	2.4053	1/2	20.420	33.183	15	47.124	176.71	27	84.823	572.56
13/64	.63814	.03241	13/16	5.6941	2.5802	5/8	20.813	34.472	1/4	47.909	182.65	1/4	85.608	583.21
7/32	.68722	.03758	7/8	5.8905	2.7612	3/4	21.206	35.785	1/2	48.695	188.69	1/2	86.394	593.96
15/64	.73631	.04314	15/16	6.0868	2.9483	7/8	21.598	37.122	3/4	49.480	194.83	3/4	87.179	604.81
1/4	.78540	.04909	2	6.2832	3.1416	7	21.991	38.485	16	50.265	201.06	28	87.965	615.75
17/64	.83449	.05542	1/16	6.4795	3.3410	1/8	22.384	39.871	1/4	51.051	207.39	1/4	88.750	626.80
9/32	.88357	.06213	1/8	6.6759	3.5466	1/4	22.776	41.282	1/2	51.836	213.82	1/2	89.535	637.94
19/64	.93266	.06922	3/16	6.8722	3.7583	3/8	23.169	42.718	3/4	52.622	220.35	3/4	90.321	649.18
5/16	.98175	.07670	1/4	7.0686	3.9761	1/2	23.562	44.179	17	53.407	226.98	29	91.106	660.52
21/64	1.03084	.08456	5/16	7.2649	4.2000	5/8	23.955	45.664	1/4	54.192	233.71	1/4	91.892	671.96
11/32	1.0799	.09281	3/8	7.4613	4.4301	3/4	24.347	47.173	1/2	54.978	240.53	1/2	92.677	683.49
23/64	1.1290	.10143	7/16	7.6576	4.6664	7/8	24.740	48.707	3/4	55.763	247.45	3/4	93.462	695.13
3/8	1.1781	.11045	1/2	7.8540	4.9087	8	25.133	50.265	18	56.549	254.47	30	94.248	708.86
25/64	1.2272	.11984	9/16	8.0503	5.1572	1/8	25.525	51.849	1/4	57.334	261.59	1/4	95.033	718.69
13/32	1.2763	.12962	5/8	8.2467	5.4119	1/4	25.918	53.456	1/2	58.119	268.80	1/2	95.819	730.62
27/64	1.3254	.13978	11/16	8.4430	5.6727	3/8	26.311	55.088	3/4	58.905	276.12	3/4	96.604	742.64
7/16	1.3744	.15033	3/4	8.6394	5.9396	1/2	26.704	56.745	19	59.690	283.53	31	97.389	754.77
29/64	1.4235	.16126	13/16	8.8357	6.2126	5/8	27.096	58.426	1/4	60.476	291.04	1/4	98.175	766.99
15/32	1.4726	.17257	7/8	9.0321	6.4918	3/4	27.489	60.132	1/2	61.261	298.65	1/2	98.960	779.31
31/64	1.5217	.18427	15/16	9.2284	6.7771	7/8	27.882	61.862	3/4	62.046	306.35	3/4	99.746	791.73
1/2	1.5708	.19635	3	9.4248	7.0686	9	28.274	63.617	20	62.832	314.16	32	100.531	804.25
17/32	1.6690	.22166	1/8	9.8175	7.6699	1/8	28.667	65.397	1/4	63.617	322.06	1/4	101.316	816.86
9/16	1.7671	.24850	1/4	10.210	8.2958	1/4	29.060	67.201	1/2	64.403	330.06	1/2	102.102	829.58
19/32	1.8653	.27688	3/8	10.603	8.9462	3/8	29.452	69.029	3/4	65.188	338.16	3/4	102.887	842.39
5/8	1.9635	.30680	1/2	10.996	9.6211	1/2	29.845	70.882	21	65.973	346.36	33	103.673	855.30
21/32	2.0617	.33824	5/8	11.388	10.321	5/8	30.238	72.760	1/4	66.759	354.66	1/4	104.458	868.31
11/16	2.1598	.37122	3/4	11.781	11.045	3/4	30.631	74.662	1/2	67.544	363.05	1/2	105.243	881.41
23/32	2.2580	.40574	7/8	12.174	11.793	7/8	31.023	76.589	3/4	68.330	371.54	3/4	106.029	894.62
3/4	2.3562	.44179	4	12.566	12.566	10	31.416	78.540	22	69.115	380.13	34	106.814	907.92
25/32	2.4544	.47937	1/8	12.959	13.364	1/4	32.201	82.516	1/4	69.900	388.82	1/4	107.600	921.32
13/16	2.5525	.51849	1/4	13.352	14.186	1/2	32.987	86.590	1/2	70.686	397.61	1/2	108.385	934.82
27/32	2.6507	.55914	3/8	13.744	15.033	3/4	33.772	90.763	3/4	71.471	406.49	3/4	109.170	948.42
7/8	2.7489	.60132	1/2	14.137	15.904	11	34.558	95.033	23	72.257	415.48	35	109.956	962.11
29/32	2.8471	.64504	5/8	14.530	16.800	1/4	35.343	99.402	1/4	73.042	424.56	1/4	110.741	975.91
15/16	2.9452	.69029	3/4	14.923	17.721	1/2	36.128	103.87	1/2	73.827	433.74	1/2	111.527	989.80
31/32	3.0434	.73708	7/8	15.315	18.665	3/4	36.914	108.43	3/4	74.613	443.01	3/4	112.312	1003.8

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FLUID POWER FORMULAS

BASIC FORMULAS

FORMULA FOR:	WORD FORMULA	LETTER FORMULA
FLUID PRESSURE *In Pounds/Square Inch*	PRESSURE = $\frac{\text{FORCE (}pounds\text{)}}{\text{UNIT AREA (}Square\ Inches\text{)}}$	$P = \frac{F}{A}$ or psi = $\frac{F}{A}$
FLUID FLOW RATE *In Gallons/Minute*	FLOW RATE = $\frac{\text{VOLUME (}Gallons\text{)}}{\text{UNIT TIME (}Minutes\text{)}}$	$Q = \frac{V}{T}$
FLUID POWER *In Horsepower*	HORSEPOWER = $\frac{\text{PRESSURE (}PSI\text{) X FLOW (GPM)}}{1714}$	$HP = \frac{PQ}{1714}$

FLUID FORMULAS

VELOCITY THROUGH PIPING *In Feet/Second Velocity*	VELOCITY = $\frac{.3208 \text{ x FLOW RATE THROUGH I.D. (}GPM\text{)}}{\text{INTERNAL AREA (}Square\ Inches\text{)}}$	$V = \frac{.3208Q}{A}$
COMPRESSIBILITY OF OIL *In Additional Required Oil To Reach Pressure*	ADDITIONAL VOLUME = $\frac{\text{PRESSURE (}PSI\text{) x VOLUME OF OIL UNDER PRESSURE}}{250{,}000\ (Approx.)}$	$VA = \frac{PV}{250{,}000}$ * Approximately 1/2 % per 1000 psi
COMPRESSIBILITY OF A FLUID	COMPRESSIBILITY = $\frac{1}{\text{BULK MODULUS OF THE FLUID}}$	$C(\beta) = \frac{1}{BM}$
SPECIFIC GRAVITY OF A FLUID	SPECIFIC GRAVITY = $\frac{\text{WEIGHT OF ONE CUBIC FOOT OF FLUID}}{\text{WEIGHT OF ONE CUBIC FOOT OF WATER}}$	$SG = \frac{W}{62.4283}$
VALVE (C_V) FLOW FACTOR	VALVE FACTOR (C_V) = $\frac{\text{FLOW RATE (GPM) x }\sqrt{\text{SPECIFIC GRAVITY}}}{\text{PRESSURE DROP (PSI)}}$	$C_V = \frac{Q\sqrt{SG}}{\Delta P}$
VISCOSITY IN CENTISTOKES	For Viscosities of 32 to 100 Saybolt Universal Seconds: CENTISTOKES = .2253 x SUS $-$ $\frac{194.4}{SUS}$	$CS = .2253\ SUS - \frac{194.4}{SUS}$
VISCOSITY IN CENTISTOKES	For Viscosities of 100 to 240 Saybolt Universal Seconds: CENTISTOKES = .2193 x SUS $-$ $\frac{134.6}{SUS}$	$CS = .2193\ SUS - \frac{134.6}{SUS}$
VISCOSITY IN CENTISTOKES	For Viscosities Greater Than 240 Saybolt Universal Seconds: CENTISTOKES = $\frac{SUS}{4.635}$	$CS = \frac{SUS}{4.635}$

NOTE: Saybolt Universal Seconds is often abbreviated SSU.

PUMP FORMULAS

PUMP OUTLET FLOW *In Gallons/Minute*	FLOW = $\frac{\text{RPM X PUMP DISPLACEMENT (}Cu.\ In./Rev.\text{)}}{231}$	$Q = \frac{nd}{231}$
PUMP INPUT POWER *In Horsepower Required*	HORSEPOWER INPUT = $\frac{\text{FLOW RATE OUTPUT (}GPM\text{) X PRESSURE (}psi\text{)}}{\text{1714 X EFFICIENCY (}Overall\text{)}}$	$HP_{IN} = \frac{QP}{1714\ Eff}$ or $\frac{GPM \times psi}{1714\ Eff}$
PUMP EFFICIENCY *Overall in Percent*	OVERALL EFFICIENCY = $\frac{\text{OUTPUT HORSEPOWER}}{\text{INPUT HORSEPOWER}}$ X 100	$Eff_{OV} = \frac{HP_{OUT}}{HP_{IN}} \times 100$
	OVERALL EFFICIENCY = VOLUMETRIC Eff. X MECHANICAL Eff.	$Eff_{OV} = Eff_{VOL.} \times Eff_{MECH.}$
PUMP EFFICIENCY *Overall in Percent*	VOLUMETRIC EFFICIENCY = $\frac{\text{ACTUAL FLOW RATE OUTPUT (}GPM\text{)}}{\text{THEORETICAL FLOW RATE OUTPUT (}GPM\text{)}}$ X 100	$Eff_{VOL} = \frac{O_{ACT.}}{O_{THEO.}} \times 100$
PUMP EFFICIENCY *Mechanical in Percent*	MECHANICAL EFFICIENCY = $\frac{\text{THEORETICAL TORQUE TO DRIVE}}{\text{ACTUAL TORQUE TO DRIVE}}$ X 100	$Eff_{MEC} = \frac{T_{THEO.}}{T_{ACT.}} \times 100$
PUMP LIFE B_{10} BEARING LIFE	B_{10} HOURS OF BEARING LIFE = RATED LIFE HOURS X $\frac{\text{RATED SPEED (}RPM\text{)}}{\text{NEW SPEED (}RPM\text{)}} \times \left(\frac{\text{RATED PRESSURE (}PSI\text{)}}{\text{NEW PRESSURE (}PSI\text{)}}\right)^3$	$B_{10} = \text{RATED HRS.} \times \frac{RPM_R}{RPM_N} \times \left(\frac{P_R}{P_N}\right)^3$

FLUID POWER FORMULAS

ACTUATOR FORMULAS

FORMULA FOR:	WORD FORMULA	LETTER FORMULA
CYLINDER AREA *In Square Inches*	AREA = π X RADIUS^2 (*Inches*)	$A = \pi r^2$
	= $\frac{\pi}{4}$ X DIAMETER^2 (*Inches*)	$A = \frac{\pi D^2}{4}$ or $A = .785D^2$
CYLINDER FORCE *In Pounds, Push or Pull*	FORCE = PRESSURE (psi) X NET AREA (Square Inches)	F = psi X A or F = PA
CYLINDER VELOCITY or SPEED *In Feet/Second*	VELOCITY = $\frac{231 \text{ X FLOW RATE (}GPM\text{)}}{12 \text{ X } 60 \text{ X NET AREA (}Square\ Inches\text{)}}$	$F = \frac{231Q}{720A}$ or $V = \frac{.3208Q}{A}$
CYLINDER VOLUME CAPACITY *In Gallons of Fluid*	VELOCITY = $\frac{\pi \text{ X RADIUS}^2 \text{ (}Inches\text{) X STROKE (}Inches\text{)}}{231}$	$V = \frac{\pi r^2 \, l}{231}$
	= $\frac{\text{NET AREA (}Square\ Inches\text{) X STROKE (}Inches\text{)}}{231}$	$V = \frac{A \, l}{231}$ l = *Length of Stroke*
CYLINDER FLOW RATE *In Gallons Per Minute*	FLOW RATE = $\frac{12 \text{ X } 60 \text{ X VELOCITY (}Feet/Sec.\text{) X NET AREA (}Square\ Inches\text{)}}{231}$	$Q = \frac{720vA}{231}$ or $Q = 3.117vA$
FLUID MOTOR TORQUE *In Inch Pounds*	TORQUE = $\frac{\text{PRESSURE (}psi\text{) X F.M. DISPLACEMENT (}Cu.\ In./Rev.\text{)}}{2\pi}$	$T = \frac{psi\ d}{2\pi}$ or $T = \frac{Pd}{2\pi}$
	= $\frac{\text{HORSEPOWER X } 63025}{\text{RPM}}$	$T = \frac{63025\ HP}{n}$
	= $\frac{\text{FLOW RATE (}GPM\text{) X PRESSURE (}psi\text{) X } 36.77}{\text{RPM}}$	$T = \frac{36.77QP}{n}$ or $T = \frac{36.77Qpsi}{n}$
FLUID MOTOR TORQUE/100 psi *In Inch Pounds*	TORQUE/100 psi = $\frac{\text{F.M. DISPLACEMENT (}Cu.\ Inches/Revolution\text{)}}{.0628}$	$T_{100psi} = \frac{d}{.0628}$
FLUID MOTOR SPEED *In Revolutions/Minute*	SPEED = $\frac{231 \text{ X FLOW RATE (}GPM\text{)}}{\text{F.M. DISPLACEMENT (}Cu.\ Inches/Revolution\text{)}}$	$n = \frac{231Q}{d}$
FLUID MOTOR POWER *In Horsepower Output*	HORSEPOWER = $\frac{\text{TORQUE OUTPUT (}Inch\ Pounds\text{) X RPM}}{63025}$	$HP = \frac{Tn}{63025}$

THERMAL FORMULAS

RESERVOIR COOLING CAPACITY *Based on Adequate Air Circulation*	HEAT (BTU/HR) = 2 X TEMPERATURE DIFFERENCE BETWEEN RESERVOIR WALLS AND AIR (°F) X AREA OF RESERVOIR (*Sq. Ft.*)	BTU/HR = $2.0 \text{ X } \Delta T \text{ X A}$
HEAT IN HYDRAULIC OIL (approx.) *Due to System Inefficiency (SG=.89-.92)*	HEAT (BTU/HR) = FLOW RATE (*GPM*) X 210 X TEMPERATURE DIFFERENCE (°F)	BTU/HR = $Q \text{ X } 210 \text{ X } \Delta T$
HEAT IN FRESH WATER (approx.)	HEAT (BTU/HR) = FLOW RATE (*GPM*) X 500 X TEMPERATURE DIFFERENCE (°F)	BTU/HR = $Q \text{ X } 500 \text{ X } \Delta T$

NOTE: One British Thermal Unit (BTU) is the amount of heat required to raise the temperature of one pound of water one degree. One Horsepower = 2545 BTU/HR.

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ACCUMULATOR FORMULAS

PRESSURE or VOLUME *w/ Constant "T" (Temperature)*	ORIGINAL PRESSURE X ORIGINAL VOLUME = FINAL PRESSURE X FINAL VOLUME	$P_1\ V_1 = P_2\ V_2$ Isothermic
PRESSURE or TEMPERATURE *w/ Constant "V" (Volume)*	ORIGINAL PRESSURE X FINAL TEMPERATURE = FINAL PRESSURE X ORIGINAL TEMPERATURE	$P_1\ T_2 = P_2\ T_1$ Isochoric
VOLUME or TEMPERATURE *w/ Constant "P" (Pressure)*	ORIGINAL VOLUME X FINAL TEMPERATURE = FINAL VOLUME X ORIGINAL TEMPERATURE	$V_1\ T_2 = V_2\ T_2$ Isobaric
PRESSURE or VOLUME	ORIGINAL PRESSURE X ORIGINAL VOLUME^n = FINAL PRESSURE X FINAL VOLUME^n	$P_1\ V_1^{\,n} = P_2\ V_2^{\,n}$
w/ Temperature Change Due to Heat of Compression	$\frac{\text{FINAL TEMP.}}{\text{ORIG. TEMP.}} = \left(\frac{\text{ORIG. VOLUME}}{\text{FINAL VOLUME}}\right)^{n-1} = \left(\frac{\text{FINAL PRESSURE}}{\text{ORIG. PRESSURE}}\right)^{n-1/n}$	$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{n-1} = \left(\frac{P_2}{P_1}\right)^{n-1/n}$

NOTE: Where "P" = psia (*ABSOLUTE*) = psig (*GAUGE PRESSURE*) + 14.7 psi

VOLUME & CAPACITY EQUIVALENTS

	Cubic Inches	Cubic Feet	Cubic Yards	Liters	U.S. Gallons	Imperial Gallons	Water at Max. Density 39.2°F 4°C: Pounds of Water	Water at Max. Density 39.2°F 4°C: Kilograms of Water
Cu Inches	1	.0005787	.00002143	.016384	.004329	.0036065	.0361275	.0163872
Cu Feet	1728	1	.037037	28.317	7.48052	6.23210	62.4283	28.3170
Cu Yards	46,656	27	1	764.56	201.974	168.266	1685.56	764.559
Liters	61.0234	.0353145	.001308	1	.264170	.220083	2.20462	1
U.S. Gallons	231	.133681	.004951	3.78543	1	.833111	8.34545	3.78543
Imp. Gallons	277.274	.160459	.0059429	4.54374	1.20032	1	10.0172	4.54373
Lbs Water	27.6798	.0160184	.0005929	.453592	.119825	.0998281	1	.453593

COMMON CONVERSION FACTORS

TO CONVERT	INTO	MULTIPLY BY
Atmospheres	cms of mercury	76.0
atmospheres	ft. of water (at 4°C)	33.90
atmospheres	in. of mercury (at 0°C)	29.92
atmospheres	kgs/sq cm	1.0333
atmospheres	kgs/sq meter	10,332
atmospheres	pounds/sq in.	14.70
Bar	newtons/sq m	10^5
bar	atmospheres	0.9869
bar	at (tech.)	1.0197
bar	psi	14.504
Barrels-Oil	gals-oil	42
BT Units	kg-calories	1.2520
BTUs	ft-lbs	777.9
BTUs	hp-hrs	3.927×10^{-4}
BTUs	kgs-meters	107.5
BTUs	kw-hrs	2.928×10^{-4}
BTU/Min	ft-lbs/sec	12.96
BTU/min	hp	0.02356
BTU/min	kw	0.01757
BTU/min	watts	17.57
Centimeters	inches	0.3937
cm	meters	0.01
cm	mm	10
Cms Mercury	atm	0.01316
cms mercury	ft water	0.4461
cms mercury	kgs/sq meter	136.0
cms mercury	lbs/sq ft	27.85
cms mercury	lbs/sq in	0.1934
Cms/Second	ft/min	1.969
cms/sec	ft/sec	0.03281
cms/sec	km/hr	0.036
cms/sec	meters/min	0.6
cms/sec	miles/hr	0.02237
cms/sec	miles/min	3.728×10^{-4}
Cms/Sec/Sec	ft/sec/sec	0.03281
Cubic Cms	cu ft	3.531×10^{-5}
cu cms	cu in	6.102×10^{-2}
cu cms	cu meters	10^{-6}
cu cms	cu yds	1.308×10^{-6}
cu cms	gals	2.642×10^{-4}
cu cms	liters	10^{-3}
cu cms	pints (liq)	2.113×10^{-3}
cu cms	quarts (liq)	1.057×10^{-3}
Cubic Feet	cubic cms	2.832×10^4
cu ft	cu inches	1728
cu ft	cu meters	0.02832
cu ft	cu yds	0.03704
cu ft	gals	7.48052
cu ft	liters	28.32
cu ft	pints (liq)	59.84

TO CONVERT	INTO	MULTIPLY BY
cu ft	quarts (liq)	29.92
Cu Ft/Min	cu cms/sec	472.0
cu ft/min	gals/sec	0.1247
cu ft/min	liters/sec	0.4720
cu ft/min	lbs water/min	62.43
cu ft/min	gals/min	448.831
Cu Inches	cc	16.39
cu ins	cu ft	5.787×10^{-4}
cu ins	cu meters	1.639×10^{-5}
cu ins	cu yds	2.143×10^{-5}
cu ins	gals	4.329×10^{-3}
cu ins	liters	1.639×10^{-2}
cu ins	pints (liq)	0.03463
cu ins	quarts (liq)	0.01732
Cu Meters	cc	10^4
cu M	cu ft	35.31
cu M	cu ins	61,023
cu M	cu yds	1.308
cu M	gals	264.2
cu M	liters	10^3
cu M	pints (liq)	2113
cu M	quarts (liq)	1057
Cu Yards	cu cms	7.646×10^5
cu yds	cu ft	27
cu yds	cu ins	46.656
cu yds	cu meters	0.7646
cu yds	gals	202.0
Decimeters	meters	0.1
Degs (Angle)	minutes	60
Degs (angle)	radians	0.01745
Degs (angle)	secs	3600
Degrees/Sec	radians/sec	0.01745
degs/sec	revs/min	0.1667
degs/sec	revs/sec	0.002778
Feet	cms	30.48
ft	ins	12
ft	meters	0.3048
ft	yds	1/3
Ft of Water	atms	0.02950
ft of w	ins mercury	0.8826
ft of w	kgs/sq cm	0.03048
ft of w	lbs/sq ft	62.32
ft of w	lbs/sq in	0.4328
Feet/Min	cms/sec	0.5080
ft/min	ft/sec	0.01667
ft/min	kms/hr	0.01829
ft/min	meters/min	0.3048
ft/min	miles/hr	0.01136
Ft/Sec/Sec	cms/sec/sec	30.48
ft/sec/sec	Meters/sec/sec	0.3048

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COMMON CONVERSION FACTORS

TO CONVERT	INTO	MULTIPLY BY
Ft-Pounds	BTUs	1.286×10^{-3}
ft lbs	hp-hrs	5.050×10^{-7}
ft lbs	kg-calories	3.241×10^{-4}
ft lbs	kg-meters	0.1383
ft lbs	kw-hrs	3.766×10^{-7}
Ft-lbs/Min	BTUs/min	1.286×10^{-3}
ft-lbs/min	ft-lbs/sec	0.01667
ft-lbs/min	hp	3.03×10^{-5}
ft-lbs/min	kg-calories/min	3.241×10^{-4}
ft-lbs/min	kws	2.260×10^{-5}
Ft-Lbs/Sec	BTUs/min	7.717×10^{-2}
ft-lbs/sec	hp	1.818×10^{-3}
ft-lbs/sec	kg-calories/min	1.945×10^{-2}
ft-lbs/sec	kws	1.356×10^{-3}
Gallons	ccs	3785
gals	cu ft	0.1337
gals	cu ins	231
gals	cu meters	3.785×10^{-3}
gals	liters	3.785
gals	pints (liq)	8
gals	quarts (liq)	4
Gallons, Imp	US gals	1.20095
gallons, US	imp gals	0.83267
Gals Water	lbs water	8.3304
Gallons/Min	cu ft/sec	2.228×10^{-3}
gals/min	liters/sec	0.06308
gals/min	cu ft/hr	8.0208
Horse-Power	BTUs/min	42.44
hp	ft-lbs/min	33,000
hp	ft-lbs/sec	550
hp	hp (metric)	1.014
hp	kg-calories/min	10.70
hp	kws	0.7457
hp	watts	745.7
Hp-Hours	BTUs	2547
hp-hrs	ft-lbs	1.98×10^{6}
hp-hrs	kg-calories	641.7
hp-hrs	kg-meters	2.737×10^{5}
hp-hrs	kw-hrs	0.7457
Inches	cms	2.540
Inches	mms	25.4
Ins Mercury	atms	0.03342
ins mercury	ft water	1.133
ins mercury	kgs/sq cm	0.03453
ins mercury	lbs/sq ft	70.73
ins mercury	lbs/sq in	0.4912
Ins of Water	atms	0.002458
ins of w	ins mercury	0.07355
ins of w	kgs/sq cm	0.002540
ins of w	lbs/sq ft	5.202

TO CONVERT	INTO	MULTIPLY BY
ins of w	lbs/sq in	0.03613
Kilograms	dynes	980,665
kgs	lbs	2.205
kgs	tons (short)	1.102×10^{-3}
kgs	grams	1000
Kgs/Sq Cm	atms	0.9678
kgs/sq cm	ft water	32.81
kgs/sq cm	ins mercury	28.96
kgs/sq cm	lbs/sq ft	2048
kgs/sq cm	lbs/sq in	14.22
Kilometers	cms	10^{5}
kms	ft	3281
kms	meters	10^{3}
kms	miles	0.6214
Kms/Hr	cms/sec	27.78
kms/hr	ft/min	54.68
kms/hr	ft/sec	0.9113
kms/hr	meters/min	16.67
kms/hr	miles/hr	0.6214
Kms/Hr/Sec	cms/sec/sec	27.78
kms/hr/sec	ft/sec/sec	0.9113
kms/hr/sec	Meters/sec/sec	0.2778
Kilowatts	BTUs/min	56.92
kws	ft-lbs/min	4.425×10^{4}
kws	ft-lbs/sec	737.6
kws	hp	1.341
kws	kg-calories/min	14.34
kws	watts	10^{3}
Kilowatt-Hrs	BTUs	3415
kw-hrs	ft-lbs	2.655×10^{6}
kw-hrs	hp-hours	1.341
kw-hrs	kg-calories	860.5
kw-hrs	kg-meters	3.67×10^{5}
Liters	ccs	10^{3}
liters	cu ft	0.03531
liters	cu ins	61.02
liters	cu meters	10^{-2}
liters	gals	0.2642
liters	quarts (liq)	1.057
Liters/Min	gals/sec	4.403×10^{-3}
Meters	cms	100
meters	ft	3.281
meters	ins	39.37
meters	kms	10^{-3}
meters	mms	10^{3}
Meters/Min	cms/sec	1.667
meters/min	ft/min	3.281
meters/min	ft/sec	0.05468
meters/min	kms/hr	0.06
meters/min	miles/hr	0.03728

COMMON CONVERSION FACTORS

TO CONVERT	INTO	MULTIPLY BY
Meters/Sec	ft/min	196.8
meters/sec	ft/sec	3.281
meters/sec	kms/hr	3.6
meters/sec	kms/min	0.06
meters/sec	miles/hr	2.237
meters/sec	miles/min	0.03728
Microns	meters	10^{-6}
microns	in	$39x10^{-6}$
Miles/Hr	cms/sec	44.70
miles/hr	ft/min	88
miles/hr	ft/sec	1.467
miles/hr	kms/hr	1.609
miles/hr	meters/min	26.82
Millimeters	cms	0.1
mms	ins	0.03937
Minutes (Angle)	radians	$2.909x10^{-4}$
Newton	kgs	0.1020
Ounces	lbs	0.0625
ozs	gram	28.349527
Ozs (Fluid)	cu in	1.805
ozs (fluid)	liters	0.02957
Pounds	ozs	16
lbs	kgs	0.4536
lbs	tons (short)	0.0005
lbs	newtons (N)	4.44
lbs	gram	453.5924
Pounds/Inch	newton-meters	0.1113
Pounds/Foot	newton-mters	1.356
Lbs of Water	cu ft	0.01605

TO CONVERT	INTO	MULTIPLY BY
lbs of water	cu in	27.73
lbs of water	gals	0.1204
Lbs of Water/Min	cu ft/sec	$2.679x10^{-4}$
Pounds/Cu Ft	lbs/cu in	$5.787x10^{-4}$
Pounds/Cu In	lbs/cu ft	1728
Pounds/Sq In	atms	0.06804
lbs/sq in	ft water	2.311
lbs/sq in	in mercury	2.036
lbs/sq in	kgs/sq cm	0.07031
Radians	degrees	57.29578
Tons (Long)	kgs	1016
tons (long)	lbs	2240
tons (long)	tons (short)	1.12000
Tons (Short)	kgs	2000
tons (short)	kps	907.18486
tons (short)	tons (long)	0.89287
tons (short)	tons (metric)	0.90718
Watts	BTUs/min	0.05692
watts	ft-lbs/min	44.26
watts	ft-lbs/sec	0.7376
watts	hp	$1.341x10^{-3}$
watts	kg-calories/min	0.01434
watts	kws	10^{-3}
Watt/Hours	BTUs	3.415
watt-hrs	ft-lbs	2655
watt-hrs	hp-hrs	$1.341x10^{-3}$
watt-hrs	kg-calories	0.8605
watt-hrs	kg-meters	367.1
watt-hrs	kw-hrs	10^{-3}

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Approximate Weights of Materials

Material	lbs. / cu. yd.	tons / cu. yd.	Material	lbs. / cu. yd.	tons / cu. td.
Andesite stone	4,887	2.44	Earth & sand, wet	3,240	1.62
Ashes	1,080	0.52	Fire Brick	3,915	1.95
Asphalt	2,700	1.35	Fire Clay	3,510	1.75
Asphaltum	2,349	1.17	Garbage	1,150	0.57
Basalt rock	4,887	2.44	Gravel, dry	2,970	1.48
Brick, soft clay	2,718	1.35	Gravel, out of water	1,620	0.81
Brick, hard clay	3,397	1.69	Granite	4,536	2.26
Brick, pressed	3,806	1.90	Lime, quick, loose	1,431	0.71
Brick, paving	4,246	2.12	Lime, quick, shaken	1,485	0.70
Block, paving	3,694	1.84	Limestone, solid	4,536	2.26
Bluestone	2,970	1.48	Limestone, loose	2,592	1.29
Cement, natural	1,512	0.75	Marble, solid	4,455	2.22
Cement, Portland	2,430	1.21	Marble, loose	2,592	1.29
Cement, Portland, set	4,941	2.47	Mortar, set	2,781	1.39
Cement, Rosendale	1,863	0.93	Mud, dry	2,430	1.21
Cinders	1,080	0.54	Mud, packed	3,105	1.55
Clay, dry	1,701	0.85	Mud, wet	2,916	1.45
Clay, wet	2,970	1.48	Pitch	1,863	0.93
Clay & gravel, dry	2,700	1.35	Plaster of Paris	2,646	1.32
Coal, anthracite	1,536	0.76	Powder, blasting	1,682	0.84
Coal, bituminous	1,275	0.64	Quartz	4,374	2.18
Coke	837	0.42	Rubbish	199.8	0.09
Concrete, cinders	2,970	1.48	Sand, dry, loose	2,619	1.30
Concrete, gravel	4,104	2.05	Sand, wet	3,186	1.59
Concrete, limestone	4,050	2.02	Sandstone	4,023	2.01
Concrete, sandstone	3,915	1.95	Slag, blank	1,890	0.94
Concrete, trap rock	4,185	2.09	Slag, screenings	2,700	1.35
Crushed stone	2,700	1.35	Slag, machine	2,592	1.29
Earth, dry, loose	1,890	0.94	Slag, sand	1,485	0.74
Earth, damp, loose	2,106	1.05	Shale	4,374	2.18
Earth, damp, packed	2,592	1.29	Slate	4,725	2.31
Earth & gravel, dry	2,700	1.35	Tar	1,674	0.83
Earth & gravel, wet	3,240	1.62	Tile	2,970	1.43
Earth & sand, dry	2,709	1.35	Trap stone	5,849	2.52

Steel & Aluminum Gauge, Thickness and Weight

Gauge	Thickness (inches)	Weight (lbs./ft²)
Steel		
3/8”	0.375	15.320
1/4” (approx. 3 Ga.)	0.250	10.200
3/16” (approx. 7 Ga.)	0.188	7.650
8 Ga.	0.164	6.875
9 Ga.	0.149	6.250
10 Ga.	0.134	5.625
11 Ga.	0.120	5.000
12 Ga.	0.105	4.375
13 Ga.	0.090	3.750
14 Ga.	0.075	3.125
Aluminum		
3/8”	0.375	5.18
1/4”	0.250	3.53
3/16”	0.188	2.65
5/32”	0.156	2.25

METRIC/INCH CONVERSION TABLE

FRACTIONS, DECIMALS AND MILLIMETERS

Inches		Millimeters
Fractions	Decimals	
—	.0004	.01
—	.004	.10
—	.01	.25
1/64	.0156	.397
—	.0197	.50
—	.0295	.75
1/32	.03125	.794
—	.0394	1.0
3/64	.0469	1.191
—	.059	1.5
1/16	.062	1.588
5/64	.0781	1.984
—	.0787	2.0
3/32	.094	2.381
—	.0984	2.5
7/64	.109	2.778
—	.1181	3.0
1/8	.125	3.175
—	.1378	3.5
9/64	.141	3.572
5/32	.156	3.969
—	.1575	4.0
11/64	.172	4.366
—	.177	4.5
3/16	.1875	4.763
—	.1969	5.0
13/64	.203	5.159
—	.2165	5.5
7/32	.219	5.556
15/64	.234	5.953
—	.2362	6.0
1/4	.250	6.350
—	.2559	6.5
17/64	.2656	6.747
—	.2756	7.0
9/32	.281	7.144
—	.2953	7.5
19/64	.297	7.541
5/16	.312	7.938
—	.315	8.0
21/64	.328	8.334
—	.335	8.5
11/32	.344	8.731
—	.3543	9.0
23/64	.359	9.128
—	.374	9.5
3/8	.375	9.525
25/64	.391	9.922
—	.3937	10.0
13/32	.406	10.319
—	.413	10.5
27/64	.422	10.716
—	.4331	11.0
7/16	.438	11.113
29/64	.453	11.509
15/32	.469	11.906
—	.4724	12.0
31/64	.484	12.303
—	.492	12.5
1/2	.500	12.700

Inches		Millimeters
Fractions	Decimals	
—	.5118	13.0
33/64	.5156	13.097
17/32	.531	13.494
35/64	.547	13.891
—	.5512	14.0
9/16	.563	14.288
—	.571	14.5
37/64	.578	14.684
—	.5906	15.0
19/32	.594	15.081
39/64	.609	15.478
5/8	.625	15.875
—	.6299	16.0
41/64	.6406	16.272
—	.6496	16.5
21/32	.658	16.669
—	.6693	17.0
43/64	.672	17.066
11/16	.6875	17.463
45/64	.703	17.859
—	.7087	18.0
23/32	.719	18.256
—	.7283	18.5
47/64	.734	18.653
—	.7480	19.0
3/4	.750	19.050
49/64	.7656	19.447
25/32	.781	19.844
—	..7874	20.0
51/64	.797	20.241
13/16	.8125	20.638
—	.8268	21.0
53/64	.828	21.034
27/32	.844	21.431
55/64	.859	21.828
—	.8661	22.0
7/8	.875	22.225
57/64	.8906	22.622
—	.9055	23.0
29/32	.9062	23.019
59/64	.922	23.416
15/16	.9375	23.813
—	.9449	24.0
61/64	.953	24.209
31/32	.969	24.606
—	.9843	25.0
63/64	.9844	25.003
1	1.000	25.400
—	1.0236	26.0
1-1/32	1.0312	26.194
1-1/16	1.062	26.988
—	1.063	27.0
1-3/32	1.094	27.781
—	1.1024	28.0
1-1/8	1.125	28.575
—	1.1417	29.0
1-5/32	1.156	29.369
—	1.1811	30.0
1-3/16	1.1875	30.163
1-7/32	1.219	30.956

Inches		Millimeters
Fractions	Decimals	
—	1.2205	31.0
1-1/4	1.250	31.750
—	1.2598	32.0
1-9/32	1.281	32.544
—	1.2992	33.0
1-5/16	1.312	33.338
—	1.3386	34.0
1-11/32	1.344	34.131
1-3/8	1.375	34.925
—	1.3779	35.0
1-13/32	1.406	35.719
—	1.4173	36.0
1-7/16	1.438	36.513
—	1.4567	37.0
1-15/32	1.469	37.306
—	1.4961	38.0
1-1/2	1.500	38.100
1-17/32	1.531	38.894
—	1.5354	39.0
1-9/16	1.562	39.688
—	1.5748	40.0
1-19/32	1.594	40.481
—	1.6142	41.0
1-5/8	1.625	41.275
—	1.6535	42.0
1-21/32	1.6562	42.069
1-11/16	1.6875	42.863
—	1.6929	43.0
1-23/32	1.719	43.656
—	1.7323	44.0
1-3/4	1.750	44.450
—	1.7717	45.0
1-25/32	1.781	45.244
—	1.8110	46.0
1-13/16	1.8125	46.038
1-27/32	1.844	46.831
—	1.8504	47.0
1-7/8	1.875	47.625
—	1.8898	48.0
1-29/32	1.9062	48.419
—	1.9291	49.0
1-15/16	1.9375	49.213
—	1.9685	50.0
1-31/32	1.969	50.006
2	2.000	50.800
—	2.0079	51.0
2-1/32	2.03125	51.594
—	2.0472	52.0
2-1/6	2.062	52.388
—	2.0866	53.0
2-3/32	2.094	53.181
2-1/8	2.125	53.975
—	2.126	54.0
2-5/32	2.156	54.769
—	2.165	55.0
2-3/16	2.1875	55.563
—	2.2047	56.0
2-7/32	2.219	56.356
—	2.244	57.0
2-1/4	2.250	57.150

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METRIC/INCH CONVERSION TABLE

FRACTIONS, DECIMALS AND MILLIMETERS

Inches		Millimeters
Fractions	Decimals	
2-9/32	2.281	57.944
—	2.2835	58.0
2-5/16	2.312	58.738
—	2.3228	59.0
2-11/32	2.344	59.531
—	2.3622	60.0
2-3/8	2.375	60.325
—	2.4016	61.0
2-13/32	2.406	61.119
2-7/16	2.438	61.913
—	2.4409	62.0
2-15/32	2.469	62.706
—	2.4803	63.0
2-1/2	2.500	63.500
—	2.5197	64.0
2-17/32	2.531	64.294
—	2.559	65.0
2-9/16	2.562	65.088
2-19/32	2.594	65.881
—	2.5984	66.0
2-5/8	2.625	66.675
—	2.638	67.0
2-21/32	2.656	67.469
—	2.6772	68.0
2-11/16	2.6875	68.263
—	2.7165	69.0
2-23/32	2.719	69.056
2-3/4	2.750	69.850
—	2.7559	70.0
2-25/32	2.781	70.6439
—	2.7953	71.0
2-13/16	2.8125	71.4376
—	2.8346	72.0
2-27/32	2.844	72.2314
—	2.8740	73.0
2-7/8	2.875	73.025
2-29/32	2.9062	73.819
—	2.9134	74.0
2-15/16	2.9375	74.613
—	2.9527	75.0
2-31/32	2.969	75.406
—	2.9921	76.0
3	3.000	76.200
3-1/32	3.0312	76.994
—	3.0315	77.0
3-1/16	3.062	77.788
—	3.0709	78.0
3-3/32	3.094	78.581
—	3.1102	79.0
3-1/8	3.125	79.581
—	3.1496	80.0
3-5/32	3.156	80.169
3-3/16	3.1875	80.963
—	3.1890	81.0
3-7/32	3.219	81.756
—	3.2283	82.0
3-1/4	3.250	82.550
—	3.2677	83.0
3-9/32	3.281	83.344
—	3.3071	84.0
3-5/16	3.312	84.1377
3-11/32	3.344	84.9314
—	3.3464	85.0
3-3/8	3.375	85.725
—	3.3858	86.0
3-13/32	3.406	86.519
—	3.4252	87.0
3-7/16	3.438	87.313
—	3.4648	88.0
3-15/32	3.469	88.108
3-1/2	3.500	88.900
—	3.5039	89.0
3-17/32	3.531	89.694
—	3.5433	90.0
3-9/16	3.562	90.4877
—	3.5827	91.0
3-19/32	3.594	91.281
—	3.622	92.0
3-5/8	3.625	92.075
3-21/32	3.656	92.869
—	3.6614	93.0
3-11/16	3.6875	93.663
—	3.7008	94.0
3-23/32	3.719	94.456
—	3.7401	95.0
3-3/4	3.750	95.250
—	3.7795	96.0
3-25/32	3.781	96.044
3-13/16	3.8125	96.838
—	3.8189	97.0
3-27/32	3.844	97.631
—	3.8583	98.0
3-7/8	3.875	98.425
—	3.8976	99.0
3-29/32	3.9062	99.219
—	3.9370	100.0
3-15/16	3.9375	100.013
3-31/32	3.969	100.806
—	3.9764	101.0
4	4.000	101.600
4-1/16	4.062	103.188
4-1/8	4.125	104.775
—	4.1338	105.0
4-3/16	4.1875	106.363
4-1/4	4.250	107.950
4-5/16	4.312	109.538
—	4.3307	110.0
4-3/8	4.375	111.125
4-7/16	4.438	112.713
4-1/2	4.500	114.300
—	4.5275	115.0
4-9/16	4.562	115.888
4-5/8	4.625	117.475
4-11/16	4.6875	119.063
—	4.7244	120.0
4-3/4	4.750	120.650
4-13/16	4.8125	122.238
4-7/8	4.875	123.825
—	4.9212	125.0
4-15/16	4.9375	125.413
5	5.000	127.000
—	5.1181	130.0
5-1/4	5.250	133.350
5-1/2	5.500	139.700
—	5.5118	140.0
5-3/4	5.750	146.050
—	5.9055	150.0
6	6.000	152.400
6-1/4	6.250	158.750
—	6.2992	160.0
6-1/2	6.500	165.100
—	6.6929	170.0
6-3/4	6.750	171.450
7	7.000	177.800
—	7.0866	180.0
—	7.4803	190.0
7-1/2	7.500	190.500
—	7.8740	200.0
8	8.000	203.200
—	8.2677	210.0
8-1/2	8.500	215.900
—	8.6614	220.0
9	9.000	228.600
—	9.0551	230.0
—	9.4488	240.0
9-1/2	9.500	241.300
—	9.8425	250.0
10	10.000	254.001
—	10.2362	260.0
—	10.6299	270.0
11	11.000	279.401
—	11.0236	280.0
—	11.4173	290.0
—	11.8110	300.0
12	12.000	304.801
13	13.000	330.201
—	13.7795	350.0
14	14.000	355.601
15	15.000	381.001
—	15.7480	400.0
16	16.000	406.401
17	17.000	431.801
—	17.7165	450.0
18	18.000	457.201
19	19.000	482.601
—	19.6850	500.0
20	20.000	508.001