Mobile Cylinder Products and Application Guide

Parker

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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.

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Manufacturing Location

20138 I-30 • Benton, AR 72019
Tel.: (800) 848-5575 • Fax: (800) 694-3392

Benton, Arkansas

Cylinders were among the first hydraulic products of Commercial Hydraulics beginning in 1928.

In 2000 Commercial Intertech Corp. merged with the Parker Hannifin Corp.

Today, the Parker Cylinder and Accumulator Division is recognized as one of the largest manufacturers of hydraulic cylinders for mobile equipment and a leading supplier to mining, truck, material handling, oil & gas, and military markets.

Parker's Cylinder and Accumulator Division products include double and single acting telescopic cylinders, welded rod cylinders and "smart cylinders" with internal electronic controls.

Parker has a reputation for high quality standard and custom-built cylinders that demonstrate engineering expertise and adept manufacturing which has establish Parker's Cylinder and Accumulator Division as the world's leading manufacturer of hydraulic cylinders.

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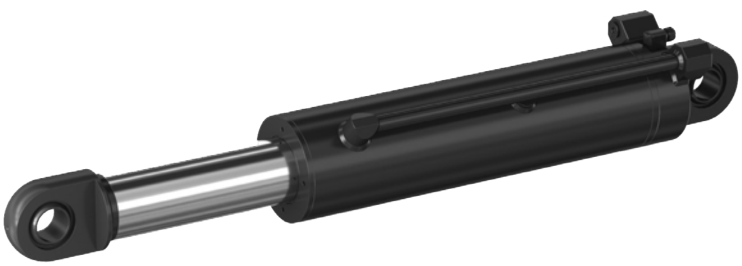
Mobile Cylinder Products and Capabilities



- **Telescopic Cylinders**
  Single Acting
  Double Acting

- **Welded Rod Cylinders**
  Custom Design
  RDH Series

- **Built to customer prints or per application specifications**

- **Standard bore sizes up to 16” diameter**

- **Stroke lengths up to 500 inches for telescopics, rods up to 300 inches**

- **Operating pressures up to 5,000 psi**

- **Various operating fluids**

- **Batch sizes 1PC to 100’s**

- **Optional materials and coatings**
  High Strength Carbon Steel
  Alloy Steel
  Nitriding
  Chrome
  Global Shield
  Induction Hardened Rods

- **Available Options**
  Load Holding Valves
  End of Stroke Hydraulic Cushions
  Proximity Switches
  Position Feedback Sensor
  Integral Manifolds and Values

Hydraulic Cylinder 10 Digit Numbers Coding

Parker Mobile Cylinder utilizes a 10 digit numbering system to place orders in our system. The model number referenced on the next page is used to define the cylinder size and type.

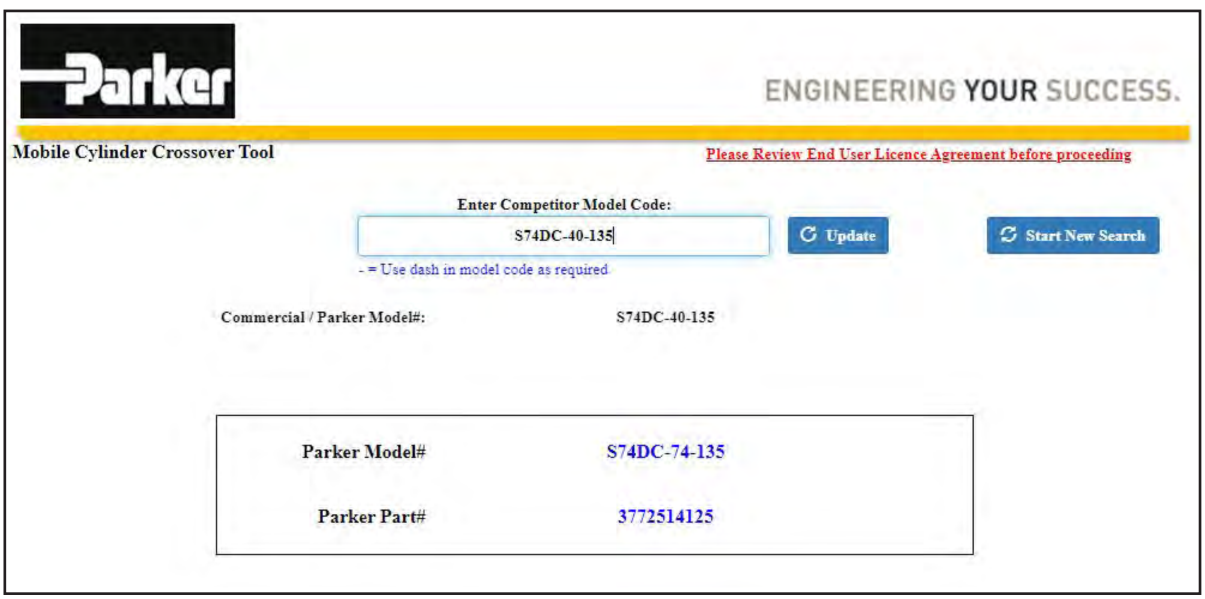
The following are examples of common ordered Parker Mobile Cylinder 10 digit numbers.

377xxxxxxx	**Assembly part number**
1HRDHxxxxxxxxx	**RDH series assembly part number**
377xxxxxx-SK	**Seal kit**
377xxxxxx-RK	**Rebuild kit**
378xxxxxxx	**Assembly part number *(legacy)***
3799000xxx	**Assembly part number *(legacy)***
3790000xxx	**Assembly part number *(legacy)***
375180xxxx	**Seal kit / rebuild kit *(legacy)***
391180xxxx	**Seal kit / rebuild kit *(legacy)***

Mobile Cylinder Crossover Tool

Compare different brands of telescopic cylinders with the click of a mouse.

https://divapps.parker.com/divapps/cyl/mobile-cylinder-crossover-tool/



The model number of a Parker Mobile (Commercial) Cylinder references its size and type. Using these numbers when ordering or inquiring greatly facilitates accurate understanding.

The following are examples of Parker Mobile Cylinder model numbers.

Single Acting Telescopic

S63MB-9-120

S	6	3	M	B	9	120
①	②	③	④	⑤	⑥	⑦

Double Acting Telescopic

SD96CC-3-199

SD	9	6	C	C	3	199
①	②	③	④	⑤	⑥	⑦

Double Acting Piston Rod

D72LB-11-83

D	72	L	B	11	83
①	②	④	⑤	⑥	⑦

1. **S** = **Single acting Telescopic Cylinder**
   SD = **Double acting Telescopic Cylinder**
   D = **Double acting Piston Rod Cylinder**

2. **Nominal O.D. of the largest moving stage on**
   Single acting and Double acting Telescopic cylinders
   or the
   Nominal Bore of Double acting Welded Rod Cylinders

3. **Number of moving stages or sleeves in a Telescopic Cylinder**

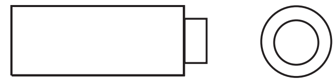
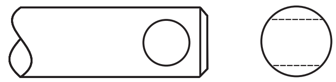
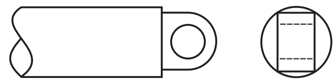
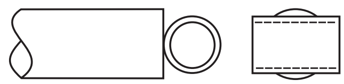
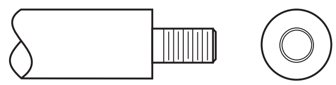
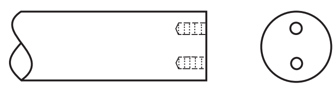
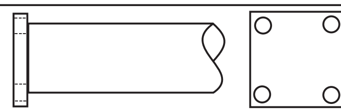
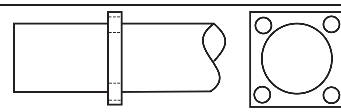
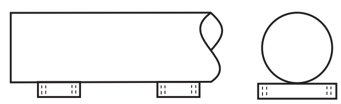
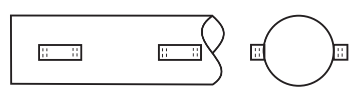
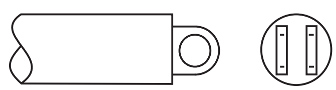
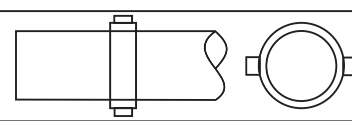
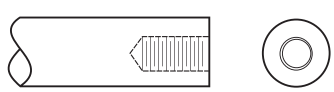
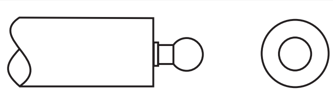
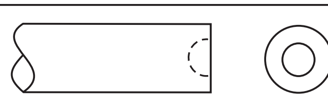
4. **Mounting option on the body or base end of cylinder**
   (See mounting Option and Code Chart for mount descriptions)

5. **Mounting option on the rod or plunger end of cylinder**
   (See mounting Option and Code Chart for mount descriptions)

6. **Modification or design variation of the cylinder**

7. **Length of cylinder stroke in inches**

Mounting Options and Code Chart

Code Letter	Mount Description	Mount Sketch	Mount Location
A	Plain No Mount		Body or Rod
B	Pin-Eye Drilled Thru Rod		Rod
C	Pin-Eye Drilled Thru Lug		Body or Rod
D	Cross Tube		Body or Rod
E	Threaded		Body or Rod
F	Drilled and Tapped		Body or Rod
G	Flange Mount at Base		Body
H	Flange Mount Mid-Body		Body
J	Foot / Pad Mount		Body
K	Centerline Mount		Body
L	Double Lug Clevis Mount		Body or Rod
M	Trunnion Mount		Body
N	Rod End Drilled and Tapped		Rod
O	Ball Mount		Body or Rod
P	Socket Mount		Body or Rod

Parker Hannifin Corporation
Cylinder and Accumulator Division
Des Plaines, Illinois

The great advantage telescopic cylinders have over conventional rod-type cylinders is their ability to provide an exceptionally long stroke in a compact initial package. The collapsed length of typical telescopic cylinders varies between 20% and 40% of their extended length. Thus, when mounting space is limited and the application needs a long stroke, a telescopic cylinder is a natural solution.

For example, a dump body typically needs to be tilted 60 degrees in order to empty completely. If the body or trailer is fitted with a conventional rod type cylinder with a one-piece barrel and stroke long enough to attain that angle the dump body could not return to a horizontal orientation for highway travel because of the cylinder's length, even when fully retracted. A telescopic cylinder easily solves this problem.

Telescopic hydraulic cylinders are relatively simple devices, but their successful application requires an understanding of this component's idiosyncrasies. Knowledge of how telescopic cylinders work and which special application criteria to consider will enable you to design them safely and economically into equipment.

Main and Stages

As the name infers, Telescopic cylinders are constructed like a telescope. Sections of DOM (drawn over mandrel) steel tubing with successively smaller diameters nest inside each other. The largest diameter section is called the main or barrel. The smaller-diameter sections that move are called stages; The smallest stage is also called the plunger. The maximum practical number of moving stages is six. Theoretically, cylinders with more stages could be designed but their stability problem would be daunting.

Telescopic cylinders normally extend from the largest stage to the smallest. This means the largest stage - with all the smaller stages nested inside it will move first and complete its stroke before the next stage begins to move. This procedure will continue for each stage until the smallest diameter stage is fully extended. Conversely, when retracting, the smallest diameter stage will retract fully before the next stage starts to move. This continues until all stages are nested back in the main.

Basic Cylinder Types

As with conventional cylinders, the two basic types of telescopic hydraulic cylinders are single and double acting. Single acting telescoping cylinders extend under hydraulic pressure and rely on gravity or some external mechanical force for retraction. Single acting cylinders are used in applications where some form of load is always on the cylinders. The classic single acting telescopic applications are dump trucks and dump trailers. Pressurized oil extends the telescopic cylinder to raise one end of the dump body and expel its load. When pressure is released, the weight of the dump body forces oil out of the cylinder and it retracts.

Double acting telescopic cylinders are powered hydraulically in both directions. They can be used in applications where neither gravity nor external force is available. They are well suited to noncritical positioning applications requiring out-and-back movement of a substantial load. A classic application is the packer-ejector cylinder in refuse vehicles and transfer trailers. The horizontally mounted cylinder pushes a platen to compress the load, then must retract with the platen so more material can be added. Gravity cannot help, so a double acting cylinder is used.

Bearings and Seals

Each stage is supported within each successively larger stage by at least two bearings. One is at the bottom outside diameter or piston end of the stage, and the other is at the top internal diameter or packing section of the next larger stage. The distance between these two bearings determines the degree by which one stage overlaps the next. Generally, this distance or overlap must increase as overall stroke increases in order to resist deflection caused by the weight of extended stages and the load.

There are several designs for sealing telescopic cylinders. One of the most common designs for sealing telescopic cylinders is the use of several hinged chevron vee seals and / or one-piece, multi-lip seals with hinged lips molded in place. The seals are held in place by a stop ring or snap ring and packing nut and they use guide bearings on the sleeve piston. The internal diameter "ID" of each stage is sealed against the outer diameter "OD" of the next smaller stage nested inside it. The style and placement of these seals varies among cylinder manufactures. The style of seal also depends on its particular function. Multiple-lip soft seals are usually found in the internal diameter at the packing section of the main and moving stages. Low-leakage hard seals are found on the piston end of double acting telescopic cylinders. These piston seals allow the cylinder to retract under pressure.

Another design used on some single acting telescopic cylinders, is the use of soft, seals on the piston, which use the full bore of the next larger stage as the effective area for extend force. These same seals contain the oil in the cylinder. The upper end of the cylinder, where the soft seals normally would be found, now contains a bearing for guidance. If any type of seal is used in the upper end of this telescopic cylinder design, it is usually a wiper/seal combination to exclude contaminants from entering the cylinders. With either type, the many sealing surfaces must compensate for normal deflection of stages as the cylinder extends.

The cylinder design with the bearing on the piston and the seal on the other end is called a displacement-type cylinder. The single acting design with a seal on the piston and a bearing at what normally would be the packing end approaches the classification of ram-type cylinder. Performance is similar to a double acting rod-type cylinder with pressurized oil being supplied only to the piston side. All the telescopic stages would stroke in this way.

Double Acting Telescopic Cylinders

Normally extension of a double acting telescopic cylinder occurs in the same manner as with the single acting type. Retraction of double acting telescopic cylinders is made possible by sealing each moving stage's piston area outside diameter with the next larger stage's inside diameter and building internal oil-transfer holes into each moving stage. The oil-transfer holes are located just above the pistons in the body of the stage. The retraction port normally is located in the top of the smallest stage. Oil flows through this port and into the smallest stage. The oil-transfer hole allows oil to enter and pressurize the volume between the next stage's internal diameter and the smaller stage's outer diameter. Pressure in this volume generates the force to move or retract the smaller stage into the larger stage.

Once this stage is fully retracted, the oil-transfer hole in the next larger stage is exposed to allow oil flow for it to retract. This retraction process continues automatically until all stages have retracted into the main. The seal on each stage selects the areas against which pressure will work.

Locating the retract port on the top of the smallest stage is the simplest way to design a double acting telescopic cylinder, but this port location typically requires an arrangement of hoses, hose protection, and hose reels to deliver oil to the moving stage. To avoid having fluid power ports spaced far apart when the cylinder is fully extended, most double acting telescopic cylinder designs locate both fluid ports in the smallest stage or plunger. The cylinder is then mounted so that the smallest stage or plunger is stationary and the larger and heavier stages would be the ones that move as the cylinder extends.

Piston seals on double acting telescoping cylinders are normally manufactured from a hard substance such as cast iron, ductile iron, or glass-reinforced nylon. The hard seals are needed to limit abrasion between the oil transfer holes and ports over which they must pass.

Single and Double Acting Combinations

There are a few unusual types of telescoping cylinders designed for specific applications. For example, a manufacturer of oil well equipment uses a type composed of both single and double acting stages to position a work-over rig. The work-over rig is a derrick or tower that is transported horizontally to the well site on a trailer. There, telescopic cylinders extend to swing the rig into a vertical position. When the rig's work is done, the telescopic cylinder pulls the rig to begin the transition from vertical back to horizontal. However, once the rig has started to tilt, no more pull force is need because of the rig's weight and gravity will continue to retract the cylinder. In other words, the cylinder needs hydraulic power for the first part of its retraction stroke, but then operates as a single acting unit.

In this type of design, the smallest moving stage is designed to be double acting; the others are single acting. The small stage can then provide push force to raise the rig, and pull force to start it back down. It is not unusual to design this type of cylinder as a skip-a-sleeve design. Skip-a-sleeve design is as it's name implies, a sleeve or stage is skipped during design. Normally a telescopic stage diameter increases approximately every inch. Example; sleeve diameter may be 3.75" fits into a 4.25" bore, 4.75" fitting into 5.25" bore, etc. In a skip-a-sleeve design, a sleeve is removed to increase the effective area and the retract force of the smallest sleeve or plunger. Example; plunger diameter is 2.75" and fits into the 4.25" bore of the 4.75" sleeve, thus increasing effective area and retract force.

Design Considerations
Three familiar formulas determine the general operating characteristics of telescoping cylinders and can be manipulated to calculate the cylinder size required for a given cycle time or load. These formulas are:

F = A X P
where:
F - force, lb
A - area, in^2
P - operating pressure, psi

S = 19.2 Q/A
where:
S - speed, fpm
Q - flow rate, gpm

T = V/231Q
where:
T - cycle time, min
V - cylinder volume (area X stroke), in^3

The basic formulas for force, speed, and cycle time that apply to conventional rod-type cylinders also can be used with telescopic cylinders. To successfully apply these formulas, the designer must know which of the multiple areas and diameters to use. To calculate the force of any stage, you must decide which area will be substituted into the formulas. This area is determined by the placement of the seals that describe the boundaries of the area. For example: the extend area of a double acting stage is determined by the seals on the pistons. Thus, the appropriate area would be calculated from the internal diameter of the next larger stage. On retraction, the area of any double acting stage is the difference between that stage's outside diameter and the inside diameter of the next larger stage.

Designers must remember that the extend area for each stage is different, so the extend force for each stage also is different. The differences in areas mean that in an application with a constant displacement pump supplying the hydraulic system, each stage will move at a different speed. This speed difference for each stage also holds true during retraction of double acting telescopic cylinders because each stage's retract area is different.

In both types of telescopic cylinders, the smallest stage determines the force capacity of the cylinder. This stage will usually have the smallest extend and retract area. During extension, this stage will generate the cylinder's minimum force; during retraction, this stage normally generates the maximum force. A double acting telescopic cylinder can exert no more retraction force than the smallest retract area provides.

After determining the effective diameter of each stage, volume can be approximated by dividing stroke by the number of stages and multiplying the quotient by each effective area. The sum of these volumes equals the approximate volume of oil to extend the cylinder. Reservoir volume should equal the cylinder's extended volume plus an initial volume of oil to fill the fully retracted cylinder and an adequate reserve for make-up oil.

Pump capacity is determined by applying the formula for speed to solve for Q (flow rate, gpm) in each stage. Inlet porting at the cylinder must be sized to accommodate the required flow for a given extension speed.

Special Design Considerations
Designers should never treat the telescopic cylinders as structural members. These cylinders should be used to generate work forces - not to stabilize the structure. They should be considered no more rigid than the columns of oil they contain. Telescopic cylinders should always have mechanical support members.

Fully extended, long stroke telescopic cylinders can become very long, slender columns, making them susceptible to buckling. The structure of a telescopic cylinder can be considered as special as a stepped column with different diameter elements, each having a different moment of inertia. Additional overlap can help stabilize such a cylinder, but more overlap increases collapsed length as well as overall column length. Sometimes a cylinder diameter larger than required for the load may be needed to keep the cylinder safe under column loading.

As stated earlier, single acting telescopic cylinders are extended by pressure and retracted by gravity or an external force. The extend speed is determined by the pump flow and flow capacity of the control valve. The retract speed is a function of the load on the cylinder and the ability of the hydraulic fluid to return to tank. Retraction speed can be controlled by metering return oil flow through the control valve. Light loads and restricted flow slow down the retraction stroke. Most single acting telescopic cylinders will not retract under their own weight. This is a result of several variables, including friction of the internal seals, attitude of the cylinder, and the type of mounting. A rigid mount with a low attitude may cause enough binding so that light loads cannot force the cylinder to retract.

As with any type of cylinder, heavy side loads should be avoided. Because of telescopic cylinder's multiple moving stages, side loading can cause internal binding that could result in mis-staging and possible stalling of the cylinder's movement. Because the overlap of each successive stage must be designed and manufactured with running and machining tolerances, these areas can act like hinges, allowing some movement. Longer overlap helps limit this movement, but cannot eliminate it. This is a complicated engineering design situation: the longer the overlap, the longer the cylinder's collapsed length.

Flow, Pressure Control

A three-way, three-position valve can provide raise, lower and hold control for a single acting cylinder. Retraction speed of single acting cylinders may be controlled by manually metering flow through the valve's return port. As an alternative, some systems use an orifice in the return line, valve, or cylinder port that is sized to limit flow and, thus, limit retraction speed.

Four-way, three-position valving is needed to perform the same control functions on double acting types. The additional pathway provides a route to tank for oil displaced from the plunger end.

Dealing with Intensification

Due to its construction, double acting telescopic cylinders will act as pressure intensifiers during extension and flow multipliers during retraction. These two phenomenon are directly related to the large difference in effective area between the extend and retract side of each stage piston. This ratio can be as high as 10:1, or even greater. During extension of a double acting telescopic cylinder, hydraulic oil is pumped into the extend port and exhausted out the retract port. If exhaust flow is impeded or restricted, the retract side of the cylinder can be pressurized to a level equal to the extend pressure multiplied by the differential area ratio. A dead block of exhaust flow can produce pressures high enough to destroy the cylinder. If any type of holding or check valve is installed in the retract line or on the retract port, the pressure intensification phenomenon can become dangerous. In the case of a 10:1 stage, a 2000 psi main pressure would result in an intermediate plunger pressure of 20,000 psi if the flow from the plunger is blocked. A similar, though less hazardous condition often results when the plunger side outlet line is reduced for design reasons or as the result of clogging or misconnection. The circuit must be designed so that these valves open before (or simultaneously with) the application of extend pressure to the cylinder.

When a double acting cylinder retracts, the opposite occurs. Oil is pumped into the retract port and exhausted through the extend port. The exhaust flow will be equal to the retract flow multiplied by the differential area ratio. With a 10:1 ratio, a 20-gpm retract flow becomes a 200-gpm exhaust flow. If the extend lines or valves are too small and flow is restricted, backpressure can occur in the cylinder to slow the retract speed. If the backpressure equals the pump's retract pressure, the cylinder will stall and not retract.

Telescopic cylinder manufacturers attempt to size the ports to eliminate or reduce the potential for this phenomenon, but designers should size other components in the hydraulic circuit with this in mind. Most problems relating to these phenomenon result from increasing pump flow or downsizing lines, connectors, or control valves after the cylinder has been specified for operation with larger components.

Seal Bypass

Piston seals in double acting telescopic cylinders normally are manufactured from a hard substance, such as cast iron, ductile iron, or glass reinforced nylon. Hard seals are needed to resist abrasion when the seals slide across the transfer holes. However, these seals are not as efficient as soft urethane or rubber seals, so small amounts of oil can bypass them. This bypass flow actually can cause a cylinder to stall if pump flow is less than the seal's allowable leakage rate. This may become a problem if the cylinder is required to stroke at low speeds. Consequently, loading should be limited to a level slightly below the cylinder's rated force at a given pressure, and a minimum flow rate of 15 GPM is recommended for operation.

Bypass leakage also can allow a cylinder to drift in either direction while holding a load. Drift is extremely hazardous if the cylinder is holding a load on the retract area. If a piston drifts past the internal transfer holes in a stage, the retract oil will rapidly transfer to the extend area - causing the cylinder to extend abruptly. This is possible because the retract oil volume is less than the extend volume, due to the large differential area ratio. Therefore, a double acting telescoping cylinder should not be expected to hold a load on retraction.

Summary

It should now be evident that specifying telescoping cylinders requires knowledge beyond that of conventional cylinders. The best insurance to guard against unforeseen problems, especially for those lacking familiarity with telescoping cylinders, is to draw from the experience of manufacturer's application engineers.

Parker has the engineering expertise to alter telescopic cylinder designs to suit a variety of special application considerations. Our application engineers are available to provide assistance in selecting or designing the right cylinder for your specific application, and advising about circuitry to operate it safely and efficiently.

Single Acting "S" Series, Single & Multiple Stage Cylinders

Sleeve or Plunger O.D. (inches)	Effective Area (sq. inches)	Load Capacity (lbs) @ 2000 p.s.i.	Displacement per inch of stroke (gallons)
1.75	2.41	4,811	0.010
2.75	5.94	11,880	0.026
3.75	11.04	22,089	0.048
4.75	17.72	35,441	0.077
5.75	25.97	51,935	0.112
6.75	35.78	71,570	0.155
7.90	49.02	98,034	0.212
9.38	69.03	138,059	0.299
10.75	90.76	181,526	0.393
12.50	122.72	245,438	0.531
14.00	153.94	307,877	0.666

Double Acting "SD" Series, Multiple Stage Cylinders

Sleeve or Plunger O.D. (inches)	Bore of Main or Sleeve (inches)	Effective Area (sq. inches) to Extend	Effective Area (sq. inches) to Retract	Load Capacity (lbs) @ 2000 PSI Extending	Load Capacity (lbs) @ 2000 PSI Retracting	Displacement per inch of Stroke (gallons)* to Extend	Displacement per inch of Stroke (gallons)* to Retract
1.75	2,25	3.98	1.57	7,952	3,142	0.017	0.007
2.75	3.25	8.29	2.35	16,592	4,712	0.036	0.010
3.75	4.25	14.18	3.14	28,372	6,283	0.061	0.014
4.75	5.25	21.64	3.92	43,296	7,854	0.094	0.017
5.75	6.25	30.68	4.71	61,360	9,426	0.133	0.020
6.75	7.25	41.28	5.49	82,564	10,994	0.179	0.024
7.90	8.44	55.68	6.97	111,360	13,946	0.242	0.030
9.38	9.88	76.59	7.56	153,180	15,120	0.332	0.033
10.75	11.50	103.87	13.11	207,738	26,213	0.450	0.057
12.50	13.00	132.73	10.01	265,465	20,028	0.575	0.043
14.00	14.50	165.13	11.19	330,261	22,384	0.715	0.048

Welded Rod Cylinder - Theoretical Push Forces for Cylinders

Cylinder Bore Ø	Piston Area (In.^{2})	Cylinder Push Stroke Force in Pounds at Various Pressures (psi)						
		100	250	500	1000	1500	2000	3000
1.50	1.77	177	443	885	1770	2651	3540	5310
2.00	3.14	314	785	1570	3140	4712	6280	9420
2.50	4.91	491	1228	2455	4910	7363	9820	14730
3.25	8.30	830	2075	4150	8300	12444	16600	24900
4.00	12.57	1257	3143	6285	12570	18850	25140	37710
5.00	19.64	1964	4910	9820	19640	29453	39280	58920
6.00	28.27	2827	7068	14135	28270	42412	56540	84810
7.00	38.49	3849	9623	19245	38490	57727	76980	115470
8.00	50.27	5027	12568	25135	50270	75398	100540	150810

Welded Rod Cylinder - Theoretical Pull Forces for Cylinders

Cylinder Bore Ø	Piston Rod Ø	Piston Rod Area (In.^{2})	Cylinder Pull Force in Pounds at Various Pressures (psi)						
			100	250	500	1000	1500	2000	3000
1.50	0.625	0.307	146	365	730	1460	2190	2920	4380
	1.000	0.785	98	245	491	982	1473	1964	2946
2.00	1.000	0.785	236	589	1178	2355	3533	4710	7065
	1.375	1.480	166	414	828	1655	2483	3310	4965
2.50	1.000	0.785	413	1031	2063	4125	6188	8250	12375
	1.375	1.480	343	856	1713	3425	5138	6850	10275
	1.750	2.410	250	625	1250	2500	3750	5000	7500
3.25	1.375	1.480	682	1704	3408	6815	10223	13630	20445
	1.750	2.410	589	1473	2945	5890	8835	11780	17670
	2.000	3.140	516	1290	2580	5160	7740	10320	15480
4.00	1.750	2.410	1016	2540	5080	10160	15240	20320	30480
	2.000	3.140	943	2358	4715	9430	14145	18860	28290
	2.500	4.910	766	1915	3830	7660	11490	15320	22980
5.00	2.000	3.140	1650	4125	8250	16500	24750	33000	49500
	2.500	4.910	1473	3683	7365	14730	22095	29460	44190
	3.000	7.070	1257	3143	6285	12570	18855	25140	37710
	3.500	9.620	1002	2505	5010	10020	15030	20040	30060
6.00	2.500	4.910	2336	5840	11680	23360	35040	46720	70080
	3.000	7.070	2120	5300	10600	21200	31800	42400	63600
	3.500	9.620	1865	4663	9325	18650	27975	37300	55950
	4.000	12.570	1570	3925	7850	15700	23550	31400	47100
7.00	3.000	7.070	3142	7855	15710	31420	47130	62840	94260
	3.500	9.620	2887	7218	14435	28870	43305	57740	86610
	4.000	12.570	2592	6480	12960	25920	38880	51840	77760
	4.500	15.900	2259	5648	11295	22590	33885	45180	67770
	5.000	19.630	1886	4715	9430	18860	28290	37720	56580
8.00	3.500	9.620	4065	10163	20325	40650	60975	81300	121950
	4.000	12.570	3770	9425	18850	37700	56550	75400	113100
	4.500	15.900	3437	8593	17185	34370	51555	68740	103110
	5.000	19.630	3064	7660	15320	30640	45960	61280	91920
	5.500	23.760	2651	6628	13255	26510	39765	53020	79530

Formulas

Cylinder Formulas
Thrust or force of any cylinder:

F = A x P
P = F ÷ A
A = F ÷ P

F = Force or thrust, in pounds
A = Piston area in square inches (.7854 x D^2)
P = PSI (Gauge pressure in pounds per square inch)

HP = Pounds of push (or pull) x Distance (in feet) / 550 x Time (in seconds)

$$HP = \frac{\text{Pounds of push (or pull) x Distance (in feet)}}{550 \text{ x Time (in seconds)}}$$

HP = Horsepower

Circle Formula:
A = D x D x .7854
A = D^2 x 0.7854
A = π x R^2
A = π x D^2 ÷ 4

Circumference = 2 x R x π
Circumference = π x D

D = $\sqrt{A/.7854}$

A = Area in^2 (Area sq. in.)
R = Radius (1/2 of Diameter)
D = Diameter in inches
π = 3.14

Hydraulic Cylinder Piston travel speed:
V1 (in/min) = CIM ÷ A
V2 (ft/min) = Q x 19.25 ÷ A
V3 (ft/sec) = Q x 0.3208 ÷ A
Q (GPM) = 3.117 x V3 (ft/sec) x A
Q (GPM) = CIM ÷ 231

V1 = Velocity or piston travel speed, inches per minute
V2 = Velocity or piston travel speed, feet per minute
V3 = Velocity or piston travel speed, feet per second
CIM = Flow rate in cubic inches per minute (in^3)
A = Effective area in square inches (in^2)
Q = GPM Gallons per minute
1 Gallon = 231 in^3 (cubic inch)

Volume required to move a piston a given distance:
V = A x L

V = Volume in cubic inches (in^3)
A = Area in square inches (in^2)
L = Length or stroke in inches

Regenerative Cylinder
Extend Speed = Rod Volume ÷ Flow Rate in^3

Area to Retract = Area to extend - Rod Area

Cylinder Ratio = Area to extend ÷ Area to retract

Note:
Ratio can be used to calculate pressure intensification and flow intensification.

Effective force of a cylinder working at an angle to direction of the load travel:
F = T x sin A

T = Total cylinder force, in pounds
F = Part of the force which is effective, in pounds
A = Least angle, in degrees, between cylinder axis and load direction.

Moment Arm Equations / Levers:
F x Df = W x Dw
F = W x Dw ÷ Df^W
W = F x Df ÷ Dw
Df = W ÷ F x Dw
Dw = F ÷ W x Df

F = Cylinder force
Df = Cylinder force distance to pivot
W = Weight or Load Force
Dw = Weight or Load Force distance to pivot

Toggle Force:
T = F x A ÷ 2 x B

T = Toggle Force
F = Cylinder Force
A = Distance cylinder centerline to toggle
B = Remaining stroke

Force for piercing or shearing sheet metal:
F = P x T x PSI

F = Force required, in pounds
P = Perimeter around area to be sheared, in inches
T = Sheet thickness in inches
PSI = Sheer strength rating of the material in pounds per square inch.

P.O. Check Application:

$$\text{Release PSI} = \frac{\text{Cap End Area x Max. W.P. - Load}}{\text{Rod End Area}}$$

Max. W.P. = Pressure Rating of Components

$$\text{Ratio} = \frac{\text{Max Working PSI}}{\text{Release PSI}}$$

Example;
2 to 1 Ratio = 1 square inch (in^2) at 1000 psi working pressure will open when a Release pressure of 500 psi is applied to a 2 square inches (in^2) area.

Formulas

Hydraulic Pump Equations

Horsepower Required to Drive Hydraulic Pump:
HP = PSI x GPM ÷ 1714
HP = (PSI x GPM) ÷ (1714 x EFFICIENCY)

HP = Horsepower
PSI = Gauge pressure in pounds per square inch
GPM = Oil flow in gallons per minute
EFFICIENCY = Efficiency of hydraulic pump

Important:
As all systems are less than 10% efficient an efficiency factor must be added to the calculated input horsepower.

Example:
Input hp = 10 gpm x 1500 psi ÷ 1714 (constant) = 8.75 hp x 0.85 (efficiency) = required input 10 hp

Rule of thumb:
For every 1 HP of drive, the equivalent of 1 GPM @ 1500 PSI can be produced.

Rule of thumb:
To idle a pump when it is unloaded will require about 5% of its full rated horsepower.

Note:
1 hp = 33,000 ft lbs per min or 33,000 lbs raised 1 ft in 1 min
1 hp = 550 ft. lbs. per second
1 hp = 746 Watts or 0.746 kw
1 hp = 42.4 Btu per min
1 hp = 2545 Btu per hour
BTU = The energy to raise one pound of water one degree Fahrenheit.

Flow Formulas:
GPM (theoretical) = RPM x CIR ÷ 231

GPM = Oil flow in gallons per minute
CIR = Cubic Inch (in3) per Revolution
RPM = Pump revolutions per minute

$$\textbf{Volume required (gpm)} = \frac{\textbf{Volume Displaced x 60}}{\textbf{Time (s) x 231}}$$

$$\textbf{Flow rate (gpm)} = \frac{\textbf{Velocity (ft/s) x Area (in2)}}{\textbf{0.3208}}$$

Note:
Fluid is pushed or drawn into a pump
Pumps do not pump pressure, their purpose is to create flow. (Pressure is a result of resistance to flow).

Torque and horsepower relations:
T = HP x 63025 ÷ RPM
HP = T x RPM ÷ 63025
RPM = HP x 63025 ÷ T

T = Torque, inch-lbs
RPM = Speed, revs / minute
HP = Horsepower

Note:
For Torque in foot-lbs use 5252 in place of 63025

Note:
Work (in lbs) = force (lbs) x distance (in)

Power = Force x Distance ÷ Time

Theoretical Pressure = T x 6.28 ÷ CIR

T = Torque, inch-lbs
CIR = Cubic Inch (in^3) per Revolution

Pump Efficiencies:

$$\textbf{Volumetric Efficiency} = \frac{\textbf{Actual GPM x 100}}{\textbf{Theoretical Flow}}$$

$$\textbf{Mechanical Efficiency} = \frac{\textbf{Actual PSI x 100}}{\textbf{Theoretical Pressure}}$$

$$\textbf{Overall Efficiency} = \frac{\textbf{Output HP x 100}}{\textbf{Input HP}}$$

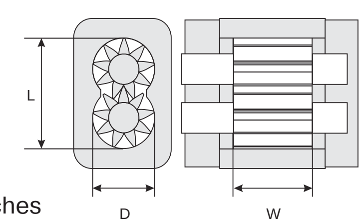
Overall Efficiency = Mech. Eff. x Volumetric Eff.

Theoretical Flow = RPM x CIR ÷ 231
Theoretical Pressure = T x 6.28 ÷ CIR
Input HP = PSI x GPM ÷ 1714
Output HP = T x RPM ÷ 63025

T = Torque, inch-lbs
CIR = Cubic Inch (in^3) per Revolution
GPM = Flow in gallons per minute
PSI = Gauge pressure in pounds per square inch
RPM = Pump revolutions per minute

Gear Displacement Calculation:
The volumetric displacement of a gear pump or motor can be approximated by measurement of the internal parts and substituting the values in the following formula:

V = 6.03 × W × (2 x D -L) × (L - D ÷ 2)



Where
V = displacement in in^3/rev
W = gear width in inches
D = gear tip diameter in inches
L = dimension across both gears when meshed in inches

Hydraulic Motor Equations

Note: Hydraulic motors are typically classified as high speed motors (500 - 10,000 rpm) or low speed motors (0 - 1,000 rpm).

Relationship between displacement and torque of a hydraulic motor:
T = HP x 63025 ÷ RPM
HP = T x RPM ÷ 63205
RPM = HP x 63025 ÷ T

Note:
For Torque in foot-lbs use 5252 in place of 63025

T = CIR x PSI ÷ 6.28
CIR = T ÷ PSI x 6.28
PSI = T x 6.28 ÷ CIR

T = (GPM x PSI x 36.77) ÷ 6.28
GPM = (T ÷ PSI ÷ 36.77) x 6.28
PSI = (T ÷ GPM ÷ 36.77) x 6.28

Note:
Divide PSI by Mechanical Efficiency if required. For Torque in foot-lbs use 75.36 in place of 6.28

T = Torque, inch-lbs
CIR = Cubic Inch (in^3) per Revolution
GPM = Flow in gallons per minute
PSI = Pressure difference across motor
RPM = Pump revolutions per minute
HP = Horsepower

Torque General Info:
Torque = Radius x Load

Torque (in-lbs) = Lever Length (in.) x Pull (lbs)

Radius = 1/2 of Diameter

Circumference = 3.14 x Diameter

Foot Pound = in-lbs ÷ 12

Inch Pound = ft-lbs x 12

Motor Speed:
GPM = RPM x CID ÷ 231
RPM = GPM x 231 ÷ CID
CID = GPM ÷ RPM x 231

Speed = (336 x MPH) ÷ Wheel Diameter (in.)

Side load on pump or motor shaft:
F = (HP x 63024) ÷ (RPM x R)

F = Side load, in pounds, against shaft
R = Pitch radius of sheave on pump shaft, in inches
HP = Driving power applied to shaft.

Torque and horsepower relations:

Volumetric Efficiency = Actual Speed x 100 / Theoretical Speed

Mechanical Efficiency = Actual Torque x 100 / Theoretical Torque

Overall Efficiency = Output HP x 100 / Input HP

Overall Efficiency = Mech. Eff. x Volumetric Eff.

Theoretical Speed = GPM x 231 ÷ CIR
Theoretical Torque (in lbs) = CIR x PSI ÷ 6.28
Input HP = PSI x GPM ÷ 1714
Output HP = T x RPM ÷ 63025

T = Torque, inch-lbs
CIR = Cubic Inch (in3) per Revolution
GPM = Flow in gallons per minute
PSI = Pressure difference across motor
RPM = Pump revolutions per minute

Note:
For Torque in foot-lbs use 5252 in place of 63025

Draw Bar Pull, Moving a load up an incline:
F = L x sin

F = Force
W = Weight or load
sin = Sin of incline or angle

Rule of thumb:
Grades less than or equal to 100 use the degree of the angle. Grades greater than 100 use sin.

Grade (% of Slope) = Rise ÷ Run

Draw Bar Pull, Friction:
F = W x M

F = Force
W = Weight or load
M = Coefficient of friction

Draw Bar Pull, Moving a load up an incline with friction:
F to move load = (W x sin) + (W x cos x M)
F to hold load = (W x sin) - (W x cos x M)

F = Force
W = Weight or load
M = Coefficient of friction
sin = Sin of incline or angle
cos = Cosine of incline or angle

Formulas

Velocity of oil flow in pipe:
V = GPM x 0.3208 ÷ A
A = GPM x 0.3208 ÷ V
GPM = A x V ÷ 0.3208

V = Oil velocity in feet per second
GPM = Flow in gallons per minute
A = Inside area of pipe in square inches.

Rule of thumb:
Pump suction lines 2 to 4 fps
Pressure lines up to 500 PSI - 10 to 15 fps
Pressure lines 500 to 3000 PSI - 15 to 20 fps Pressure lines over 3000 PSI - 25 fps
All oil lines in air-over-oil system - 4 fps
fps = feet per second

Barlow formula (hoop stress):
P = 2 x t x S ÷ D

P = Working pressure in PSI with a 4:1 Design Factor
t = Wall thickness, in inches
S = Allowable stress (12,500 with a 4:1 Design Factor)
D = Outside diameter in inches.
D = $\sqrt{A/.7854}$

Atmosphere:
Atmospheric pressure is 14.7 psi at sea level
One Bar is equal to 14.5 psi (Atmos. - 1.01 Bar)
The pressure created by one foot of water is .433 psi

Atmospheric Ratio = 14.7 ÷ PSI = 33.9 ÷ (X)

Atmospheric will lift water 33.9 feet
1 inch Hg = .491 psi
14.7 psi = 29.92 hg
Y inch Hg Absolute = (29.92 - Y) x .491 = PSI
PSI = lbs ÷ in2
Hg = Inches of mercury

Filtration:
1 Micron = .000039”
149 Micron = 100 Mesh
74 Micron = 200 Mesh
44 Micron = 325 Mesh
Beta 75 = 98.7%
Beta 100 = 99%
Beta 200 = 99.5%Gas

Beta Ratio = Upstream Count ÷ Downstream Count

Efficiency Percent (%) = 1 - (1 ÷ Beta Ratio) x 100

Gas Formulas:
PSIG (PSI Gage) = PSIA - 14.7
PSIA (PSI Absolute) = PSIG + 14.7

Isothermal (Boyle’s Law for behavior of Gases)

$\mathbf{P_1 \times V_1 = P_2 \times V_2}$

P_1 = Pre-charge Pressure + 14.7
V_1 = Initial Gas Volume
P_2 = System Pressure + 14,7
V_2 = Compressed Gas Volume

P_1 and V_1 are initial pressure and volume; P_2 and V_2 are final conditions.

Note:
Isothermal operation occurs when compression or expansion is slow enough to allow transfer of heat out of or into the accumulator.

Adiabatic
$\mathbf{P_1 \times V_1 \times T_2 = P_2 \times V_2 \times T_1}$
$\mathbf{P_1 \times V_1 \div T_1 = P_2 \times V_2 \div T_2}$

P_1 = Pre-charge Pressure + 14.7
V_1 = Initial Gas Volume
P_2 = System Pressure + 14.7
V_2 = Compressed Gas Volume
T_1 = Initial Temp. Absolute (Rankine)
T_2 = Increased Temp. Absolute (Rankine)
T_1, P_1 and V_1 are initial temperature, pressure and volume
T_2, P_2 and V_2 are final conditions.

Note:
Adiabatic operation occurs when compression or expansion is rapid so that there is no transfer of heat. The adiabatic equation is used where compression or expansion occurs in less than 1 minute.

Rule of thumb:
Compressibility of hydraulic oil: Volume reduction is approximately 0.5% for every 1000 PSI pressure. Compressibility of water: Volume reduction is about 0.3% for every 1000 PSI pressure.

Rankine = Fahrenheit + 460
Kelvin = Celsius + 278

Celsius to Fahrenheit = (C + 17.78) x 1.8 = Fahrenheit
Fahrenheit to Celsius = F - 32 ÷ 1.8 = Celsius
Initial Gas Volume - Compressed Gas = Usual Oil

Formulas

Reservoir Cooling:
HP Radiated = Sq. Ft. x TD ÷ 1000
Sq. Ft. = HP x 1000 ÷ TD
TD = HP x 1000 ÷ Sq. Ft.

HP = Power radiating capacity expressed in horsepower Sq. Ft. = Surface area, in square feet
TD = Temperature difference (Delta) in °F between oil and surrounding air.

If the tank is half full, divide the answer by 2.
If the tank is stainless steel (CRES), divide the answer by 2.
If the tank is aluminum, multiply the answer by 2.8.

1 HP = 2545 BTU
1 HP = 746 Watts
BTU = the energy to raise one pound of water one degree Fahrenheit

Rule of thumb:
Each watt will raise the temperature of 1 gallon of oil by 1 °F per hour.

Reservoir Heating:
BTU's to heat a reservoir = Oil volume (ft^3) x 62.4 Specific Heat (.5) x Specific Gravity (.89) Temp. Delta (Differential)

BTU ÷ 2545 = HP per Hour
HP x 746 = Watts

Note:
The following applies to petroleum based hydraulic fluids.

Hydraulic oil serves as a lubricant and is practically non-compressible. It will compress approximately 0.5% at 1000 psi.

The weight of hydraulic oil may vary with a change in viscosity, however, 55 to 58 lbs/ft^3 covers the viscosity range from 150 SUS to 900 SUS @ 100 degrees F.

Pressure at the bottom of a one foot column of oil will be approximately 0.4 psi.

To find the pressure at the bottom of any column of oil, multiply the height in feet by 0.4.

Atmospheric pressure equals 14.7 psia at sea level.

psia (pounds per square inch absolute).

Gauge readings to not include atmospheric pressure unless marked psia.

Energy Formulas:
1 Kw = 1.3 hp
1 hp = 550 ft-lbs/s
Hydraulic hp = gpm x psi ÷ 1714
Torque (in-lbs) = psi x disp. (in^3/rev) ÷ 6.28
Torque (in-lbs) = hp x 63025 ÷ Rpm
hp = Torque (ft-lbs) x rpm ÷ 5252
Btu (per hour) = Δpsi x gpm x 1.5

Formulas in SI Metric Units

Fluid power formulas in English units are shown in the left column. When the industry converts to SI (International) units, these formulas will take the form shown in the right column.

English Units	**Metric Units**
Torque, HP, Speed Relations in Hydraulic Pumps and Motors	
T = HP x 5252 ÷ RPM	**T = Kw x 9543 ÷ RPM**
HP = T x RPM ÷ 5252	**Kw = T x RPM ÷ 9543**
RPM = HP x 5252 ÷ T	**RPM = Kw x 9543 ÷ T**
T = Torque in ft-lbs.	T = Torque, Nm (Newton-meters)
RPM = Speed in revs. min	RPM = Speed, revs/min
HP = Horsepower	Kw = Power in kilowatts
Hydraulic Power Flowing Through the Pipes	
HP = PSI x GPM ÷ 1714	**Kw = Bars x dm3/min ÷ 600**
HP = Horsepower	Kw = Powers in kilowatts
PSI = Gauge pressure in lbs/in^2	Bars = System pressure
GPM = Flow in Gallons per minute	dm^3/min = Flow, cu. dm/minute
Force Developed by an Air or Hydraulic Cylinder	
T = A x PSI	**N = A x Bars x 10**
T = Force or thrust in-lbs.	N = Cylinder force in Newtons
A = Piston area in in^2	A = Piston area, sq. centimeters
PSI = Gauge pressure in lbs/in^2	Bars = Gauge pressure
Travel Speed of a Hydraulic Cylinder Piston	
S = V ÷ A	**S = V ÷ 6A**
S = Travel speed in in/min	S = Travel speed, meter/sec
V = Volume of oil to cylinder in in^3/min	V = Oil flow dm3/minute
A = Piston area in in^2	A = Piston area, square centimeters
Barlow's Formula - Burst Pressure of Pipe & Tubing	
P = 2t x S ÷ O	**P = 2t x S ÷ O**
P = Burst pressure, PSI	P = Burst pressure, bars
t = Pipe wall thickness, inches	t = Pipe wall thickness, mm
S = Tensile str., pipe material, PSI	S = Tensile str., pipe material, bars
O = Outside diameter of pipe, inches	O = Outside diameter of pipe, mm
Velocity of Oil Flow in Hydraulic Lines	
V = GPM x 0.3208 ÷ A	**V = dm3/min ÷ 6A**
V = Velocity, feet per second GPM = Oil flow, gallons/minute	V = Oil velocity, meters/second
A = Inside area of pipe, sq. inches	dm^3/min = Oil flow, cu.dm/minute
	A = Inside area of pipe, sq.cm.
Recommended Maximum Oil Velocity in Hydraulic Lines	
fps = feet per second	mps = meters per second
Pump suction lines - 2 to 4 fps	Pump suction lines - .6 to 1.2 mps
Pres. lines to 500 PSI - 10 to 15 fps	Pres. lines to 350 bar - 3 to 4½ mps
Pres. lines to 3000 PSI - 15 to 20 fps	Pres. lines to 200 bar - 4½ to 6 mps
Pres. lines over 3000 PSI - 25 fps	Pres. lines over 200 bar - 7½ mps
Oil lines in air/oil system - 4 fps	Oil lines in air/oil system - 1¼ mps

Formulas in SI Metric Units

LENGTH
1 micron (µ) = 0.00004 inch (in.)
1 millimeter (mm) = 0.039 in.
1 centimeter (cm) = 0.3937 in.
1 decimeter (dm) = 0.3281 foot (ft.) 1 meter (m) = 39.37 in.
= 3.281 ft.
= 1.0937 yards (yds.)

AREA - SQUARE
1 square millimeter = 0.00155 square inch (in^2)
1 square centimeter = 0.155 in^2
1 square decimeter = 15.5 in^2
= 0.10764 square feet (ft^2)

AREA - CUBIC
1 cubic centimeter = 0.061 cubic inch (in^3)
= 0.0002642 U.S. liquid gallons
1 cubic decimeter = 61.023 in.3

LIQUID MEASURE
1 milliliter (ml) = 0.0338176 (oz.)
1 deciliter (dl) = 3.381 (oz.)
1 liter (l) = 1.0569 quarts (qt.)
= 0.26417 gallon (gal.)
1 drop = 0.05 cubic centimeter (cc)
= 0.00169 oz.

WEIGHT
1 gram (g) = 0.0353 ounce (oz.)
1 kilogram (kg.) = 2.2046 pounds (lb.)
1 metric ton = 0.9842 U.S. ton

TEMPERATURE
˚Celsius = 5/9 (˚Fahrenheit - 32)

FLOW - LIQUID
1 liter/minute (lpm) = 0.2642 U.S. gallon/minute (gpm)

FORCE
1 Newton (N) = 0.225 pound (lb.)

FREQUENCY
1 cycle/second (cps) = 1 Hertz (H)

ABSOLUTE VISCOSITY
1 centipoise (@ 0.9 specific gravity) = 5.35 SUS

POWER
1 Kilowatt (kw) = 1.34 horsepower (HP)
1 horsepower (HP) = 33,000 foot-pounds (ft-lbs)/minute
= 550 foot-pounds (ft-lbs)/second
= 42.4 BTU/minute
= 746 watts

PRESSURE
1 bar = 14.5 pounds per square inch (psi) — above atmospheric
= 33.8 foot water column
= 42 foot oil column
= 29.92 inches of mercury (in. Hg)
1 millimeter of mercury (mm Hg) = 0.03937 in. Hg — below atmospheric
1 psi = 2.0416 in. Hg
= 27.71 in. water
1 foot column of water = 0.433 psi
1 foot column of oil = 0.390 psi

TORQUE
1 Newton-meter (Nm) = 8.88 inch-pounds (in-lbs)

VELOCITY
1 meter per second (m/s) = 3.28 feet/second (fps)

Single Acting Telescopic Cylinder

Basic Cylinder Types
As with conventional cylinders, the two basic types of telescopic hydraulic cylinders are single and double acting.

Single acting telescoping cylinders extend under hydraulic pressure and rely on gravity or some external mechanical force for retraction. Single acting cylinders are used in applications where some form of load is always on the cylinders. The classic single acting telescopic applications are dump trucks and dump trailers. Pressurized oil extends the telescopic cylinder to raise one end of the dump body and expel its load. When pressure is released, the weight of the dump body forces oil out of the cylinder and it retracts.

Bleederless Telescopic Cylinders

Customer Unmet Need

Bleeding cylinders is a tough dirty job for the dump truck and trailer industry. No one really wants to bleed the cylinder because it is a dirty, dangerous, and environmentally hazardous job as the mechanic must climb in and out of the dump bed to adjust the bleeder screw. Failure to bleed the cylinder will result in early cylinder failure in addition to cylinder mis-staging, and excessive costly hydraulic repairs.

Solution

Parker has developed a special bleed system that is incorporated into the cylinder that allows air to bleed every time the dump bed goes up and down. This keeps the cylinder free of air and as a result the bleeding of oil and air is eliminated.

Value Added

- Fleets using Parker's high quality cylinders will benefit by saving the labor charges from bleeding cylinders throughout the life time of the Dump Bed. Estimated savings range from $800-$2400

- OEM's save a minimum of 1/2 gallon of hydraulic oil to 4.5 gallons of oil on 8" and 9" cylinders. For a trailer manufacturer selling 500 a year this would save $23,625 a year.

Product Features

- No air to bleed
- No speedy dry to sweep
- No EPA to deal with
- No more climbing into dirty beds
- Fewer hydraulic repairs
- Completely interchangeable with all manufacturers cylinders
- Size Range from 4" to the largest 9" cylinders
- Reduced weight over standard cylinders with bleeder screws

Production Specification and Design Advantages

General Specifications

- Heavy duty service
- Sleeve diameters – 1.75" through 14.00"
- Strokes – 36.00" through 500.00"
- Mounts – standard and custom available
- Nominal pressure – 2,000 psi[1] (140 Bar)
- Standard fluid media – filtered hydraulic oil[2]
- Standard temperature – -40˚F to +200˚F

[1] If hydraulic pressure exceeds 2,000 psi (140 Bar), send application data for engineering evaluation and recommendation.
[2] See Seal Information pages for appropriate seals with different fluid media.

Material Specifications

Cylinder body	High strength carbon steel
Sleeve and plunger	High strength carbon steel
Sleeve v-packing seal	Hytrel+Rubber
Sleeve wiper seal	Polyurethane
Sleeve bearing	Glass Reinforced Nylon

In line with our policy of continuing product improvement, specifications in this catalog are subject to change.

Design Advantages

- Set screws with nylon ball for locking packing nuts.
- Snap-on, glass-filled bearings that absorb contaminants without damaging cylinder walls.
- Threaded steel stop rings for easier servicing and more reliable stopping action.
- Wave springs and chevron packing for self compensating seals.
- Polyurethane sleeve wiper seals that resist higher temperatures without extrusion.
- Adjustable v-packing for low and high pressure sealing.

Hydraulic Cylinder Load and Displacements

"S" Series Single Acting, Single & Multiple Stage Cylinders

Sleeve or Plunger O.D. (inches)	Effective Area (sq. inches)	Load Capacity (lbs) @ 2000 p.s.i.	Displacement per inch of stroke (gallons)
1.75	2.41	4,811	0.010
2.75	5.94	11,880	0.026
3.75	11.04	22,089	0.048
4.75	17.72	35,441	0.077
5.75	25.97	51,935	0.112
6.75	35.78	71,570	0.155
7.90	49.02	98,034	0.212
9.38	69.03	138,059	0.299
10.75	90.76	181,526	0.393
12.50	122.72	245,438	0.531
14.00	153.94	307,877	0.666

To calculate effective area in square inches: Multiply diameter times diameter times .78
Example: 5 dia. x 5 dia. = 25 x .78 = 19.63 in^2 of area

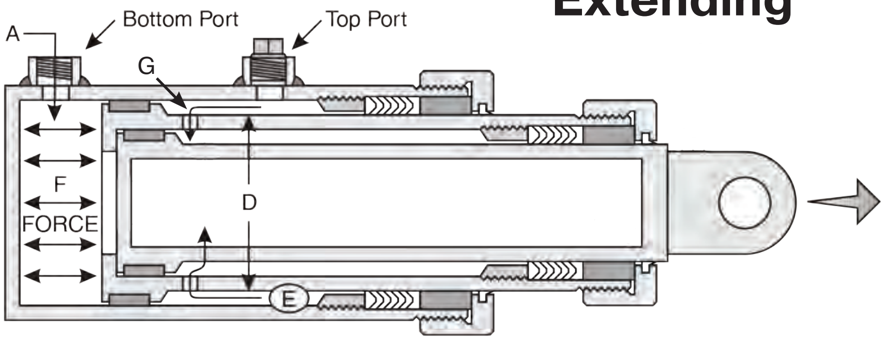
To calculate load capacity / cylinder force: Multiply effective area times operating pressure (psi)
Example: 19.63 in^2 x 1750 P.S.I = 34,361 lbs of force

To calculate the required gallons of fluid to extend a cylinder:
Add each "Displacement per inch of stroke" (from chart) for the required sleeve sizes.
Divide this total by the number of moving sleeves, then multiply that total by the desired cylinder stroke.
Note: The "Gallons required to extend" does not include the necessary fluid to fill an empty cylinder.
Example: Required fluid to extend a S83DC-40-134 single acting telescopic cylinder with following stage sizes:

5.75" O.D.= .112
6.75" O.D.= .155
7.90" O.D.= .212
.479

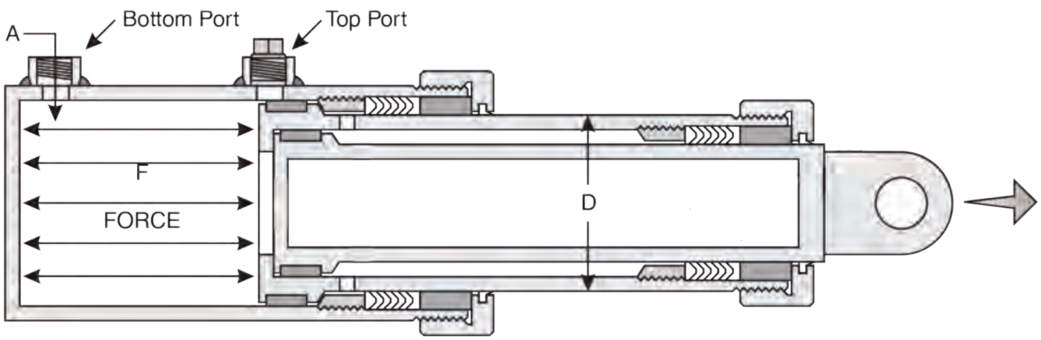
.479 ÷ 3 = .159 gallons per inch of stroke
.159 gallons per inch x 134" of stroke = 21.31 gallons to extend cylinder

Extending



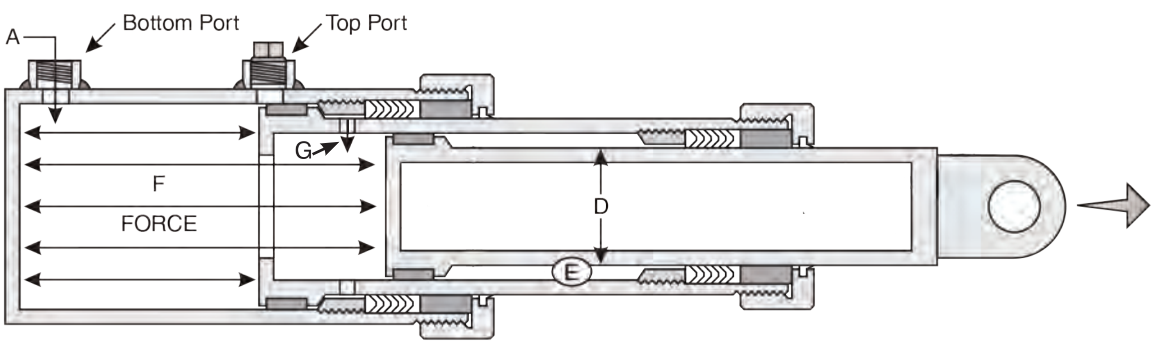
To Extend:
High pressure oil from the pump is directed by the control valve through the port (A) to fill the cylinder.

Generally, bleeding is only necessary on initial start up or if air has been allowed to enter the system (Note: Cycle cylinder 3 times to bleed any air in cylinder.
Oil pushes on the bottom of the sleeve or plunger forcing (F) it to move out. The outside diameter or sealing area of the moving sleeve or plunger (D) determines the effective area.

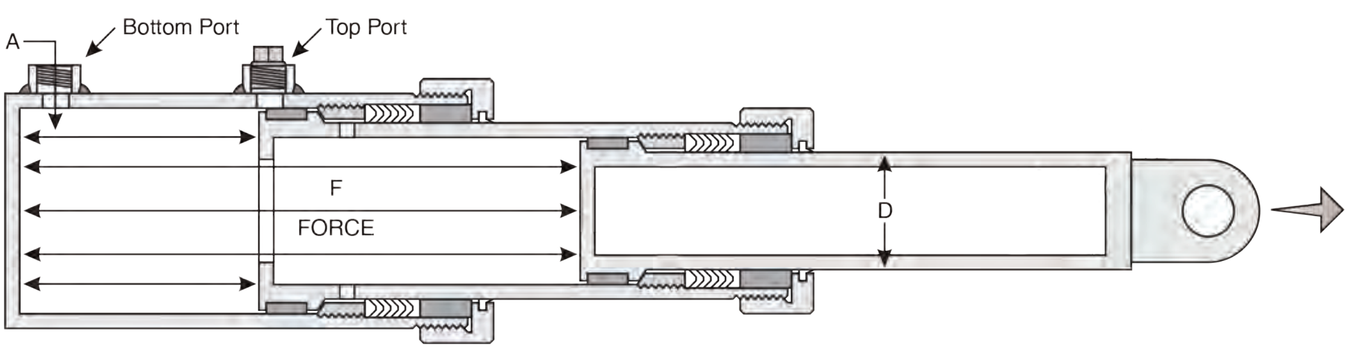


As the sleeve or plunger moves out, the oil trapped between (E) the sleeve or plunger wall is released through transfer holes (G) which are drilled in the sleeve.

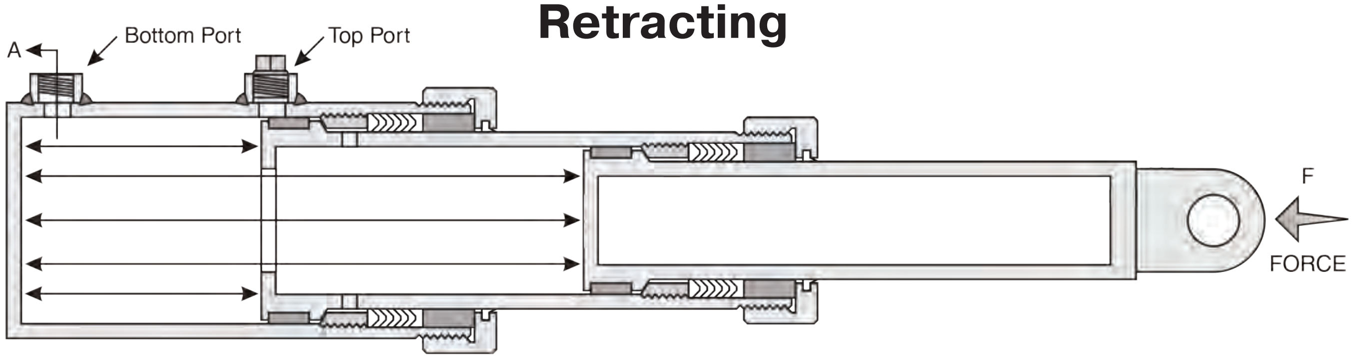
Under normal operating conditions the largest diameter moving sleeve extends first, then the next largest sleeve, etc.



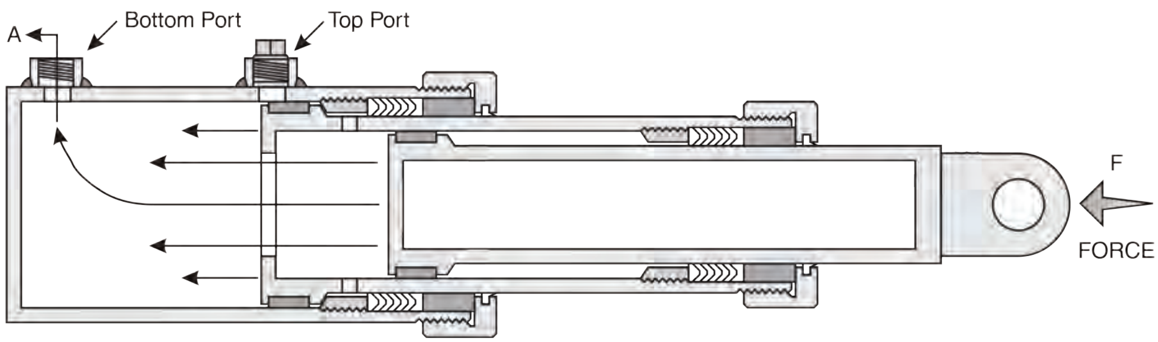
So at a given PSI (pressure) and GPM (gallons per min.) the cylinder will develop less force and increase in speed as it changes to the next moving stage.



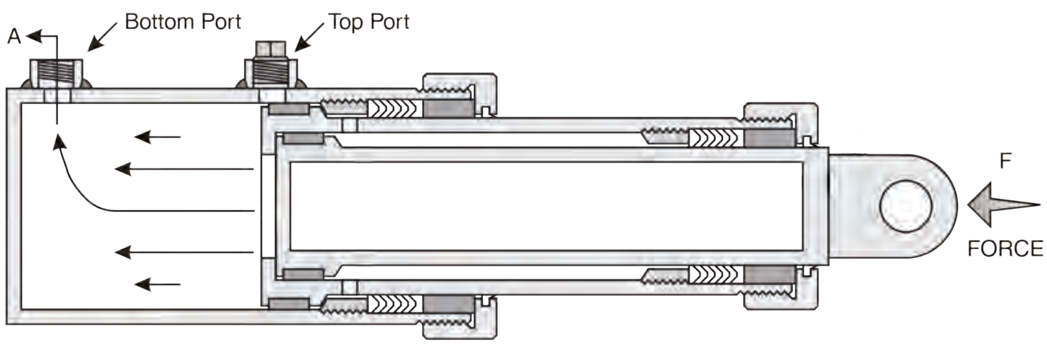
Retracting



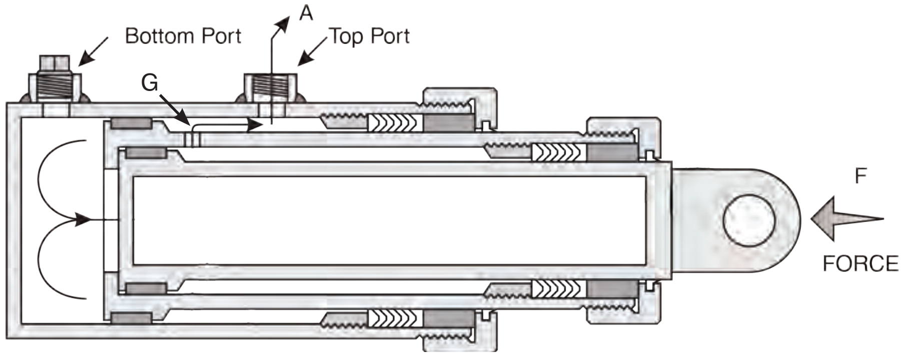
To Retract
A single acting cylinder must be retracted by gravity or mechanical means (F).



Under normal operating conditions the plunger or smallest diameter sleeve is pushed closed first, forcing oil out through port (A), then the next smallest, etc.



Note: If the top port is used, the speed of the cylinder may be reduced because of the oil flow restriction as the oil passes thru the transfer holes (G).



WARNING!
Telescopic cylinders commonly installed on dumping vehicles are devices intended to provide only a lifting force. The cylinder is not a structural member, and is not designed for, nor intended to provide stability to the dumping vehicle. Rollover or lateral tilt can cause the cylinder to bend, bulge or separate causing the dump body to drop suddenly, resulting in severe injury or death and/or damage to the unit and cylinder, if the following warnings are not observed.

Hydraulic cylinders are not to be used as a stabilizer on a dump body or dump trailer. The hydraulic cylinder will not prevent the dump body or trailer from rollover or lateral tilt. The cylinder is strictly a lifting device and is not a structural member of the unit. Cylinders are not to be used as a means of stabilizing the unit.

The hydraulic cylinder mounted in the unit should be free to find its own trajectory line of extension, free of any lateral loading of the plungers. Misalignment of the top or bottom mountings, or mounting pins too tight, may cause scoring of the plungers, leaking, or improper sequencing which could cause the unit to upset.

The hydraulic cylinder will not withstand lateral or side pressure when the unit is leaning. Only activate the cylinder when the tractor and trailer are in a straight line (not jack-knifed). A jackknife position of the tractor with the trailer is not recommended when dumping. In a jackknifed position, the upper coupler pivots on bearings, contributing nothing to dump stability. When the tractor and trailer are straight, the coupler bearings are normally 34 inches apart, assisting in stabilizing the dump.

Do not activate the cylinder while on unlevel or soft ground, or during heavy crosswinds. Doing so may cause the unit to upset. Uneven terrain, causing the trailer wheels to be 3 1/2 inches to 4 inches higher than the other side, puts the top of the body 12 inches to 14 inches off center when the cylinder is fully extended. On fresh fill, loaded trailer wheels may sink on one side, again setting up potential tip over. On road construction, the crown is also critical on spread application, as in dumping on a slope. A 4 inch plus, height differential of wheels on an axle 8 feet wide, is another rollover potential. Do not attempt dumping operations in high gusty wind conditions. If possible, raise the dump body directly into the wind.

A blown tire or a severely under inflated tire can cause dump instability, when dumping. Always check tires visually for cuts or punctures by nails and metal. Make sure all tires are inflated properly. Proper tire inflation also improves wear and fuel economy.

Do not activate the cylinder while personnel or equipment are alongside or behind the dump body or trailer.
A hung load is commodity that does not discharge when a dump body is raised to an elevated position. This condition exists due to surface adhesion between the commodity and the interior of the dump body. To avoid a tip over due to a hung load, the driver should be warned by an observer or be aware of the material's moisture content, if this condition exists, immediately lower the dump body.

The operator should stay at the controls during the entire dumping operation. An operator who fails to stay at the controls will never control the body when it starts to lean over for a tip over. If a problem exists, and the body starts to lean, the operator should immediately lower the dump body or trailer and check and remedy any potential problems, then resume dumping the load. It is important to slowly position the cylinder control valve into the hold position to avoid subjecting the cylinder to a high pressure.

Do not overload the unit. The load must be distributed evenly during loading or unloading to avoid rollover and lateral tilt. Loads stuck while the cylinder is partially or completely extended increases the hazard of rollover and lateral tilt. Lower the dump body or trailer entirely with the cylinder control valve partially open (avoid lowering the dump body or trailer with the cylinder control valve completely open). Then unload the dump body or trailer manually or with an alternative mechanical aid.

Overloading is a very common occurrence that aggravates all the above conditions that cause a tip over.

WARNING!
Shock pressure can cause severe injury or death and/or damage to the unit and cylinder.

Do not use the cylinder to loosen loads stuck in the dump body or trailer. Lower the dump body or trailer entirely with the cylinder control valve partially open (avoid lowering the dump body or trailer with the cylinder control valve completely open). Then unload the dump body or trailer manually or with an alternative mechanical aid.

Humping is a rapid acceleration / deceleration method used to loosen a hung load from a trailer. If the load is off center and the trailer is moved, a tip over may occur. Also, serious damage to the hoist may occur if an extreme humping motion is used to get a sticky load out of the body.

Do not move the truck and jam the brakes while the cylinder is partially or fully extended to loosen loads stuck in the dump body or trailer. 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. Lower the dump body or trailer entirely with the cylinder control valve partially open (avoid lowering the dump body or trailer with the cylinder control valve completely open). Then unload the dump body or trailer manually or with an alternative mechanical aid.

Do not move the truck until the dump body or trailer is lowered completely.

WARNING!
Over pressurizing the cylinder can cause severe injury or death and/or damage to the unit and cylinder.
(Normally 2,000 P.S.I. unless otherwise approved).
Do not operate a cylinder at pressures above factory recommended operating pressures.

WARNING!
Worn or damaged hydraulic hoses can cause severe injury or death and/or damage to the unit and cylinder.
Hydraulic hoses should be checked regularly and replaced if worn out or damaged.

NOTICE!

Do not drive the unit while the P.T.O. or hydraulic pump is engaged.

The hydraulic oil should be checked and changed regularly to avoid contamination leading to internal cylinder damage.

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

Cylinder should be free of entrapped air. It is advisable to bleed air from the cylinder weekly to free entrapped air. This will result in a smoother operation.

The cylinder should float in the pin mountings. The cylinder should be installed with 1/16” to 1/8” of clearance between the pin and the pin hole if the mounting eye is less than 5” wide or with 1/8” to 3/16” clearance if the mounting eye is wider than 5”. There should be a clearance of 1/8” to 1/4” per side on eyes less than 5” wide and 1/4” 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 plunger or one of the sleeves should be extended a minimum of 1/4” when the dump body is in the down position.

Closed Length Calculations for Single Acting, Single & Mutliple Stage Cylinders

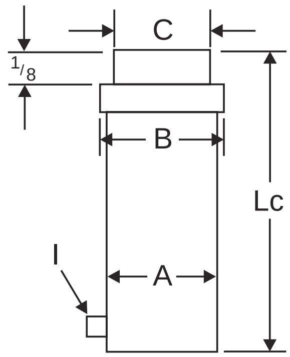
Closed length (Lc) for S Models is computed by one of the three equations below. Model number and stroke required determines which equation to use. Example: To find Lc for S41 cylinder with 68” stroke. Under S41 column, use equation III, because the stroke is over 50”.

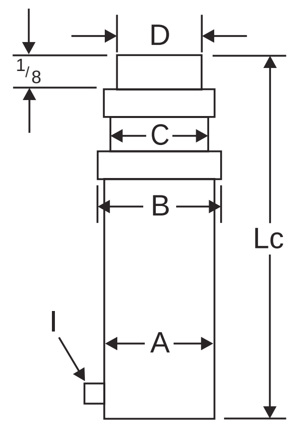
$$Lc = Stroke + X_1 + X_2 = 68” + 7.50” + \frac{(68 - 50)}{10} = 68” + 7.50” + (1.8)$$

Use next largest whole number. = 68” + 7.50” + 2” = 77.50”.

The closed length (Lc) is 77.50”. Add Lc 77.50” to the stroke 68” for extended length of 145.50”

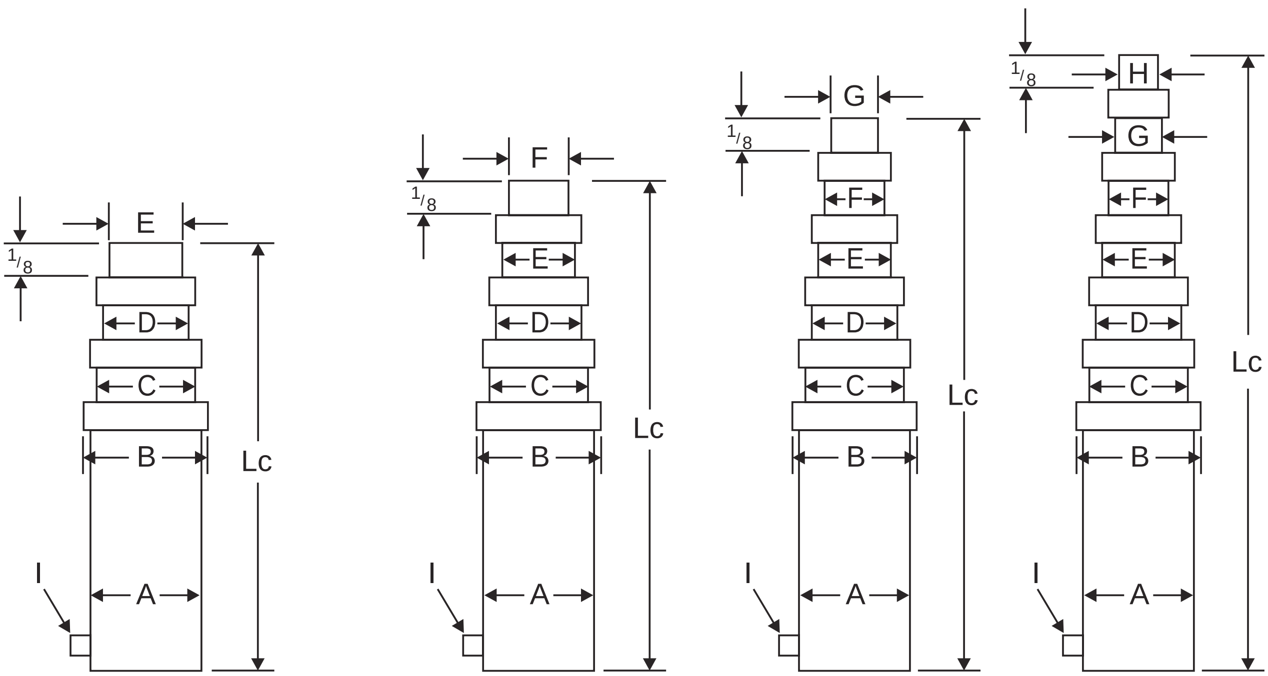
Note - Closed length (LC) does not include end mount dimensions





		SINGLE STAGE								2 STAGE					
Cylinder Dimensions (inches)		S31	S41	S51	S61	S71	S81	S91		S42	S52	S62	S72	S82	S92
Main Cylinder O.D.	A	3 3/4	4 3/4	5 3/4	6 3/4	8	9 1/8	10 13/16	A	4 3/4	5 3/4	6 3/4	8	9 1/8	10 13/16
Largest Packing Nut O.D.	B	4 3/8	5 3/8	6 3/8	7 3/8	8 5/8	9 7/8	11 3/4	B	5 3/8	6 3/8	7 3/8	8 5/8	9 7/8	11 3/4
1st Sleeve O.D.	C	2 3/4	3 3/4	4 3/4	5 3/4	6 3/4	7 7/8	9 3/8	C	3 3/4	4 3/4	5 3/4	6 3/4	7 7/8	9 3/8
2nd Sleeve O.D.	D								D	2 3/4	3 3/4	4 3/4	5 3/4	6 3/4	7 7/8
3rd Sleeve O.D.	E								E						
4th Sleeve O.D.	F								F						
5th Sleeve O.D.	G								G						
6th Sleeve O.D.	H								H						
NPT Port	I	3/4	3/4	3/4	1	1	1 1/4	1 1/4	I	3/4	3/4	1	1	1 1/4	1 1/4
Max. Stroke at 2000 PSI		71	84	88	95	118	128	190		126	137	138	164	186	265
Closed Length - Lc Equation I	X	5.75	5.75	5.75	6.00	6.00	6.50	6.62	X	6.69	6.69	6.94	6.94	7.44	7.56
	L_C	Stroke + X up to 35" stroke O.L. = 1 1/4"							L_C	$\frac{Stroke}{2}$ + X up to 35" stroke O.L. = 1 1/4"					
Equation II	X_1	7.50	7.50	7.50	7.75	7.75	8.25	8.38	X_1	8.44	8.44	8.69	8.69	9.19	9.31
	L_C	Stroke + X_1 36" to 50" stroke O.L. = 3"							L_C	$\frac{Stroke}{2}$ + X_1 36" to 50" stroke O.L. = 3"					
Equation III	X_2	$\frac{Stroke - 50}{10}$ (To next largest whole number)							X_2	$\frac{Stroke - 50}{20}$ (To next largest whole number)					
	L_C	Stroke + X_1 + X_2 over 50" stroke O.L. = 3" + X_2							L_C	$\frac{Stroke}{2}$ + X_1 + X_2 over 50" stroke O.L. = 3" + X_2					

Closed Length Calculations for Single Acting, Single & Mutliple Stage Cylinders



	3 STAGE					4 STAGE					5 STAGE				6 STAGE		
	S53	S63	S73	S83	S93		S64	S74	S84	S94		S75	S85	S95		S86	S96
A	5 3/4	6 3/4	8	9 1/8	10 13/16	A	6 3/4	8	9 1/8	10 13/16	A	8	9 1/8	10 13/16	A	9 1/8	10 13/16
B	6 3/8	7 3/8	8 5/8	9 7/8	11 3/4	B	7 3/8	8 5/8	9 7/8	11 3/4	B	8 5/8	9 7/8	11 3/4	B	9 7/8	11 3/4
C	4 3/4	5 3/4	6 3/4	7 7/8	9 3/8	C	5 3/4	6 3/4	7 7/8	9 3/8	C	6 3/4	7 7/8	9 3/8	C	7 7/8	9 3/8
D	3 3/4	4 3/4	5 3/4	6 3/4	7 7/8	D	4 3/4	5 3/4	6 3/4	7 7/8	D	5 3/4	6 3/4	7 7/8	D	6 3/4	7 7/8
E	2 3/4	3 3/4	4 3/4	5 3/4	6 3/4	E	3 3/4	4 3/4	5 3/4	6 3/4	E	4 3/4	5 3/4	6 3/4	E	5 3/4	6 3/4
F						F	2 3/4	3 3/4	4 3/4	5 3/4	F	3 3/4	4 3/4	5 3/4	F	4 3/4	5 3/4
G						G					G	2 3/4	3 3/4	4 3/4	G	3 3/4	4 3/4
H						H					H				H	2 3/4	3 3/4
I	3/4	1	1	1 1/4	1 1/4	I	1	1	1 1/4	1 1/4	I	1	1 1/4	1 1/4	I	1 1/4	1 1/4
	181	186	204	224	312		238	262	265	352		335	336	410		T.B.A.	T.B.A.
X	7.62	7.88	7.88	8.38	8.50	X	8.81	8.81	9.31	9.44	X	9.75	10.25	10.38	X	11.19	11.31
L_C	$\frac{\text{Stroke}}{3} + X$ O.L. = 1 1/4" up to 50" stroke					L_C	$\frac{\text{Stroke}}{4} + X$ O.L. = 1 1/4" up to 70" stroke				L_C	$\frac{\text{Stroke}}{5} + X$ O.L. = 1 1/4" up to 85" stroke			L_C	$\frac{\text{Stroke}}{6} + X$ O.L. = 1 1/4" up to 100" stroke	
X_1	9.38	9.62	9.62	10.12	10.25	X_1	10.56	10.56	11.06	11.19	X_1	11.50	12.00	12.12	X_1	12.94	13.06
L_C	$\frac{\text{Stroke}}{3} + X_1$ O.L. = 3" 51" to 75" stroke					L_C	$\frac{\text{Stroke}}{4} + X_1$ O.L. = 3" 71" to 100"				L_C	$\frac{\text{Stroke}}{5} + X_1$ O.L. = 3" 86" to 125" stroke			L_C	$\frac{\text{Stroke}}{6} + X_1$ O.L. = 3" 101" to 150" stroke	
X_2	$\frac{\text{Stroke - 75}}{30}$ (To next largest whole number)					X_2	$\frac{\text{Stroke - 100}}{40}$ (To next largest whole number)				X_2	$\frac{\text{Stroke - 125}}{50}$ (To next largest whole number)			X_2	$\frac{\text{Stroke - 150}}{60}$ (To next largest whole number)	
L_C	$\frac{\text{Stroke}}{3} + X_1 + X_2$ O.L. = 3" + X_2 over 75" stroke					L_C	$\frac{\text{Stroke}}{4} + X_1 + X_2$ O.L. = 3" + X_2 over 100" stroke				L_C	$\frac{\text{Stroke}}{5} + X_1 + X_2$ O.L. = 3" + X_2 over 125" stroke			L_C	$\frac{\text{Stroke}}{6} + X_1 + X_2$ O.L. = 3" + X_2 over 150" stroke	

Front Mount Dump Body Stroke & Lifting Calculation

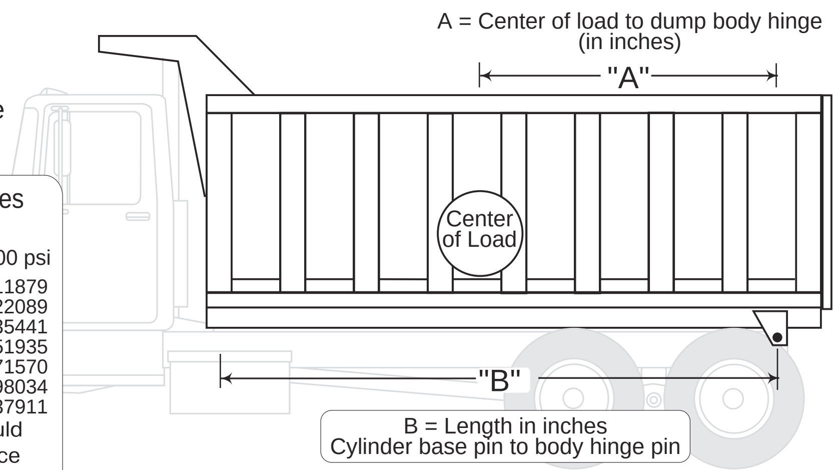
Note: This guide is for use to determine approximate stroke and lifting requirements for a Front Mount Dump Body, they should not be used for Frameless Type Trailers, Underbody, Telescopic Farm (slant forward or rearward), or Scissor Type Hoists. Final dimensions and calculations should be determined by an engineering drawing.

Formula for Calculating Initial Required Cylinder Force to Lift a Load

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

Example

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



Commercial Telescopic Lifting Capacities

Stage O.D. in inches	System operating pressure 800 psi	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

Note: For a good design, initial pressure should not exceed 800 psi at start of lift.Effective force (capacity) is only that of the sleeve / stage which is moving and will decrease as cylinder changes to the next moving sleeve. The effective force will also be reduced if the cylinder is pushing at an angle.

Formula for Calculating the Required Cylinder Stroke for a Dump Angle

"B" X "D" = Approximate Stroke

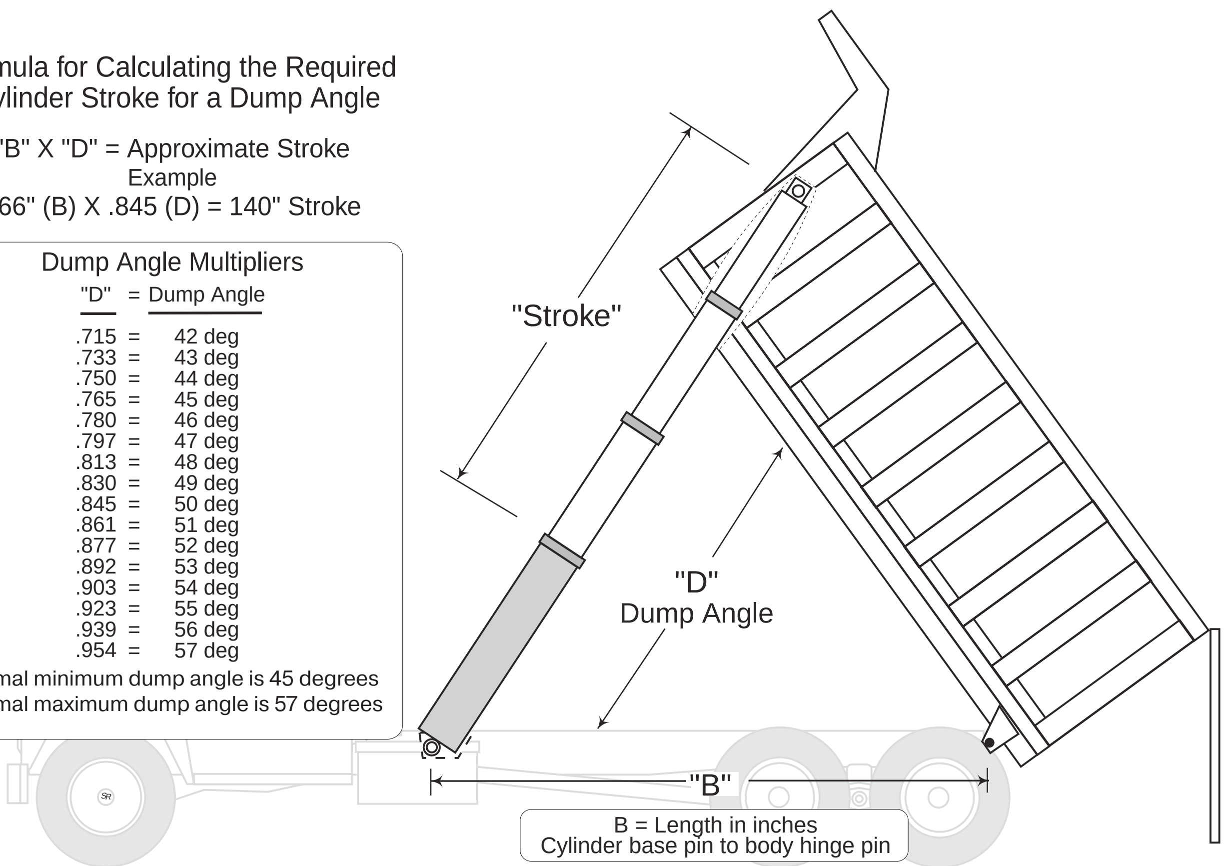
Example

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

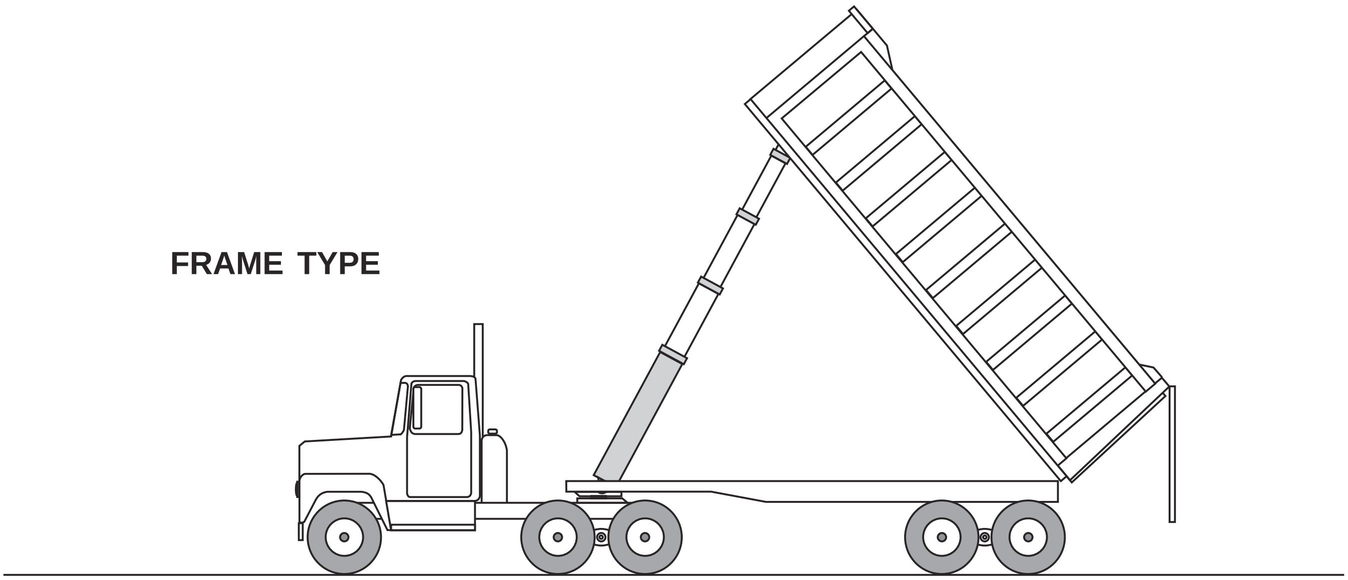
Normal minimum dump angle is 45 degrees
Normal maximum dump angle is 57 degrees



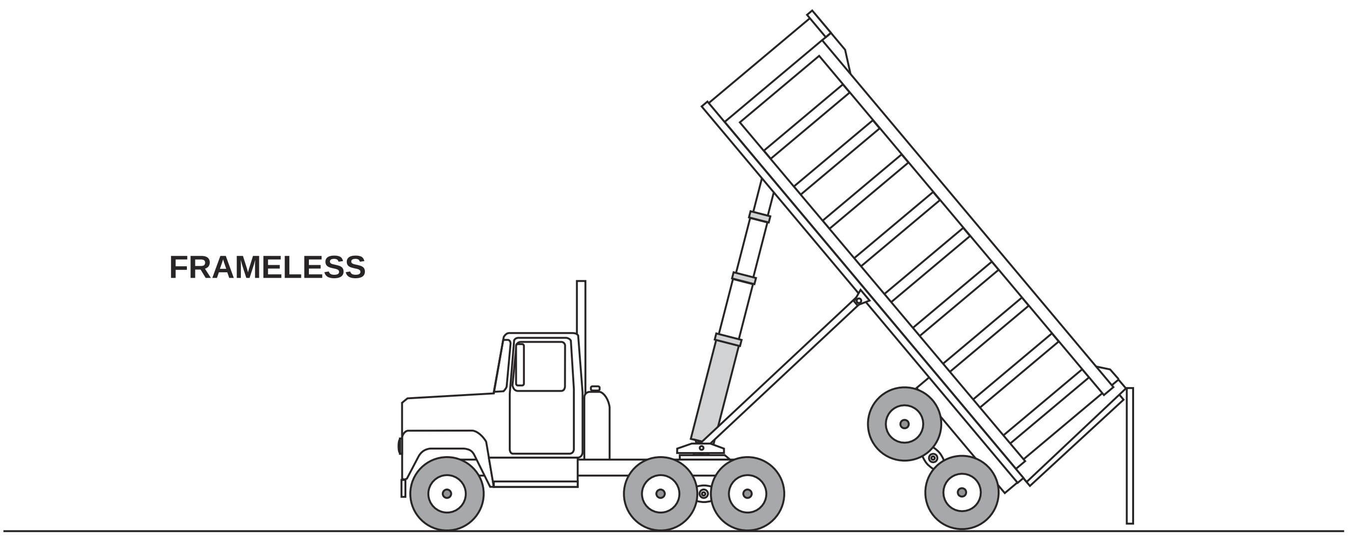
⚠ **PROP 65 WARNING** **WARNING:** This product can expose you to chemicals including **Lead and Lead Compounds** which are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

Dump Trailer Type Identification Chart

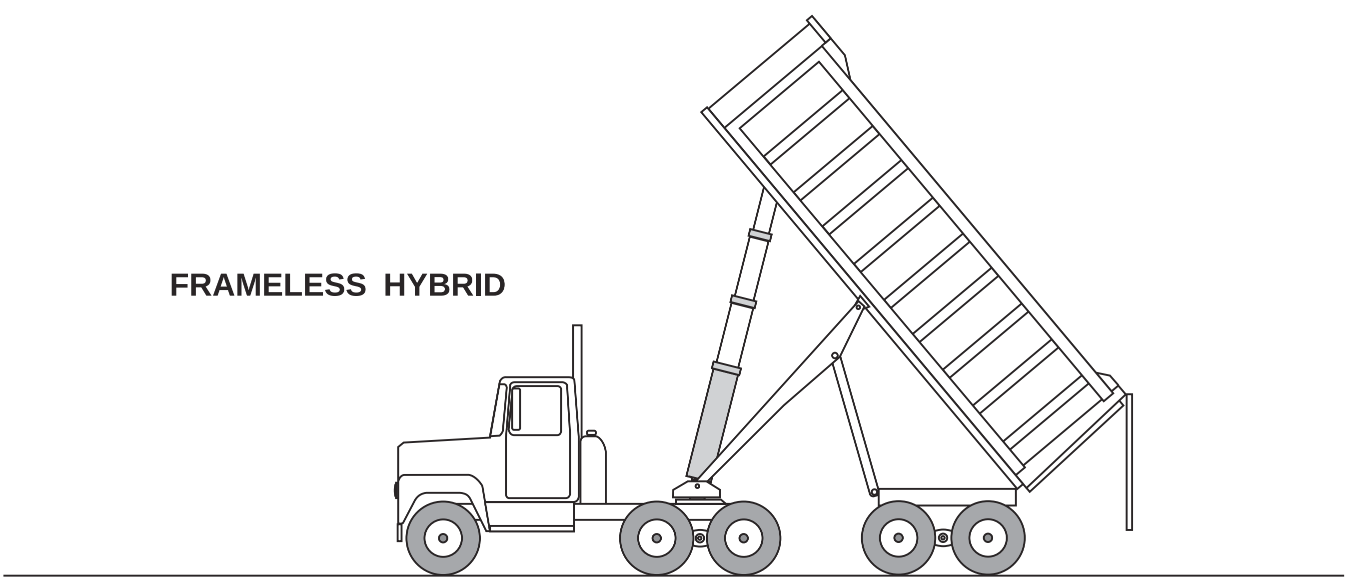
FRAME TYPE



FRAMELESS



FRAMELESS HYBRID



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Parker Hannifin Corporation
Cylinder and Accumulator Division
Des Plaines, Illinois

Repair Kits

For Standard Parker Single acting Dump Body Cylinders.

Parker's genuine replacement parts are available in kits to rebuild or repack our dump body cylinders. These parts are the same as originally installed.

As with all hydraulic repairs, be sure your shop is properly equipped and that the work area is clean.

Rebuilding kits consist of:
1. Wiper Rings
2. Packing Assemblies
3. Gland Bearing Rings
4. Wave Springs
5. Piston Bearings
6. Set Screws
7. Nylon Balls

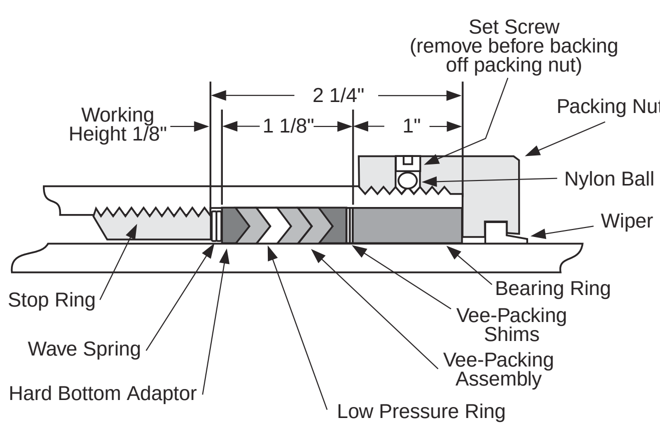
Repacking kits consist of:
1. Wiper Rings
2. Packing Assemblies

Order information
Please order by part number

Cylinder Model	Rebuild Kit Number		Repack Kit Number	
	Model Number	Part Number	Model Number	Part Number
S53 Series	A300-253	3751804017	A300-11	3911804020
S62 Series	A300-256	3751804020	A300-262	3751804026
S63 Series	A300-254	3751804018	A300-104	3911804109
S64 Series	A300-257	3751804021	A300-230	3911804237
S73 Series	A300-255	3751804019	A300-238	3751804002
S74 Series	A300-258	3751804022	A300-239	3751804003
S84 Series	A300-259	3751804023	A300-49	3911804054
S85 Series	A300-260	3751804024	A300-22	3911804060
S95 Series	A300-261	3751804025	A300-240	3751804004

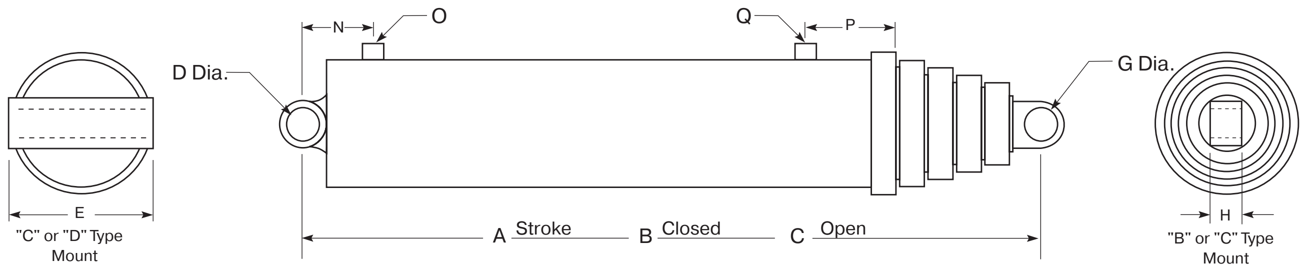
Cylinder Packing Installation
Remove shims from packing set and measure packing height under finger pressure. Add one shim for each 1/32" that the packing measures under 1-1/8". Measure depth to top of stop ring from top of tube. This dimension should be 2-1/4", however, it may vary slightly due to seating of the stop ring. Add one shim to the packing set for every 1/32" that this dimension measures over 2-1/4" or remove one shim from the packing set for every 1/32" that this dimension measures under 2-1/4". Install wave spring with gap edge against top of the cylinder stop ring. Soak packing in hydraulic oil for a few minutes. (Check bottom adapter. Only hard type can be used with the wave spring). Install packing, one ring at a time, in the proper sequence as shown in the sketch. Note: The soft, low pressure ring must be in the second position from the pressure side. Installed packing height need not be checked because wave spring will vary this dimension.

Installation of bearing and packing nut will compress wave spring for proper packing pre-load. Pull down tight against tube.



Parker Hannifin Corporation
Cylinder and Accumulator Division
Des Plaines, Illinois

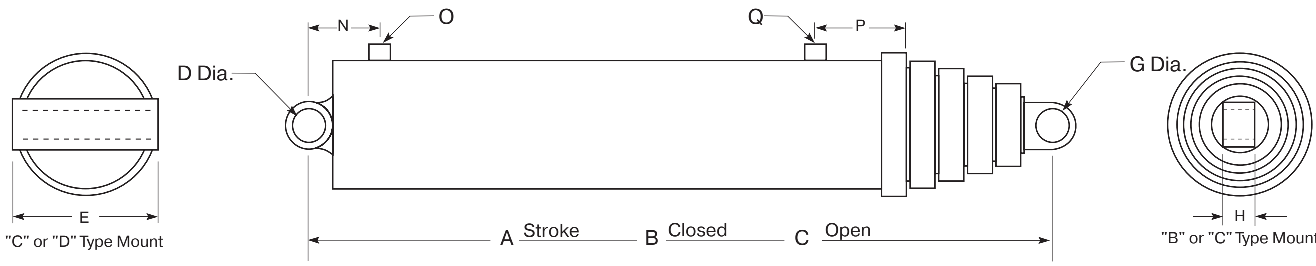
Single Acting Telescopic Cylinders with CC, DB and DC Mounts



MODEL NUMBER	PART NUMBER	NOMINAL STAGE OD	NUMBER STAGES	A STROKE	B CLOSED	C OPEN	D PIN	E WIDTH	G PIN	H WIDTH
S42CC-19-40	3771012052	4	2	40.00	32.44	72.44	1.50	2.00	1.50	2.00
S43DB-3-75	3781013005	4	3	75.00	33.88	108.88	2.00	5.00	1.25	1.69
S52CC-41-54.62	3771512092	5	2	54.62	38.00	92.62	2.50	3.62	2.50	3.62
S52CC-41-67.25	3771512091	5	2	67.25	46.75	114.06	2.50	3.62	2.50	3.62
S52DB-9-67.50	3771512080	5	2	67.50	46.75	114.25	3.00	5.50	2.00	3.00
S53DB-13-60	3781513005	5	3	60.00	30.00	90.00	2.00	6.00	1.50	2.63
S53DB-18-90	3781513008	5	3	90.00	39.75	129.75	2.00	6.00	1.50	2.63
S53DC-65-104	3771513168	5	3	104.00	47.69	151.69	2.00	7.00	1.75	2.00
S53DC-65-107	3771513169	5	3	107.56	48.38	155.94	2.00	7.00	1.75	2.00
S53DC-65-120	3771513166	5	3	120.13	53.06	173.19	2.00	7.00	1.75	2.00
S53DC-65-126	3771513170	5	3	126.63	54.56	181.19	2.00	7.00	1.75	2.00
S53DC-66-72	3771513172	5	3	72.00	37.19	109.19	2.00	7.00	1.63	1.50
S53DC-66-84	3771513171	5	3	84.00	41.19	125.19	2.00	7.00	1.63	1.50
S53DC-68-105	3771513176	5	3	105.00	48.50	153.50	2.00	7.75	1.75	1.50
S53DC-68-120	3771513177	5	3	120.00	52.50	172.50	2.00	7.75	1.75	1.50
S53DC-68-123	3771513178	5	3	123.00	54.50	177.50	2.00	7.75	1.75	1.50
S53DC-68-99	3771513175	5	3	99.00	46.50	145.50	2.00	7.75	1.75	1.50
S63DC-101-104	3771413319	6	3	103.94	47.00	150.94	2.00	7.00	2.00	2.00
S63DC-101-107	3771413320	6	3	107.56	48.38	155.94	2.00	7.00	2.00	2.00
S63DC-101-120	3771413321	6	3	120.06	52.62	172.68	2.00	7.00	2.00	2.00
S63DC-101-126	3771413322	6	3	126.31	54.56	180.87	2.00	7.00	2.00	2.00
S63DC-101-140	3771413324	6	3	140.25	59.81	200.06	2.00	7.00	2.00	2.00
S63DC-101-150	3771413318	6	3	149.88	63.00	212.88	2.00	7.00	2.00	2.00
S63DC-101-86	3771413316	6	3	86.75	40.88	127.63	2.00	7.00	2.00	2.00
S63DC-101-92	3771413317	6	3	92.00	45.00	137.00	2.00	7.00	2.00	2.00
S63DC-102-120	3771413325	6	3	120.00	53.50	173.50	2.38	8.00	2.19	1.50
S63DC-102-126	3771413326	6	3	126.00	55.50	181.50	2.38	8.00	2.19	1.50
S63DC-102-138	3771413327	6	3	138.00	59.50	197.50	2.38	8.00	2.19	1.50
S63DC-102-150	3771413328	6	3	150.00	66.00	216.00	2.38	8.00	2.19	1.50
S63DC-102-162	3771413329	6	3	162.00	67.50	229.50	2.38	8.00	2.19	1.50
S63DC-79-67	3771413260	6	3	67.00	36.50	103.50	3.00	7.88	1.75	1.50
S63DC-96-130	3771413308	6	3	130.00	56.00	186.00	2.00	7.00	2.00	2.00
S63DC-96-82.50	3771413306	6	3	82.50	43.56	126.06	2.00	7.00	2.00	2.00
S63DC-97-111	3771413309	6	3	111.00	49.94	160.94	2.00	7.00	2.00	2.00
S63DC-97-123	3771413310	6	3	123.00	54.94	177.94	2.00	7.00	2.00	2.00

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve.

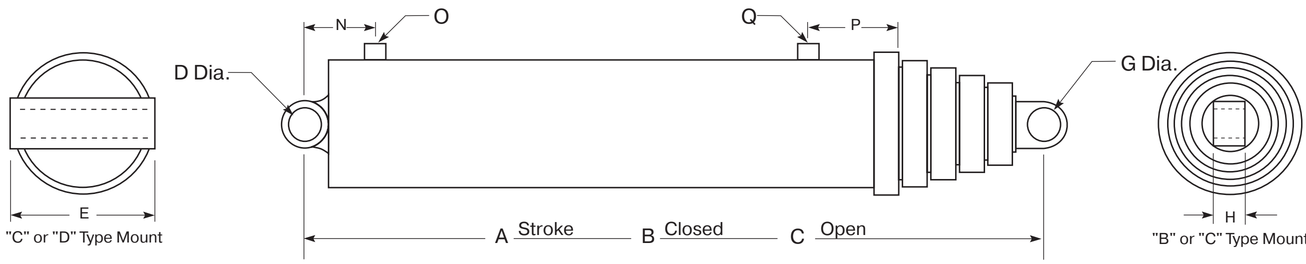
Single Acting Telescopic Cylinders with CC, DB and DC Mounts



PART NUMBER	N LOCATION	O SIZE	P LOCATION	Q SIZE	GALS TO FILL	GALS TO EXTEND	WEIGHT LBS	REBUILD KIT*	REPACK KIT*
3771012052	14”	1/2” NPT			2.07	2.46	52	3751805175	3751805174
3781013005			19”	1/2” NPT	0.77	2.11	85	3751805720	3751804368
3771512092	3.88”	#8 SAE			2	3.4	120	3751805581	3751805580
3771512091	3.88”	#8 SAE			2.51	4.17	145	3751805581	3751805580
3771512080	20”	#12 SAE			2.42	4.2	135	3751805581	3751805580
3781513005			19”	1/2” NPT	1.7	3	120	3751804017	3911804020
3781513008			19”	3/4” NPT	1.22	4.45	200	3751804017	3911804020
3771513168			15.50”	1” NPT	2.4	5.89	175	3751804017	3911804020
3771513169			9.94”	1” NPT	2.4	5.89	178	3751804017	3911804020
3771513166			15.50”	1” NPT	2.42	5.9	195	3751804017	3911804020
3771513170			6.12”	1” NPT	2.42	5.9	205	3751804017	3911804020
3771513172	19.50”	3/4” NPT			1.8	3.5	165	3751804017	3911804020
3771513171	19.50”	3/4” NPT			1.8	3.5	170	3751804017	3911804020
3771513176	24.81”	#16 90D SAE			2	5.2	170	3751804017	3911804020
3771513177	24.81”	#16 90D SAE			1.62	5.9	220	3751804017	3911804020
3771513178	24.81”	#16 90D SAE			2.8	6.1	232	3751804017	3911804020
3771513175	24.81”	#16 90D SAE			1.95	4.87	165	3751804017	3911804020
3771413319	20.81”	1” NPT			1.75	8.05	250	3751804018	3911804109
3771413320	20.81”	1” NPT			1.82	8.37	256	3751804018	3911804109
3771413321	20.81”	1” NPT			2.03	9.33	275	3751804018	3911804109
3771413322	20.81”	1” NPT			2.13	9.84	285	3751804018	3911804109
3771413324	20.81”	1” NPT			2.37	10.94	310	3751804018	3911804109
3771413318	20.81”	1” NPT			2.53	11.71	325	3751804018	3911804109
3771413316	20.81”	1” NPT			1.47	6.79	225	3751804018	3911804109
3771413317	20.81”	1” NPT			1.56	7.14	195	3751804018	3911804109
3771413325	24.91”	#16 90D SAE			2.02	9.4	270	3751804018	3911804109
3771413326	24.91”	#16 90D SAE			2.13	9.9	275	3751804018	3911804109
3771413327	24.91”	#16 90D SAE			2.33	11.1	300	3751804018	3911804109
3771413328	24.91”	#16 90D SAE			2.54	11.9	330	3751804018	3911804109
3771413329	24.91”	#16 90D SAE			2.75	12.64	330	3751804018	3911804109
3771413260	20.50”	3/4” NPT			2.18	5.12	180	3751805654	3751805594
3771413308	20.81”	1” 90D NPT			2.15	10.85	295	3751804018	3911804109
3771413306	20.81”	1” 90D NPT			2.15	10.85	230	3751804018	3911804109
3771413309	3.81”	1” NPT	24”	1” NPT	1.87	8.61	270	3751804018	3911804109
3771413310	3.81”	1” NPT	29”	1” NPT	2.08	9.63	285	3751804018	3911804109

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve. *Reference kit information on page 35.

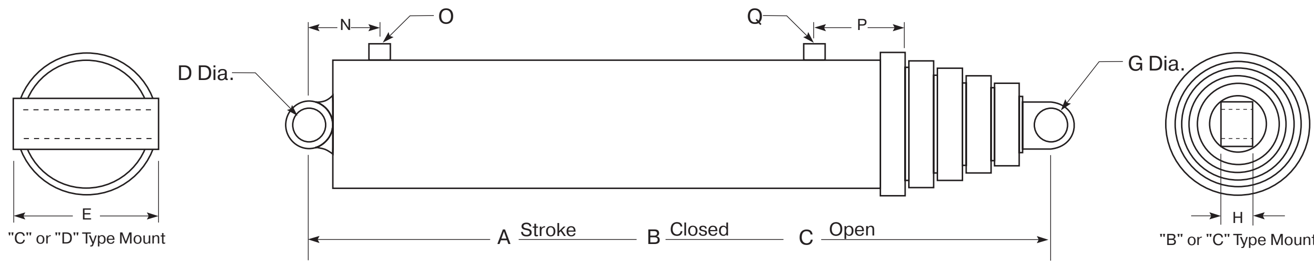
Single Acting Telescopic Cylinders with CC, DB and DC Mounts



MODEL NUMBER	PART NUMBER	NOMINAL STAGE OD	NUMBER STAGES	A STROKE	B CLOSED	C OPEN	D PIN	E WIDTH	G PIN	H WIDTH
S64DB-12-135	3771414058	6	4	135.00	47.19	182.19	1.75	8.00	1.50	2.69
S64DB-12-156	3771414056	6	4	156.00	53.19	209.19	1.75	8.00	1.50	2.69
S64DC-14-156	3771414059	6	4	156.00	53.62	209.62	2.00	7.25	2.00	1.75
S64DC-15-157	3771414061	6	4	157.00	58.56	215.56	1.50	7.00	1.50	2.00
S73DC-66-110	3772513127	7	3	110.63	50.06	160.69	2.00	8.25	2.00	2.00
S73DC-66-120	3772513132	7	3	120.00	53.12	173.12	2.00	8.25	2.00	2.00
S73DC-66-124	3772513128	7	3	124.88	54.81	179.69	2.00	8.25	2.00	2.00
S73DC-66-129	3772513135	7	3	129.00	56.50	185.50	2.00	8.25	2.00	2.00
S73DC-66-140	3772513129	7	3	140.44	60.00	200.44	2.00	8.25	2.00	2.00
S73DC-66-150	3772513131	7	3	150.00	63.50	213.50	2.00	8.25	2.00	2.00
S74DC-74-120	3772514124	7	4	120.00	44.12	164.12	2.00	8.25	2.00	2.00
S74DC-74-135	3772514125	7	4	135.00	48.44	183.44	2.00	8.25	2.00	2.00
S74DC-74-140	3772514122	7	4	140.00	49.75	189.75	2.00	8.25	2.00	2.00
S74DC-74-156	3772514123	7	4	156.00	53.75	209.75	2.00	8.25	2.00	2.00
S74DC-74-161	3772514120	7	4	161.75	55.31	217.06	2.00	8.25	2.00	2.00
S74DC-74-167	3772514130	7	4	167.00	56.25	223.25	2.00	8.25	2.00	2.00
S74DC-74-180	3772514126	7	4	180.00	61.12	241.12	2.00	8.25	2.00	2.00
S84DC-66-140	3772914080	8	4	140.00	49.75	189.75	2.00	9.50	2.00	2.00
S84DC-66-148	3772914081	8	4	147.75	51.50	199.25	2.00	9.50	2.00	2.00
S84DC-66-156	3772914086	8	4	156.00	53.75	209.75	2.00	9.50	2.00	2.00
S84DC-66-161	3772914082	8	4	160.00	55.75	215.75	2.00	9.50	2.00	2.00
S84DC-66-170	3772914083	8	4	170.00	57.25	227.25	2.00	9.50	2.00	2.00
S84DC-66-180	3772914084	8	4	180.00	59.75	239.75	2.00	9.50	2.00	2.00
S84DC-66-188	3772914085	8	4	188.00	61.75	249.75	2.00	9.50	2.00	2.00
S85DC-66-170	3772915164	8	5	170.00	49.88	21988	2.00	9.50	2.00	2.00
S85DC-66-190	3772915166	8	5	189.00	54.62	243.62	2.00	9.50	2.00	2.00
S85DC-66-197	3772915162	8	5	196.13	55.25	251.38	2.00	9.50	2.00	2.00
S85DC-66-220	3772915167	8	5	219.00	60.00	279.00	2.00	9.20	2.00	2.00
S85DC-66-235	3772915161	8	5	234.00	64.62	298.62	2.00	9.50	2.00	2.00
S85DC-66-250	3772915160	8	5	249.00	68.62	317.62	2.00	9.50	2.00	2.00
S85DC-66-265	3772915165	8	5	265.00	71.00	336.00	2.00	9.50	2.00	2.00
S85DC-66-285	3772915163	8	5	285.00	78.50	363.50	2.00	9.50	2.00	2.00

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve.

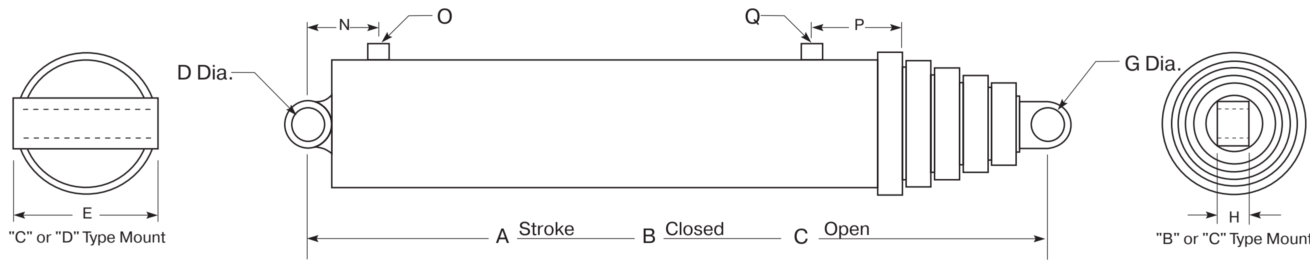
Single Acting Telescopic Cylinders with CC, DB and DC Mounts



PART NUMBER	N LOCATION	O SIZE	P LOCATION	Q SIZE	GALS TO FILL	GALS TO EXTEND	WEIGHT LBS	REBUILD KIT*	REPACK KIT*
3771414058			5.50”	2, 3/4” NPT	2.6	8.1	275	3751804021	3911804237
3771414056			5.50”	2, 3/4” NPT	3.2	10.1	293	3751804021	3911804237
3771414059	6.31”	1” NPT			2.5	10.01	310	3751804021	3911804237
3771414061	4.31”	1” NPT			3.8	9.5	310	3751804021	3911804237
3772513127	7.06”	1” NPT	4.62”	1” NPT	2.34	12.6	335	3751804019	3751804002
3772513132	7.06”	1” NPT	4.62”	1” NPT	2.4	13.5	360	3751804019	3751804002
3772513128	7.06”	1” NPT	4.62”	1” NPT	2.53	14.2	370	3751804019	3751804002
3772513135	8.56”	1” NPT	4.62”	1” NPT	2.6	14.7	385	3751804019	3751804002
3772513129	7.06”	1” NPT	4.62”	1” NPT	2.84	16.1	400	3751804019	3751804002
3772513131	7.06”	1” NPT	4.62”	1” NPT	3.1	17.1	420	3751804019	3751804002
3772514124	7.06”	1” NPT	4.62”	1” NPT	2.2	11.5	325	3751804022	3751804003
3772514125	7.06”	1” NPT	4.62”	1” NPT	2.5	13	375	3751804022	3751804003
3772514122	7.06”	1” NPT	4.62”	1” NPT	2.6	13.5	365	3751804022	3751804003
3772514123	7.06”	1” NPT	4.62”	1” NPT	2.9	15.1	388	3751804022	3751804003
3772514120	7.06”	1” NPT	4.62”	1” NPT	3.0	15.5	405	3751804022	3751804003
3772514126	7.06”	1” NPT	4.62”	1” NPT	3.5	17.4	430	3751804022	3751804003
3772514130	7.06”	1” NPT	4.62”	1” NPT	3.1	16.1	420	3751804022	3751804003
3772914050	6.50”	1” NPT	5.62”	1” NPT	7.6	23.3	570	3751804023	3911804054
3772914080	6.50”	1” NPT	5.62”	1” NPT	3	19.1	488	3751804023	3911804054
3772914081	6.50”	1” NPT	5.62”	1” NPT	3.2	20.2	515	3751804023	3911804054
3772914086	6.50”	1” NPT	5.62”	1” NPT	3.4	21.3	535	3751804023	3911804054
3772914082	6.50”	1” NPT	5.62”	1” NPT	3.5	22	555	3751804023	3911804054
3772914083	6.50”	1” NPT	5.62”	1” NPT	3.7	23.4	568	3751804023	3911804054
3772914084	6.50”	1” NPT	5.62”	1” NPT	3.9	24.7	591	3751804023	3911804054
3772914085	6.50”	1” NPT	5.62”	1” NPT	4.1	25.8	610	3751804023	3911804054
3772915164	6.50”	1” NPT	5.62”	1” NPT	3.4	20	516	3751804024	3911804060
3772915166	6.50”	1” NPT	5.62”	1” NPT	3.8	22.3	555	3751804024	3911804060
3772915162	6.50”	1” NPT	5.62”	1” NPT	3.9	23.1	560	3751804024	3911804060
3772915167	6.50”	1” NPT	5.62”	1” NPT	4.4	25.9	565	3751804024	3911804060
3772915161	6.50”	1” NPT	5.62”	1” NPT	4.7	27.7	650	3751804024	3911804060
3772915160	6.50”	1” NPT	5.62”	1” NPT	5	29.5	685	3751804024	3911804060
3772915165	6.50”	1” NPT	5.62”	1” NPT	5.3	31.5	715	3751804024	3911804060
3772915163	6.50”	1” NPT	5.62”	1” NPT	5.7	34	795	3751804024	3911804060

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve. *Reference kit information on page 35.

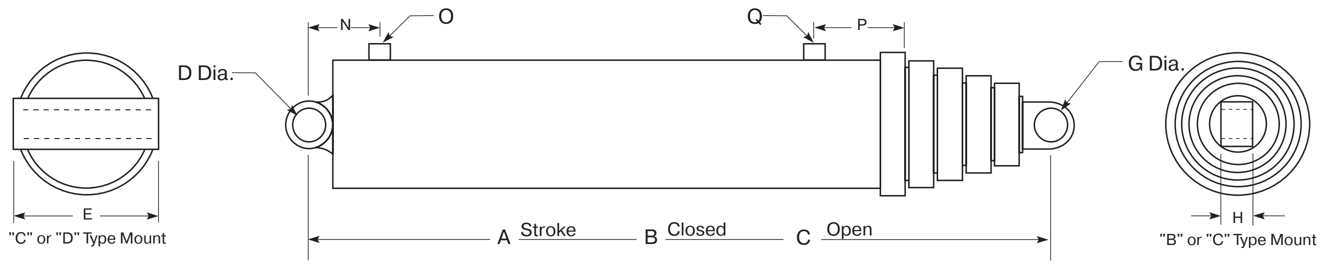
Single Acting Telescopic Cylinders with CC, DB and DC Mounts



MODEL NUMBER	PART NUMBER	NOMINAL STAGE OD	NUMBER STAGES	A STROKE	B CLOSED	C OPEN	D PIN	E WIDTH	G PIN	H WIDTH
S95DC-52-190	3773115068	9	5	190.00	56.00	246.00	2.00	10.88	2.00	2.00
S95DC-52-220	3773115064	9	5	218.00	62.44	280.44	2.00	10.88	2.00	2.00
S95DC-52-235	3773115063	9	5	233.00	65.44	298.44	2.00	10.88	2.00	2.00
S95DC-52-250	3773115061	9	5	248.00	68.44	316.44	2.00	10.88	2.00	2.00
S95DC-52-265	3773115069	9	5	265.00	72.62	337.62	2.00	10.88	2.00	2.00
S95DC-52-280	3773115067	9	5	280.00	78.62	358.62	2.00	10.88	2.00	2.00
S95DC-52-300	3773115066	9	5	300.00	79.00	379.00	2.00	10.88	2.00	2.00
S95DC-52-320	3773115065	9	5	320.00	83.00	403.00	2.00	10.88	2.00	2.00
S95DC-52-340	3773115062	9	5	340.00	87.00	427.00	2.00	10.88	2.00	2.00

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve.

Single Acting Telescopic Cylinders with CC, DB and DC Mounts

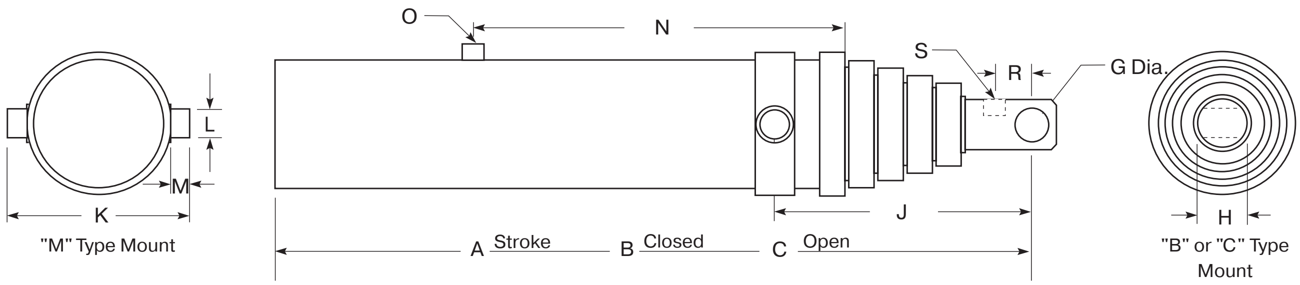


PART NUMBER	N LOCATION	O SIZE	P LOCATION	Q SIZE	GALS TO FILL	GALS TO EXTEND	WEIGHT LBS	REBUILD KIT*	REPACK KIT*
3773115068	6.50”	1” NPT	5.75”	1” NPT	3.9	22.4	835	3751804025	3751804004
3773115064	6.50”	1” NPT	5.75”	1” NPT	6.8	36.2	855	3751804025	3751804004
3773115063	6.50”	1” NPT	5.75”	1” NPT	7.1	38.7	880	3751804025	3751804004
3773115061	6.50”	1” NPT	5.75”	1” NPT	7.5	41.3	1100	3751804025	3751804004
3773115069	6.50”	1” NPT	5.75”	1” NPT	8.2	44.6	1200	3751804025	3751804004
3773115067	6.50”	1” NPT	5.75”	1” NPT	9.3	47.6	1215	3751804025	3751804004
3773115066	6.50”	1” NPT	5.75”	1” NPT	9.6	50.2	1230	3751804025	3751804004
3773115065	6.50”	1” NPT	5.75”	1” NPT	9.8	54.1	1200	3751804025	3751804004
3773115062	12.50”	1” NPT	5.75”	1” NPT	10.2	59.9	1245	3751804025	3751804004

*Reference kit information on page 35.

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve.

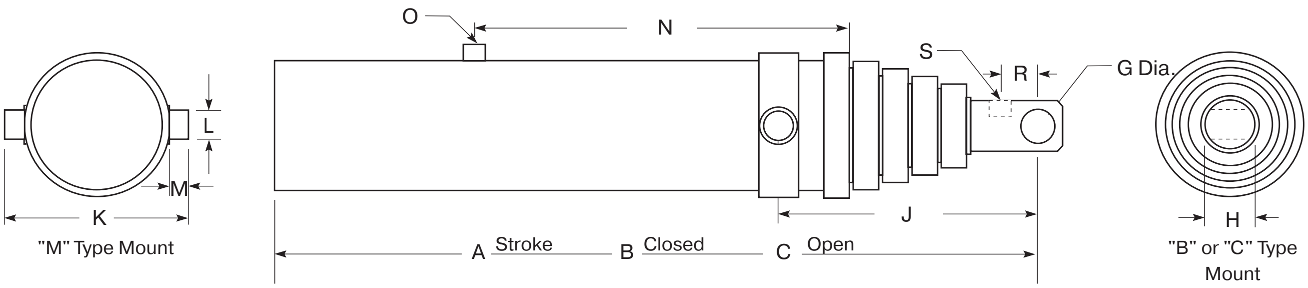
Single Acting Telescopic Cylinders with CC, DB and DC Mounts



MODEL NUMBER	PART NUMBER	NOMINAL STAGE OD	NUMBER STAGES	A STROKE	B CLOSED	C OPEN	G PIN	H WIDTH	J TR to PIN	K WIDTH	L DIA.	M LGTH
S63MB-8-140	3771413124	6	3	140.25	61.62	201.9	1.5	3.62	14.37	12.38	1.8	1.69
S63MB-8-150	3771413206	6	3	150	63.0	213.0	1.5	3.62	14.37	12.38	1.8	1.69
S63MB-8-160	3771413201	6	3	160	66.25	226.25	1.5	3.62	14.37	12.38	1.8	1.69
S74MB-3-154	3772514058	7	4	154	55.62	209.6	1.5	3.62	14.37	12.25	1.8	1.69
S74MB-3-172	3772514062	7	4	172	58.34	230.3	1.5	3.62	14.37	12.25	1.8	1.63
S85MC-48-200	3772915121	8	5	199	55	254	2	3	15.5	14	2.3	1.25
S85MC-48-220	3772915122	8	5	219	59	278	2	3	15.5	14	2.3	1.25
S85MC-48-235	3772915123	8	5	234	65	299	2	3	15.5	14	2.3	1.25
S85MC-48-250	3772915120	8	5	249	67	316	2	3	15.5	14	2.3	1.25
S85MC-48-265	3772915119	8	5	265	71	336	2	3	15.5	14	2.3	1.25
S85MC-48-280	3772915118	8	5	280	78.87	358.9	2	3	15.5	14	2.3	1.25

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve.

Single Acting Telescopic Cylinders with CC, DB and DC Mounts

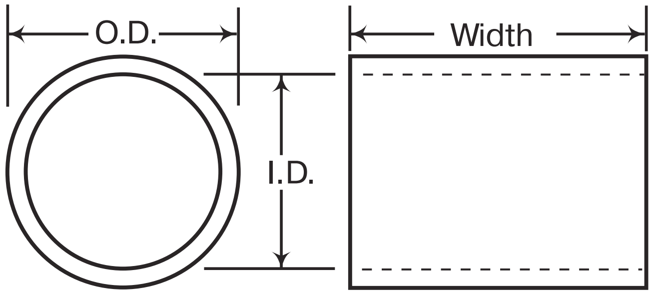


PART NUMBER	N LOCATION	O SIZE	P LOCATION	Q SIZE	GALS TO FILL	GALS TO EXTEND	WEIGHT LBS	REBUILD KIT	REPACK KIT
3771413124			2”	1” NPT	4.9	11.2	280	3751806509	3751804287
3771413206			2”	1” NPT	4.9	11.8	345	3751806509	3751804287
3771413201			2”	1” NPT	4.9	12.5	360	3751806509	3751804287
3772514058			2”	1” NPT	5.2	15.1	412	3751804022	3751804003
3772514062			2”	1” NPT	5.6	16.6	436	3751804022	3751804003
3772915121			2”	1” NPT	6.4	23.5	620	3751804024	3911804060
3772915122			2”	1” NPT	7.1	26.1	640	3751804024	3911804060
3772915123			2”	1” NPT	7.8	27.1	670	3751804024	3911804060
3772915120			2”	1” NPT	8.4	29.1	720	3751804024	3911804060
3772915119			2”	1” NPT	8.7	31.6	780	3751804024	3911804060
3772915118			2”	1” NPT	9.8	34.1	800	3751804024	3911804060

Note: Diameters D and G are for nominal pin size, for actual hole size refer to print.
Note: Nominal Stage OD, refers to the Largest Moving Sleeve.

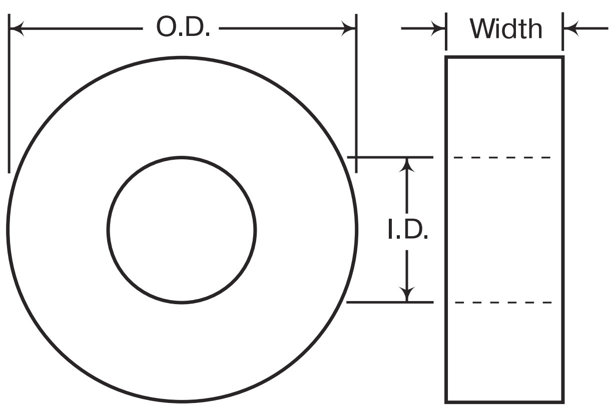
⚠ **PROP 65 WARNING** **WARNING:** This product can expose you to chemicals including **Lead and Lead Compounds** which are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

Accessories to Modify Cylinder Mounting Pin Hole Diameters and Mount Widths



Pin - Eye Mount Bushings

Model Number	Part Number	Nominal Dimensions
CC1519-1-1.5	3751519556	1.50 I.D X 2.00 O.D. X 1.50 Wide
CC1519-1-2.0	3751519557	1.50 I.D X 2.00 O.D. X 2.00 Wide
CC1519-2-1.5	3751519558	1.75 I.D X 2.00 O.D. X 1.50 Wide
CC1519-2-2.0	3751519559	1.75 I.D X 2.00 O.D. X 2.00 Wide
CC1519-3-2.0	3751519560	1.31 I.D X 2.00 O.D. X 2.00 Wide
CC1519-4-2.0	3751519561	1.68 I.D X 2.00 O.D. X 2.00 Wide



Pin - Eye Mount Spacers

Model Number	Part Number	Nominal Dimensions
CC1519-5-0.25	3751519562	1.81 I.D X 3.00 O.D. X 0.25 Wide
CC1519-5-0.50	3751519563	1.81 I.D X 3.00 O.D. X 0.50 Wide
CC1519-5-1.0	3751519564	1.81 I.D X 3.00 O.D. X 1.00 Wide
CC1519-5-0.75	3751519565	1.81 I.D X 3.00 O.D. X 0.75 Wide
CC1519-6-0.25	3751519566	2.12 I.D X 3.00 O.D. X 0.25 Wide
CC1519-6-0.50	3751519567	2.12 I.D X 3.00 O.D. X 0.50 Wide
CC1519-6-1.0	3751519568	2.12 I.D X 3.00 O.D. X 1.00 Wide
CC1519-6-0.75	3751519569	2.12 I.D. X 3.00 O.D. X 0.75 Wide

Double Acting Telescopic Cylinder

Basic Cylinder Types
As with conventional cylinders, the two basic types of telescopic hydraulic cylinders are single and double acting.

Double acting telescopic cylinders are powered hydraulically in both directions. They can be used in applications where neither gravity nor external force is available. They are well suited to noncritical positioning applications requiring out-and-back movement of a substantial load. These cylinders are designed with multiple nested barrels that collapse and expand, allowing for a compact retracted length and long extended length when compared to traditional single stage hydraulic cylinders. A classic application is the packer-ejector cylinder in refuse vehicles and transfer trailers. The horizontally mounted cylinder pushes a platen to compress the load, then must retract with the platen so more material can be added. Gravity cannot help, so a double acting cylinder is used.

"SD" Series Double-Acting, Multiple Stage Cylinder

Sleeve or Plunger O.D. (inches)	Bore of Main or Sleeve (inches)	Effective Area (sq. inches) to Extend	Effective Area (sq. inches) to Retract	Load Capacity (lbs) @ 2000 PSI Extending	Load Capacity (lbs) @ 2000 PSI Retracting	Displacement per inch of Stroke (gallons)* to Extend	Displacement per inch of Stroke (gallons)* to Retract
1.75	2,25	3.98	1.57	7,952	3,142	0.017	0.007
2.75	3.25	8.29	2.35	16,592	4,712	0.036	0.010
3.75	4.25	14.18	3.14	28,372	6,283	0.061	0.014
4.75	5.25	21.64	3.92	43,296	7,854	0.094	0.017
5.75	6.25	30.68	4.71	61,360	9,426	0.133	0.020
6.75	7.25	41.28	5.49	82,564	10,994	0.179	0.024
7.90	8.44	55.68	6.97	111,360	13,946	0.242	0.030
9.38	9.88	76.59	7.56	153,180	15,120	0.332	0.033
10.75	11.50	103.87	13.11	207,738	26,213	0.450	0.057
12.50	13.00	132.73	10.01	265,465	20,028	0.575	0.043
14.00	14.50	165.13	11.19	330,261	22,384	0.715	0.048

Note: The Effective area to RETRACT a Standard "SD" series double acting multiple stage cylinder is the effective area of the PLUNGER (plunger bore area minus the plunger O.D. area).
Example: Retract force for a SD94CC-X-190 (which has 5.75" O.D. plunger and fits in 6.25" bore) would be 9,426 lbs @ 2,000 psi, based on a 4.71 sq. in. effective area.

To calculate effective area in square inches: Multiply diameter times diameter times .78
Example: 5 dia. x 5 dia. = 25 x .78 = 19.63 sq. in. of area

To calculate load capacity / cylinder force: Multiply effective area times operating pressure (psi)
Example: 19.63 Square inches x 1750 P.S.I = 34,361 lbs of force

To calculate the required gallons of fluid to extend a cylinder:
Add each "Displacement per inch of stroke" (from chart) for the required sleeve sizes.
Divide this total by the number of moving sleeves, then multiply that total by the desired cylinder stroke.
Note: The "Gallons required to extend" does not include the necessary fluid to fill an empty cylinder.
Example: Required fluid to extend a SD83CC-X-134 single-acting telescopic cylinder with following stage sizes:

5.75" O.D.= .133
6.75" O.D.= .179 .554 ÷ 3 = .185 gallons per inch of stroke
7.90" O.D.= .242 .185 gallons per inch x 134" of stroke = 24.8 gallons to extend cylinder
.554

Production Specification and Design Advantages

General Specifications

- Heavy duty service
- Sleeve diameters – 1.75" through 14.00"
- Strokes – 36.00" through 500.00"
- Mounts - standard and custom available
- Nominal pressure – 2,000 psi[1] (140 Bar)
- Nominal min flow required - 15 gpm
- Standard fluid media – filtered hydraulic oil[2]
- Standard temperature – -40˚F to +200˚F

Material Specifications

Cylinder body	High strength carbon steel
Sleeve and plunger	High strength carbon steel
Sleeve v-packing seal	Hytrel+Rubber
Sleeve wiper seal	Polyurethane
Sleeve bearing	Glass Reinforced Nylon
Piston bearing	Cast-Iron

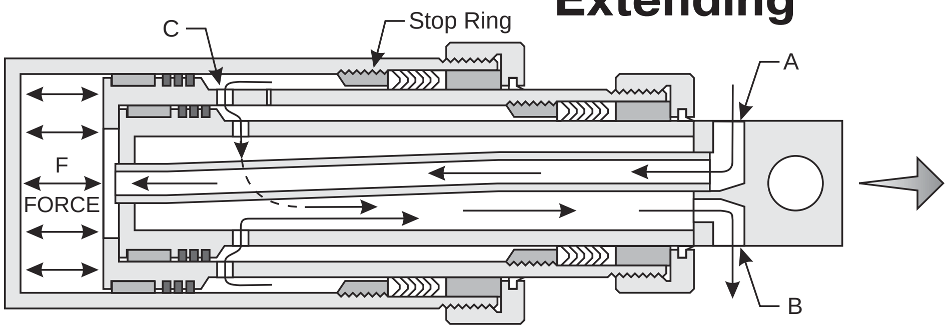
[1] If hydraulic pressure exceeds 2,000 psi (140 Bar), send application data for engineering evaluation and recommendation.
[2] See Seal Information pages for appropriate seals with different fluid media.

In line with our policy of continuing product improvement, specifications in this catalog are subject to change.

Design Advantages

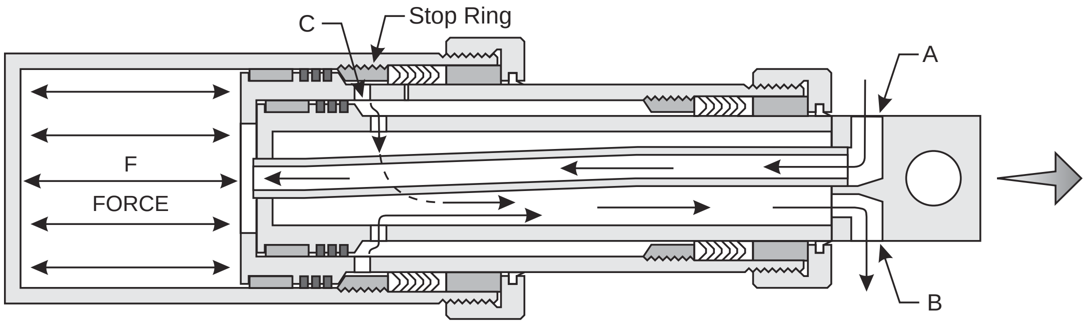
- Set screws with nylon ball for locking packing nuts.
- Snap-on, glass-filled bearings that absorb contaminants without damaging cylinder walls.
- Threaded steel stop rings for easier servicing and more reliable stopping action.
- Wave springs and chevron packing for self compensating seals.
- Polyurethane sleeve wiper seals that resist higher temperatures without extrusion.
- Adjustable v-packing for low and high pressure sealing.

Extending

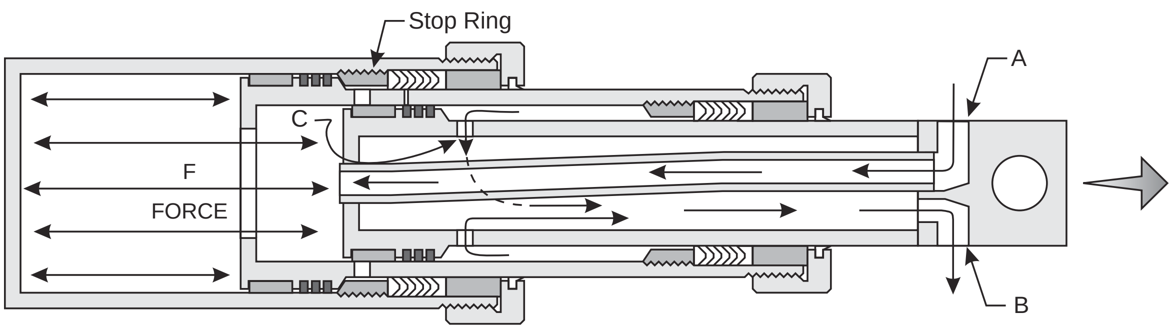


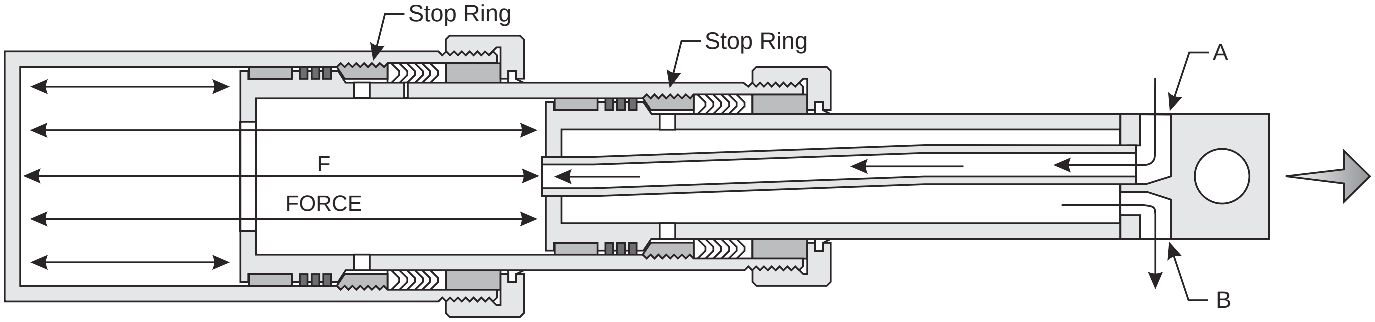
To Extend:
High pressure oil is directed by the control valve into port A. The oil passes through the transfer tube in the rod to the base of the cylinder.

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. So at a given PSI (pressure) and GPM (gallons per min.) the cylinder will develop less force and increase in speed as it changes to the next moving stage. Oil trapped between the sleeves escapes through holes (C) in each sleeve and returns to the tank through port B.





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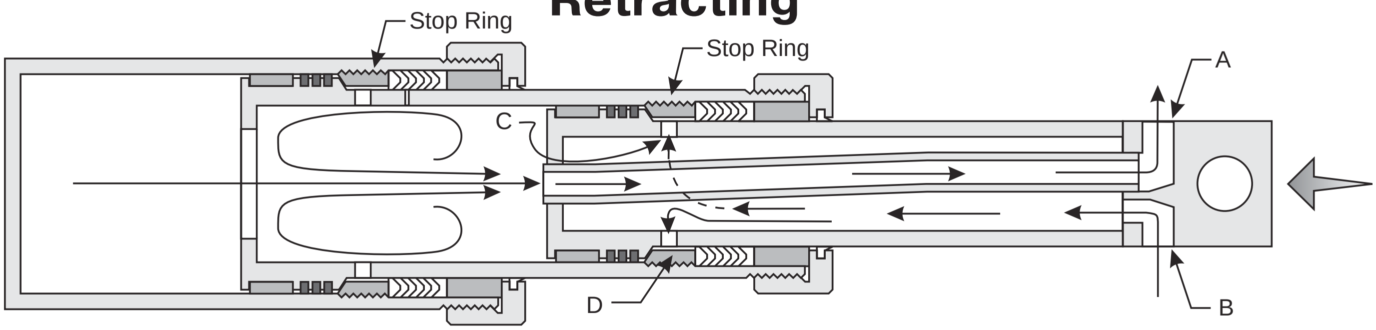
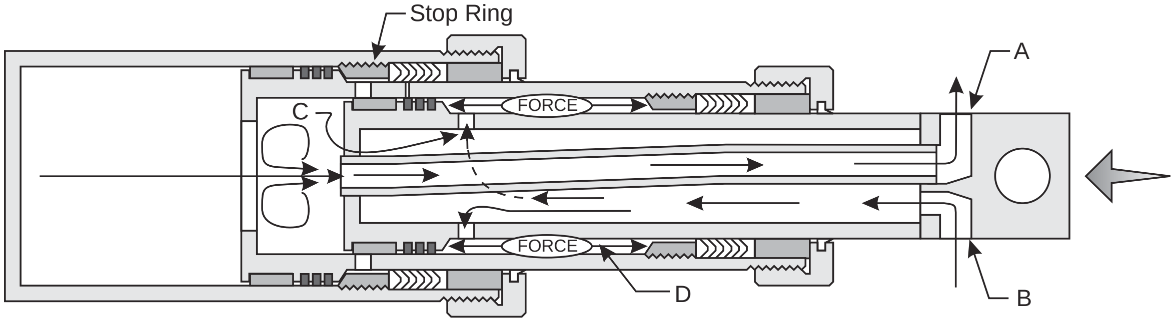
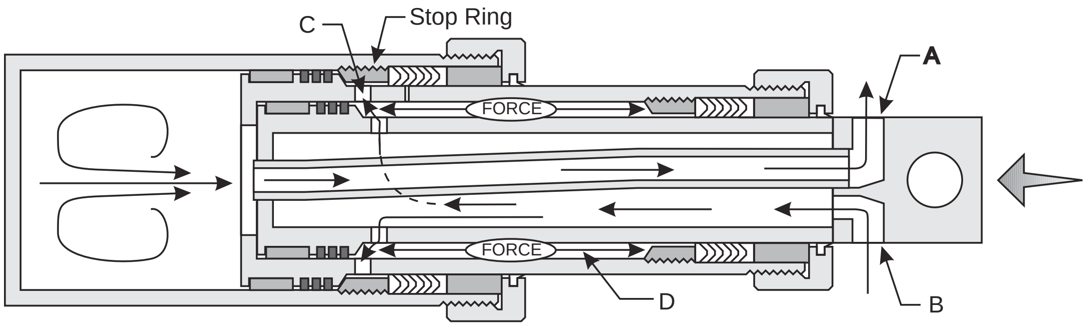
Retracting



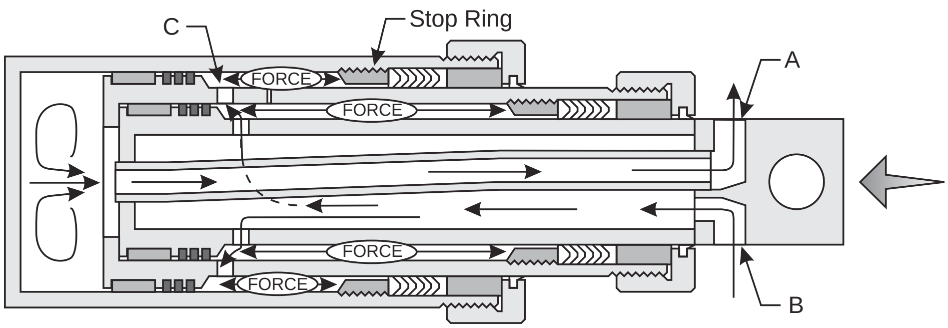
To Retract:
High pressure oil is directed by the control valve into port B. The pressure is applied to the effective area (D) of the plunger which retracts first.



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.



Safety Precautions for Double Acting Telescopic Cylinders

WARNING!
Rollover or lateral tilt can cause severe injury or death and/or damage to the unit and cylinder.

The hydraulic cylinder will not prevent the unit from rollover or lateral tilt. The cylinder is strictly a lifting device and is not a structural member of the unit. Cylinders are not to be used as a means of stabilizing the unit.

The hydraulic cylinder mounted in the unit should be free to find its own trajectory line of extension and retraction so as not to cause improper sequencing and excessive wear to the plungers and internal components. Misalignment could cause the unit to upset. On longer stroke cylinders mounted horizontally, supports should be added to the center of the extended cylinder to increase the column strength of the cylinder.

The hydraulic cylinder will not withstand lateral pressure when the unit is leaning. Only activate the cylinder when the tractor and trailer are in a straight line (not jack-knifed). Do not activate the cylinder while on unlevel or soft ground, or during heavy crosswinds. Doing so may cause the unit to upset.

Do not activate the cylinder while personnel or equipment are alongside or behind the unit.

WARNING!
Shock pressure can cause severe injury or death and/or damage to the unit and cylinder.

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

Do not extend the cylinder 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.

Check the cylinder operation to ensure the plungers extend in sequence with the largest diameter plunger moving first, then the next largest, etc. When retracting, the smallest plunger should move first, then the next smallest, etc. Mis-staging could cause the unit to upset and/or damage the cylinder due to excessive pressure build-up.

Safety Precautions for Double Acting Telescopic Cylinders

WARNING!
Over pressurizing the cylinder can cause severe injury or death and/or damage to the unit and cylinder.

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

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

NOTICE!

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 psi trying to extend the cylinder, oil pressure trapped on the retract side of the cylinder could see 20,000 psi.

A double acting telescopic cylinder normally requires at least 15 gpm oil flow to retract properly. Make sure the hydraulic pump is developing the required flow.

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 sequence 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.

The hydraulic oil should be checked and changed regularly to avoid contamination leading to internal cylinder damage.

Grease the pin mountings regularly.

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.

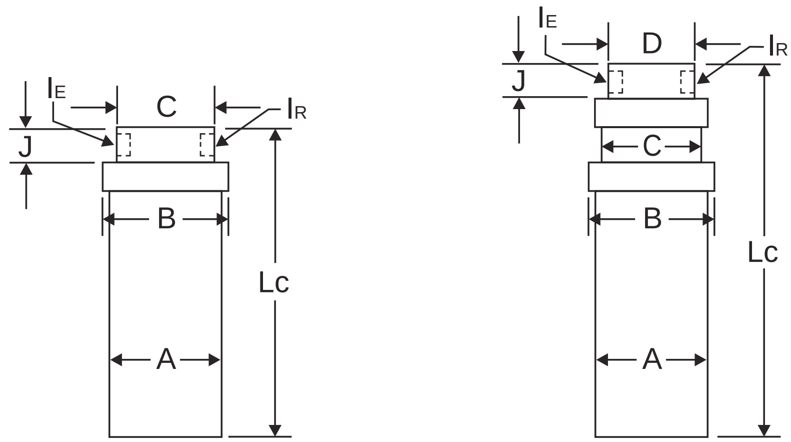
Closed Length Calculations for Double Acting Single & Multiple Stage Cylinders

*Closed length (Lc) for SD Models is computed by one of the three equations below. Model number and stroke required determines which equation to use. Example: To find Lc for SD41 cylinder with 68" stroke. Under SD41 column, use equation III, because the stroke is over 66".

$$Lc = \text{Stroke} + X_1 + X_2 = 68" + 12" + \frac{(68 - 50)}{4.5} = 68" + 12" + (.666)$$

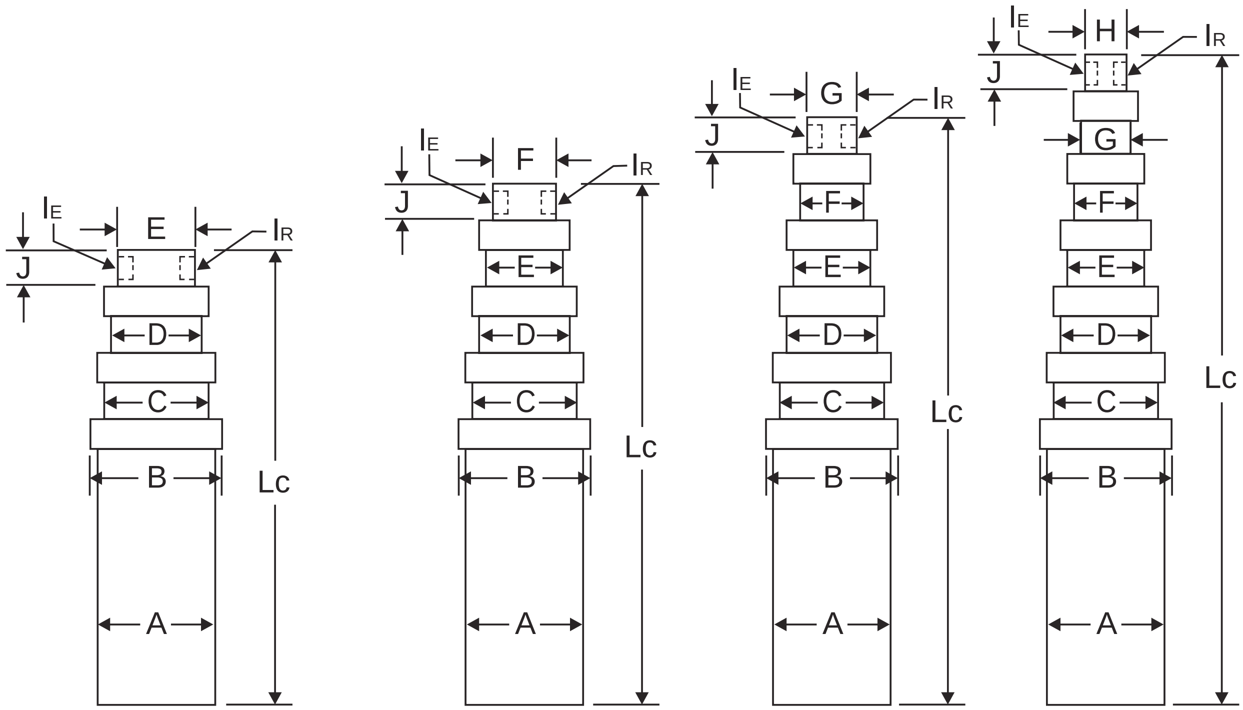
Use next largest whole number. = 68" + 12" + 1" = 81".

The closed length (Lc) is 81" to the stroke 68" for extended length of 149"



		SINGLE STAGE								2 STAGE					
Cylinder Dimensions (inches)		SD31	SD41	SD51	SD61	SD71	SD81	SD91		SD42	SD52	SD62	SD72	SD82	SD92
Main Cylinder O.D.	A	$3^{3}/_{4}$	$4^{3}/_{4}$	$5^{3}/_{4}$	$6^{3}/_{4}$	8	$9^{1}/_{8}$	$10^{13}/_{16}$	A	$4^{3}/_{4}$	$5^{3}/_{4}$	$6^{3}/_{4}$	8	$9^{1}/_{8}$	$10^{13}/_{16}$
Largest Packing Nut O.D.	B	$4^{3}/_{8}$	$5^{3}/_{8}$	$6^{3}/_{8}$	$7^{3}/_{8}$	$8^{5}/_{8}$	$9^{7}/_{8}$	$11^{3}/_{4}$	B	$5^{3}/_{8}$	$6^{3}/_{8}$	$7^{3}/_{8}$	$8^{5}/_{8}$	$9^{7}/_{8}$	$11^{3}/_{4}$
1st Sleeve O.D.	C	$2^{3}/_{4}$	$3^{3}/_{4}$	$4^{3}/_{4}$	$5^{3}/_{4}$	$6^{3}/_{4}$	$7^{7}/_{8}$	$9^{3}/_{8}$	C	$3^{3}/_{4}$	$4^{3}/_{4}$	$5^{3}/_{4}$	$6^{3}/_{4}$	$7^{7}/_{8}$	$9^{3}/_{8}$
2nd Sleeve O.D.	D								D	$2^{3}/_{4}$	$3^{3}/_{4}$	$4^{3}/_{4}$	$5^{3}/_{4}$	$6^{3}/_{4}$	$7^{7}/_{8}$
3rd Sleeve O.D.	E								E						
4th Sleeve O.D.	F								F						
5th Sleeve O.D.	G								G						
6th Sleeve O.D.	H								H						
NPT Port - Extend	I_E	$^{3}/_{4}$	$^{3}/_{4}$	$^{3}/_{4}$	1	1	$1^{1}/_{4}$	$1^{1}/_{4}$	I_E	$^{3}/_{4}$	1	1	$1^{1}/_{4}$	$1^{1}/_{4}$	$1^{1}/_{4}$
NPT Port - Retract	I_R	$^{1}/_{2}$	$^{1}/_{2}$	$^{1}/_{2}$	$^{3}/_{4}$	$^{3}/_{4}$	1	1	I_R	$^{1}/_{2}$	$^{3}/_{4}$	$^{3}/_{4}$	1	1	1
Plunger Extension	J	$1^{5}/_{8}$	$1^{5}/_{8}$	$1^{5}/_{8}$	$2^{1}/_{8}$	$2^{1}/_{8}$	$2^{5}/_{8}$	$2^{5}/_{8}$	J	$1^{5}/_{8}$	$2^{1}/_{8}$	$2^{1}/_{8}$	$2^{5}/_{8}$	$2^{5}/_{8}$	$2^{5}/_{8}$
Max. Recommended Ext. Lgth. at 2000 PSI		131	155	170	186	235	272	386		171	184	199	241	275	390
Max. Stroke at 2000 PSI		59	70	77	84	106	122	174		100	108	117	142	162	234
*To Find Closed Length - Lc	X	9.38	9.38	9.38	10.12	10.12	11.12	11.25	X	13.00	13.50	13.75	14.50	14.75	14.88
Equation I	L_C	Stroke + X up to 45" stroke (O.L. = $3^{3}/_{8}$")							L_C	$\frac{\text{Stroke}}{2} + X$ up to 95" stroke (O.L. = 6")					
Equation II	X_1	12.00	12.00	12.00	12.75	12.75	13.75	13.88	X_1	$\frac{\text{Stroke} - 95}{6}$ (To next largest whole number)					
	L_C	Stroke + X_1 46" to 65" stroke (O.L. = 6")							L_C	$\frac{\text{Stroke}}{2} + X + X_1$ 95" stroke to max. (O.L. = 6" + X_1)					
Equation III	X_2	$\frac{\text{Stroke} - 65}{4.5}$ (To next largest whole number)							X_2	Not Required					
	L_C	Stroke + X_1 + X_2 66" stroke to max.							L_C	Not Required					

Closed Length Calculations for Double Acting Single & Multiple Stage Cylinders



3 STAGE	SD53	SD63	SD73	SD83	SD93
A	5 3/4	6 3/4	8	9 1/8	10 13/16
B	6 3/8	7 3/8	8 5/8	9 7/8	11 3/4
C	4 3/4	5 3/4	6 3/4	7 7/8	9 3/8
D	3 3/4	4 3/4	5 3/4	6 3/4	7 7/8
E	2 3/4	3 3/4	4 3/4	5 3/4	6 3/4
F					
G					
H					
I_E	3/4	1	1	1 1/4	1 1/4
I_R	1/2	3/4	3/4	1	1
J	1 5/8	2 1/8	2 1/8	2 5/8	2 5/8
	215	220	259	289	403
	146	150	175	194	268
X	14.00	14.75	14.75	15.75	15.88
L_C	$\frac{Stroke}{3} + X$ O.L. = 6" up to 120" stroke				
X_1	$\frac{Stroke - 120}{5}$ (To next largest whole number)				
L_C	$\frac{Stroke}{3} + X + X_1$ O.L. = 6" + X_1 120" stroke to max.				
X_2	Not Required				
L_C	Not Required				

4 STAGE	SD64	SD74	SD84	SD94
A	6 3/4	8	9 1/8	10 13/16
B	7 3/8	8 5/8	9 7/8	11 3/4
C	5 3/4	6 3/4	7 7/8	9 3/8
D	4 3/4	5 3/4	6 3/4	7 7/8
E	3 3/4	4 3/4	5 3/4	6 3/4
F	2 3/4	3 3/4	4 3/4	5 3/4
G				
H				
I_E	3/4	1	1	1 1/4
I_R	1/2	3/4	3/4	1
J	1 5/8	2 1/8	2 1/8	2 5/8
	263	289	314	425
	191	209	226	304
X	15.25	15.75	16.25	16.88
L_C	$\frac{Stroke}{4} + X$ O.L. = 6" up to 140" stroke			
X_1	$\frac{Stroke - 140}{6}$ (To next largest whole number)			
L_C	$\frac{Stroke}{4} + X + X_1$ O.L. = 6" + X_1 140" stroke to max.			
X_2				
L_C				

5 STAGE	SD75	SD85	SD95
A	8	9 1/8	10 13/16
B	8 5/8	9 7/8	11 3/4
C	6 3/4	7 7/8	9 3/8
D	5 3/4	6 3/4	7 7/8
E	4 3/4	5 3/4	6 3/4
F	3 3/4	4 3/4	5 3/4
G	2 3/4	3 3/4	4 3/4
H			
I_E	3/4	1	1
I_R	1/2	3/4	3/4
J	1 5/8	2 1/8	2 1/8
	350	370	465
	259	272	335
X	16.25	17.25	17.88
L_C	$\frac{Stroke}{5} + X$ O.L. = 6" up to 140" stroke		
X_1	$\frac{Stroke - 140}{8}$ (To next largest whole number)		
L_C	$\frac{Stroke}{5} + X + X_1$ O.L. = 6" + X_1 140" to 210" stroke		
X_2	$\frac{Stroke - 210}{3.5}$ (To next largest whole number)		
L_C	$\frac{Stroke}{5} + X + X_2 + 9$ O.L. = 15" + X_2 211" stroke to max.		

6 STAGE	SD86	SD96
A	9 1/8	10 13/16
B	9 7/8	11 3/4
C	7 7/8	9 3/8
D	6 3/4	7 7/8
E	5 3/4	6 3/4
F	4 3/4	5 3/4
G	3 3/4	4 3/4
H	2 3/4	3 3/4
I_E	3/4	1
I_R	1/2	3/4
J	1 5/8	2 1/8
	T.B.D.	T.B.D.
	T.B.D.	T.B.D.
X	17.75	18.38
L_C	$\frac{Stroke}{6} + X$ O.L. = 6" up to 150" stroke	
X_1	$\frac{Stroke - 150}{10}$ (To next largest whole number)	
L_C	$\frac{Stroke}{6} + X + X_1$ O.L. = 6" + X_1 150" to 250" stroke	
X_2	Check with Engineering	
L_C	Check with Engineering	

Standard and Custom Welded Rod Cylinders (RDH)

A welded rod hydraulic cylinder is a type of hydraulic cylinder that is used in various applications requiring the con-version of hydraulic power into mechanical power. The key feature of a welded rod hydraulic cylinder is its design: the cylinder barrel and end cap are welded together, creating a robust, sealed system. This welded construction provides a high-strength, durable design that can withstand high pressures and heavy-duty applications such as material handling, oil & gas, military, mining, construction equipment, and various types of heavy-duty market applications.

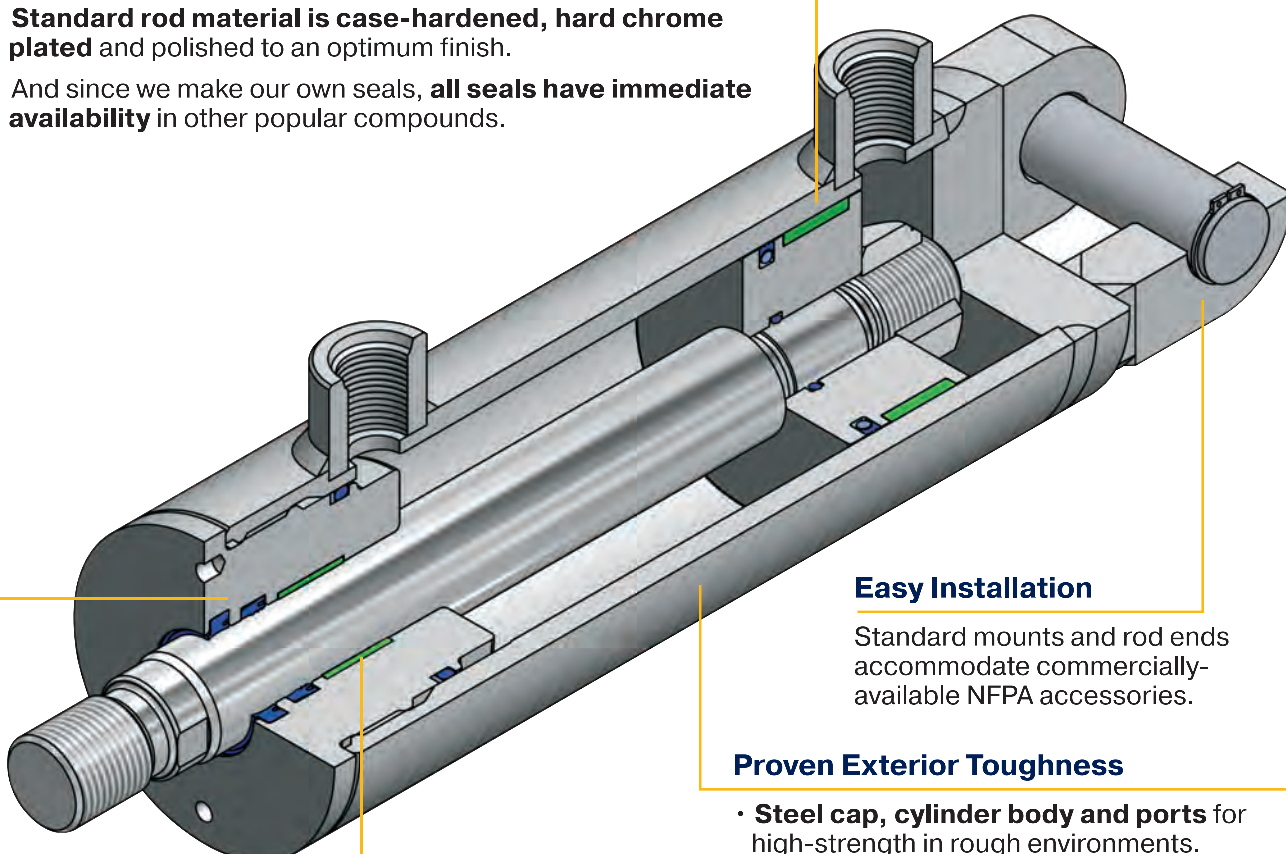
Advanced Sealing Technology

All components are manufactured by Parker and designed for high performance, long service life, low friction and zero leakage.

- **Tri-lip rod seal** (3 sealing edges!) and bi-directional piston seal feature proven leak-free performance.
- **Durable polyurethane** material is used to maximize seal life.
- **Nitrile end seals** and backup rings on a smooth bore of the cylinder body for optimal sealing and elimination of extrusion problems.
- **Composite rod and piston wear rings** are internally lubricated for reduced friction and formulated for heavy-duty, load-bearing applications.
- **Standard rod material is case-hardened, hard chrome plated** and polished to an optimum finish.
- And since we make our own seals, **all seals have immediate availability** in other popular compounds.

Switch-Ready

- **The Parker ALS Switch is the lowest cost point feedback solution** for carbon steel cylinders with a piston magnet ring.
- **Switches can be located anywhere along the stroke** and in any orientation.
- **Unique round body brackets** minimize installation time.
- **EPS & CLS threaded switches** are available for end-of-stroke sensing.



Easy Installation

Standard mounts and rod ends accommodate commercially-available NFPA accessories.

Proven Exterior Toughness

- **Steel cap, cylinder body and ports** for high-strength in rough environments.
- **Case hardened, hard chrome plated** and polished carbon steel piston rod for damage resistance, long rod seal life and low friction.
- **Outboard urethane rod wiper seal** to remove external debris and adherents from the piston rod.
- **High quality paint coating** for interior or exterior applications.

Composite Wear Rings

Parker WearGard™ bearing materials are backed by over 30 years of manufacturing expertise.

- Heat stabilized and internally lubricated for **low friction and maximum service** life in any application.
- Strength characteristics meet or exceed most metals traditionally used in wear rings.

Environmentally Friendly
RoHS-compliant materials

⚠ **PROP 65 WARNING** **WARNING:** This product can expose you to chemicals including **Lead and Lead Compounds** which are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

General Specifications

- Heavy duty service
- Standard construction – threaded head, welded cap
- Bore diameters – 1.50" through 8.00"
- Strokes – available in any practical stroke length
- Piston rod diameters –0.625" through 5.500" (based on bore size)
- Rod end styles – 5 standard, specials available
- Single rod end or double rod ends

In line with our policy of continuing product improvement, specifications in this catalog are subject to change.

- Mounting styles –9 standard styles at various application ratings
- Nominal pressure – 3,000 psi[1] (207 Bar)
- Standard fluid media – filtered hydraulic oil[2]
- Standard temperature – -10˚F to +165˚F[3]

[1] If hydraulic pressure exceeds 3,000 psi (207 Bar), send application data for engineering evaluation and recommendation.
[2] See Seal Information pages for appropriate seals with different fluid media.
[3] See Seal Information pages for lower and higher temperature service.

Material Specifications – Standard Temperatures and Applications

Head	Ductile iron
Cap	Carbon steel
Cylinder body	Carbon steel
Piston rod	Case-hardened, chrome plated high strength carbon steel
Rod seal	Polyurethane
Rod wiper seal	Urethane
Rod bearing	WearGard™
Piston	Ductile iron
Piston seal	Polyurethane
Piston seal energizer	Nitrile
Piston bearing	WearGard™ or MolyGard™
Piston fastener	Carbon steel
Piston joint o-ring	Fluorocarbon
End seal o-ring	Nitrile
Backup ring	Nitrile

Operating Temperature Options – Material and Part Changes

High temperatures (to +250˚F) Class 5	Rod seal, rod wiper seal, end seal, backup ring and piston seal energizer are fluorocarbon. Piston seal is bronze filled PTFE.
Extreme high temperatures (to +400˚F) Class 8	Rod seals, rod wiper seal and piston seal are bronze filled PTFE. End seal o-ring, backup ring and seal energizers are fluorocarbon. Bearings are UltraComp™ CGT.
Low temperatures (to -50˚F) Class 4	Piston seal energizer, end seal and backup ring are low temperature rated nitrile.

Other Standard Options – Material and Part Changes

Cylinder seal options[4] (for chemical compatibility)	Water Base Fluid Seals (Class 2) EPR Seals (Class 3) Fluorocarbon Seals (Class 5) HWCF Seals (Class 6) Mixed-Media Piston Seals (bronze filled PTFE and nitrile)
Magnetic ring	Sintered NdFeB
Piston rod material options	17-4 PH stainless steel, chrome plated 303 and 316 stainless steel are available at lower operating pressures; consult factory.

[4] See Seal Information pages for additional specifications.

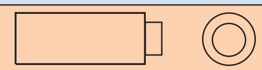
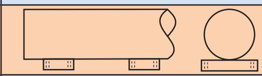
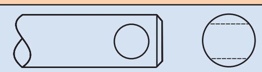
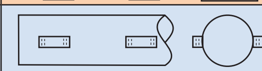
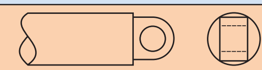
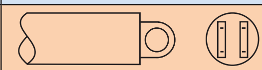
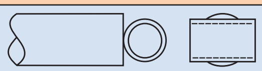
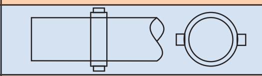
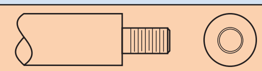
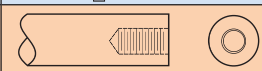
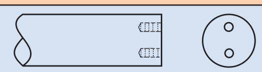
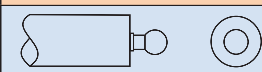
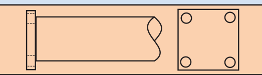
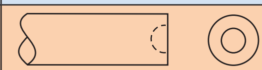
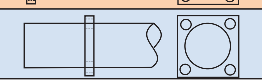
Private Labeling

For those discerning customers wanting a personal touch, we can "private label" cylinders at no charge. The information must be in text format (no logos) and the label must include our serial number and cylinder pressure rating. Just place an "S" for special in the Special Modification field and provide the private label information in the item notes. We take care of the rest!

If labels with logos are desired, contact the Cylinder and Accumulator Division for assistance.

Custom Options and Modifications - Welded Rod Cylinders

Available Mounting Styles

Code Letter	Mount Description	Mount Sketch	Mount Location	Code Letter	Mount Description	Mount Sketch	Mount Location
A	Plain No Mount		Body or Rod	J	Foot / Pad Mount		Body
B	Pin-Eye Drilled Thru Rod		Rod	K	Centerline Mount		Body
C	Pin-Eye Drilled Thru Lug		Body or Rod	L	Double Lug Clevis Mount		Body or Rod
D	Cross Tube		Body or Rod	M	Trunnion Mount		Body
E	Threaded		Body or Rod	N	Rod End Drilled and Tapped		Rod
F	Drilled and Tapped		Body or Rod	O	Ball Mount		Body or Rod
G	Flange Mount at Base		Body	P	Socket Mount		Body or Rod
H	Flange Mount Mid-Body		Body				

Custom Options and Modifications (consult factory)

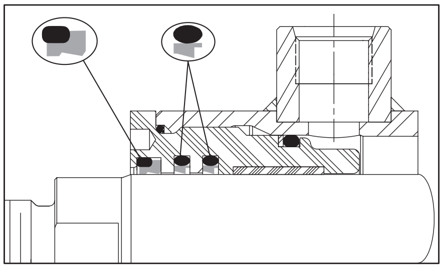
- Special Heads, Caps, Pistons and Mounts
- Mount/Port Relocation
- Oversize/Undersize Ports
- Port Thread Styles
- Port Blocks/Valve Manifold and Flow Tubing (at either end)
- Multiple Ports
- Cartridge Valves
- Air Bleeds
- Double Rod End
- Oversize/Undersize Rod Diameters
- Extra Thick Chrome Plated Piston Rod
- Rod Materials (stainless steels, alloy steels, etc.)
- Global Shield
- Nitrided Rod
- Pinned Rod to Piston
- Welded Rod to Piston
- Welded Rod End Accessory
- Extra Wrench Flats
- Rod Boot
- Parker Crown™ Wiper (Extreme Duty Non-Metallic Rod Wiper)
- Metallic Rod Wiper
- Seal Materials (additional compounds)
- Stop Tube
- Stroke Adjuster
- Point Feedback – ALS Switch (PNP/NPN Mid-Stroke Switch)
- Point Feedback – CLS-A Switch (Magnetically-Actuated End-Of-Stroke Limit Switch)
- Point Feedback – EPS-A Sensor (PNP End-Of-Stroke Proximity Sensor)
- Continuous Linear Position Feedback Linear Displacement Transducer (LDT)
- Fixed Cushions
- High Pressure Service (>3,000 PSI)
- Pneumatic Service
- Water Submersible Design
- Chrome Plated Bore
- Nickel Plated Assembly
- Application-Specific Paint (Marine-Grade, Salt-Spray Rated, Caustic Washdown, etc.)
- Stainless Steel Construction (derated operating pressure)
- Dual End Seals

The inside story on why Series RDH is your best choice in heavy duty roundline cylinders

Optional Extreme Temperature/ Low Friction Seal Assembly – Dual bronze filled PTFE rod seals and bronze filled PTFE wiper seal are energized with fluorocarbon o-rings to maintain consistent contact with the piston rod.

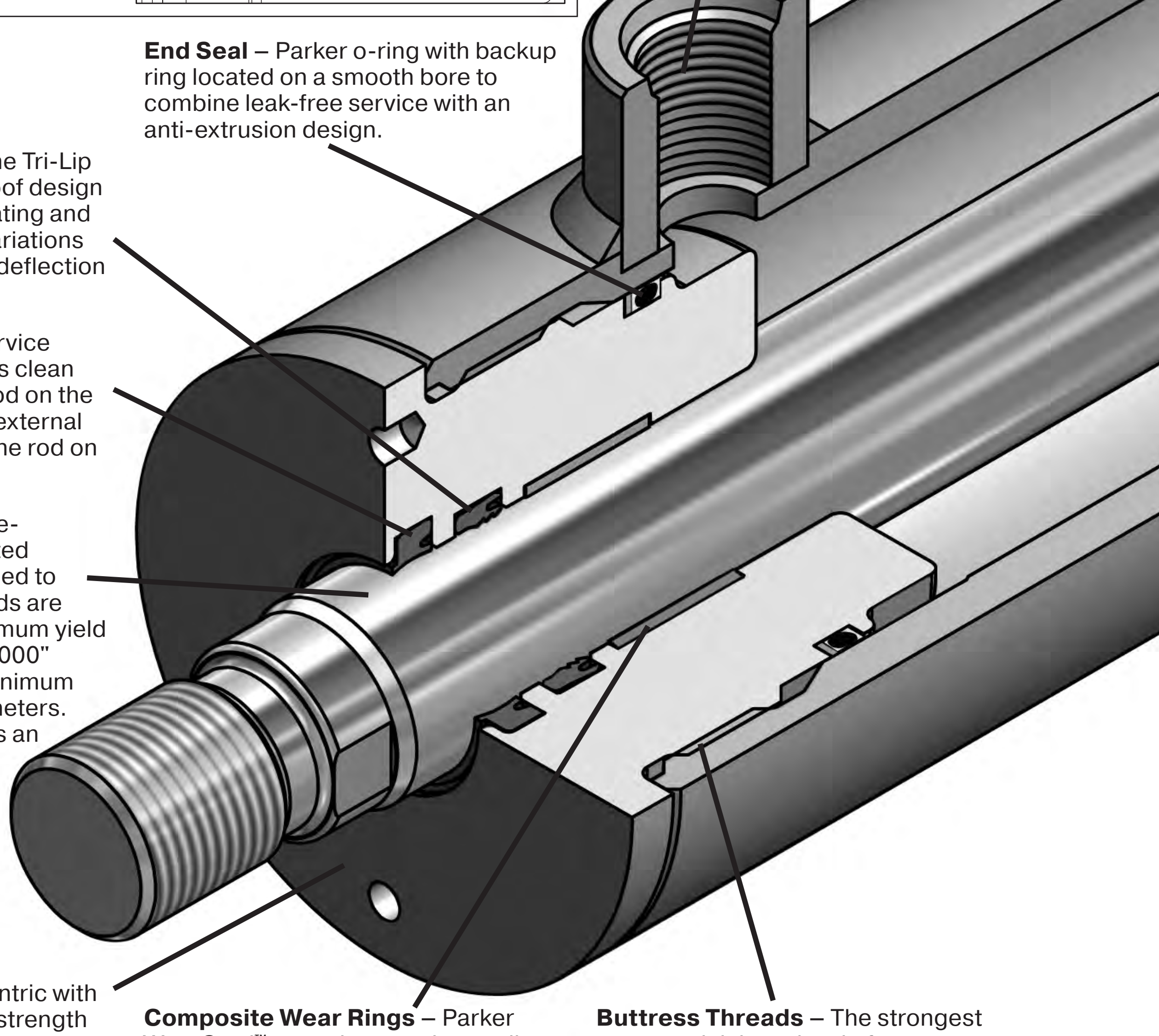
The result is excellent sealing performance with low friction. Our seal set provides a "dry rod" surface on the extend stroke with rod scraping to clean the rod on the retract stroke. Heat resistance to 400˚F with the Class 8 Seals option.

For additional details, see the Low Friction Seals page and Class 8 Seals specifications on the Seal Information page.



Ports – Seal-welded to the cylinder body. SAE straight thread o-ring ports are standard. Other port styles (NPTF, BSPP, BSPT, etc.) are also available.

End Seal – Parker o-ring with backup ring located on a smooth bore to combine leak-free service with an anti-extrusion design.



Primary Seal – Polyurethane Tri-Lip Rod Seal is a proven leakproof design – completely self-compensating and self-relieving to withstand variations and conform to mechanical deflection that may occur.

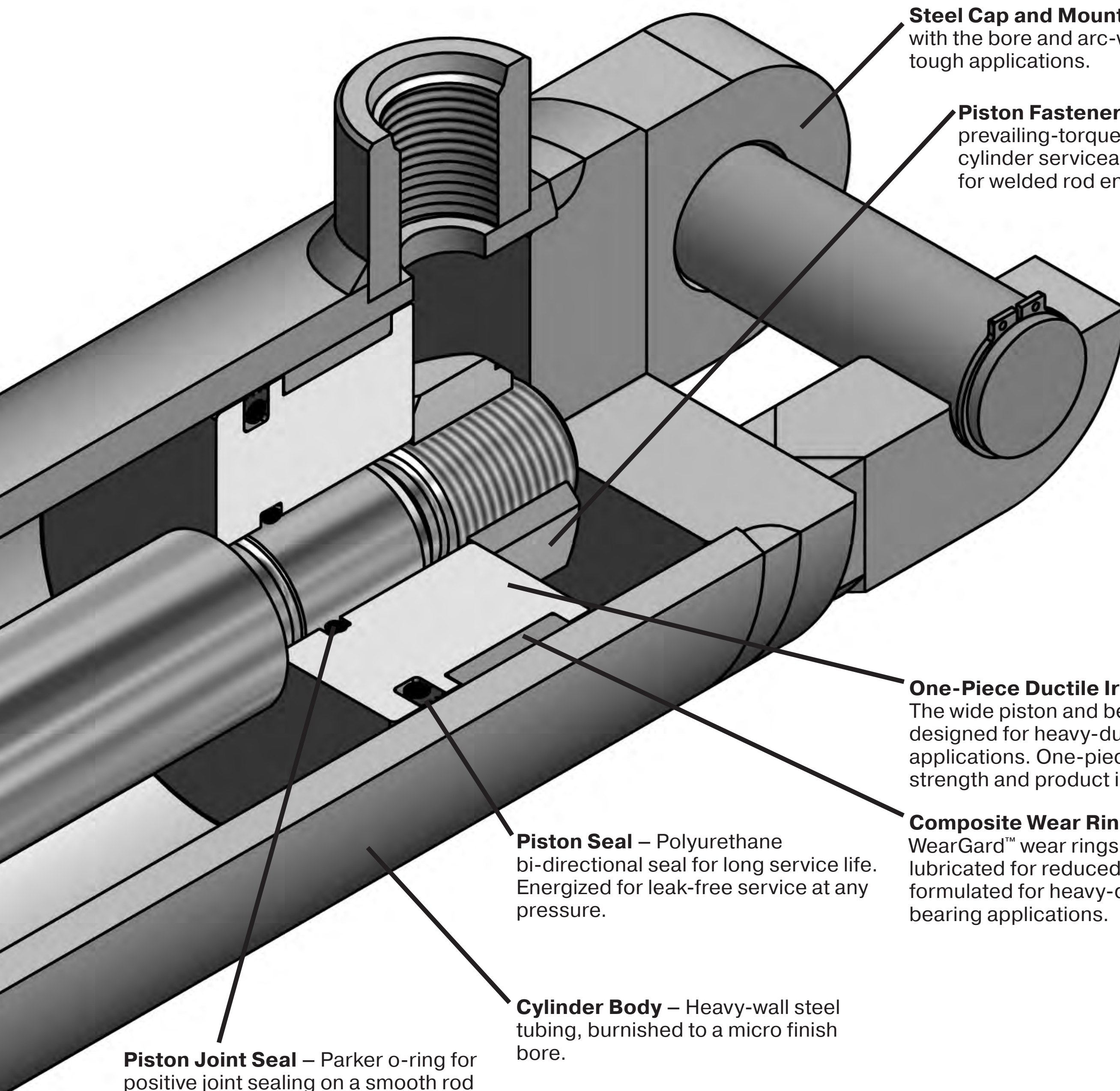
Secondary Seal – Dual-Service Urethane Wiperseal™ – wipes clean any oil film adhering to the rod on the extend stroke and removes external debris and adherents from the rod on the return stroke.

Piston Rod – Induction case-hardened, hard chrome-plated medium carbon steel, polished to an optimum finish. Piston rods are made from 100,000 psi minimum yield material for .625" through 4.000" diameters and 70,000 psi minimum yield material for larger diameters. Stainless steel is available as an option.

Ductile Iron Head – Concentric with the bore, it acts as the high-strength rod guide and housing for the rod seal, wiper seal and bearing. Torqued to the cylinder body for lasting cylinder integrity.

Composite Wear Rings – Parker WearGard™ wear rings are internally lubricated for reduced friction and formulated for heavy-duty, load-bearing applications.

Buttress Threads – The strongest commercial thread style for pressure vessels with axial and impact loading.



Steel Cap and Mount – Concentric with the bore and arc-welded for tough applications.

Piston Fastener – Carbon steel, prevailing-torque type nut[1] for cylinder serviceability (especially for welded rod ends).

One-Piece Ductile Iron Piston – The wide piston and bearing are truly designed for heavy-duty industrial applications. One-piece design for strength and product integrity.

Composite Wear Rings – Parker WearGard™ wear rings are internally lubricated for reduced friction and formulated for heavy-duty, load-bearing applications.

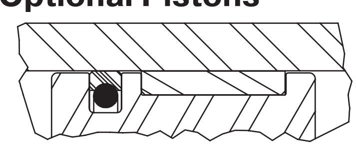
Piston Seal – Polyurethane bi-directional seal for long service life. Energized for leak-free service at any pressure.

Cylinder Body – Heavy-wall steel tubing, burnished to a micro finish bore.

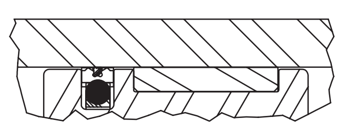
Piston Joint Seal – Parker o-ring for positive joint sealing on a smooth rod diameter.

[1] Only for 1.50" to 5.00" bores. For 6.00" to 8.00" bores, pistons are threaded and torqued to the piston rod, and set screws are used to lock the piston to the rod.

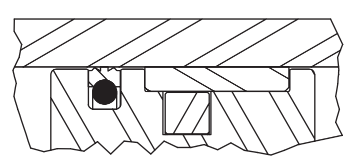
Optional Pistons



Hi Load/Low Friction Piston – Bronze filled PTFE piston seal for maximum seal life in extreme duty and side load applications.



Mixed Media Piston – Used for dissimilar fluids or a gas on either side of the piston (i.e. air/oil applications).



Magnetic Piston – Includes magnetic rings for the ALS Switch option.

Welded Rod Cylinder - Theoretical Push Forces for Cylinders

Cylinder Bore Ø	Piston Area (In.^{2})	Cylinder Push Stroke Force in Pounds at Various Pressures (psi)						
		100	250	500	1000	1500	2000	3000
1.50	1.77	177	443	885	1770	2651	3540	5310
2.00	3.14	314	785	1570	3140	4712	6280	9420
2.50	4.91	491	1228	2455	4910	7363	9820	14730
3.25	8.30	830	2075	4150	8300	12444	16600	24900
4.00	12.57	1257	3143	6285	12570	18850	25140	37710
5.00	19.64	1964	4910	9820	19640	29453	39280	58920
6.00	28.27	2827	7068	14135	28270	42412	56540	84810
7.00	38.49	3849	9623	19245	38490	57727	76980	115470
8.00	50.27	5027	12568	25135	50270	75398	100540	150810

Welded Rod Cylinder - Theoretical Pull Forces for Cylinders

Cylinder Bore Ø	Piston Rod Ø	Piston Rod Area (In.^{2})	Cylinder Pull Force in Pounds at Various Pressures (psi)						
			100	250	500	1000	1500	2000	3000
1.50	0.625	0.307	146	365	730	1460	2190	2920	4380
	1.000	0.785	98	245	491	982	1473	1964	2946
2.00	1.000	0.785	236	589	1178	2355	3533	4710	7065
	1.375	1.48	166	414	828	1655	2483	3310	4965
2.50	1.000	0.785	413	1031	2063	4125	6188	8250	12375
	1.375	1.48	343	856	1713	3425	5138	6850	10275
	1.750	2.41	250	625	1250	2500	3750	5000	7500
3.25	1.375	1.48	682	1704	3408	6815	10223	13630	20445
	1.750	2.41	589	1473	2945	5890	8835	11780	17670
	2.000	3.14	516	1290	2580	5160	7740	10320	15480
4.00	1.750	2.41	1016	2540	5080	10160	15240	20320	30480
	2.000	3.14	943	2358	4715	9430	14145	18860	28290
	2.500	4.91	766	1915	3830	7660	11490	15320	22980
5.00	2.000	3.14	1650	4125	8250	16500	24750	33000	49500
	2.500	4.91	1473	3683	7365	14730	22095	29460	44190
	3.000	7.07	1257	3143	6285	12570	18855	25140	37710
	3.500	9.62	1002	2505	5010	10020	15030	20040	30060
6.00	2.500	4.91	2336	5840	11680	23360	35040	46720	70080
	3.000	7.07	2120	5300	10600	21200	31800	42400	63600
	3.500	9.62	1865	4663	9325	18650	27975	37300	55950
	4.000	12.57	1570	3925	7850	15700	23550	31400	47100
7.00	3.000	7.07	3142	7855	15710	31420	47130	62840	94260
	3.500	9.62	2887	7218	14435	28870	43305	57740	86610
	4.000	12.57	2592	6480	12960	25920	38880	51840	77760
	4.500	15.90	2259	5648	11295	22590	33885	45180	67770
	5.000	19.63	1886	4715	9430	18860	28290	37720	56580
8.00	3.500	9.62	4065	10163	20325	40650	60975	81300	121950
	4.000	12.57	3770	9425	18850	37700	56550	75400	113100
	4.500	15.90	3437	8593	17185	34370	51555	68740	103110
	5.000	19.63	3064	7660	15320	30640	45960	61280	91920
	5.500	23.76	2651	6628	13255	26510	39765	53020	79530

Installation and Maintenance

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.

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.

Because of our self-compensating Packing design, Standard Commercial Hydraulics Cylinders require no packing adjustment. For Commercial Packing Assembly Installation Procedure see Service Repair Kit Page.

Procedure for Adjusting Telescopic Cylinder Head Nuts.
(For Cylinder designs using no Wave Springs and/or no U-Seals)
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 a 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 was loosened.
6. Tighten set screws.

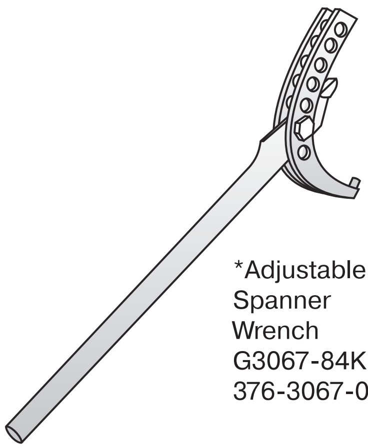
Procedure for Mis-Staging or Mis-Sequencing Cylinder.
1. Loosen set screws in head nut that holds in packing which fits over stage that is sticking.
2. Lightly tap head nut around circumference with a hammer.
3. Back head nut off 1/2 turn using a spanner or chain wrench.
4. Cycle cylinder, if cylinder 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 of these cylinders, it is advisable to bleed the air from the cylinder weekly.

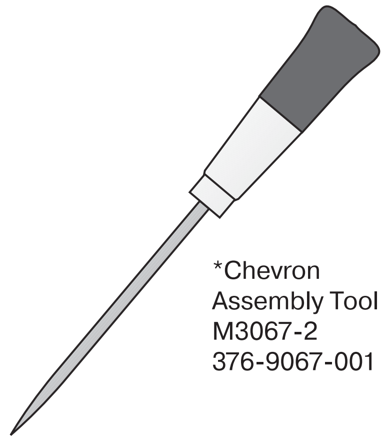
Manual bleeding is accomplished by:
1. Empty the dump body of any material.
2. Remove the cover plate from the dog house of the dump body to access the bleeder valve.
3. Fully extend the cylinder, raising the EMPTY dump bed.
4. Lower the dump to within 1 foot from resting on the frame.
5. With the fingers, 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 an Authorized Service Center for Instructions.

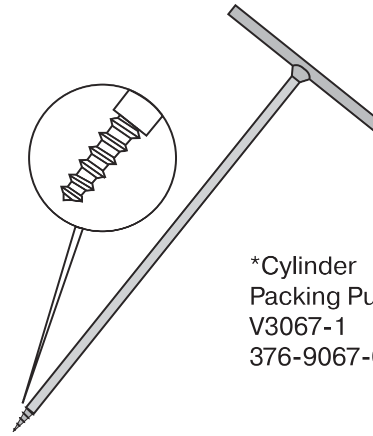
Telescopic Cylinders - Hydraulic Cylinder Required Service Tools



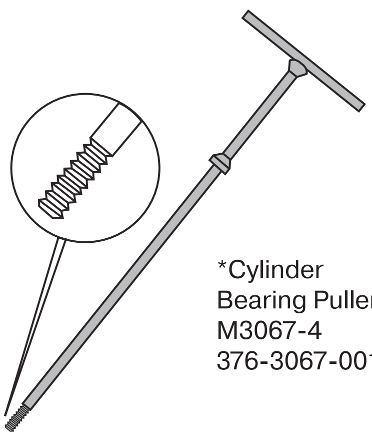
*Adjustable Spanner Wrench
G3067-84K-4
376-3067-006



*Chevron Assembly Tool
M3067-2
376-9067-001



*Cylinder Packing Puller
V3067-1
376-9067-003

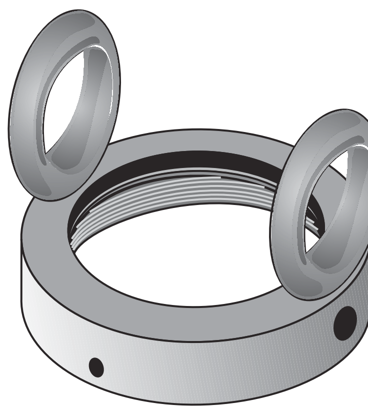


*Cylinder Bearing Puller
M3067-4
376-3067-001

*Strap Wrench
P3067
376-9067-002

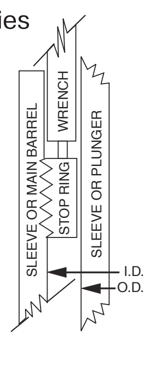
Piston Ring Plier
M3067-3K
376-3067-015

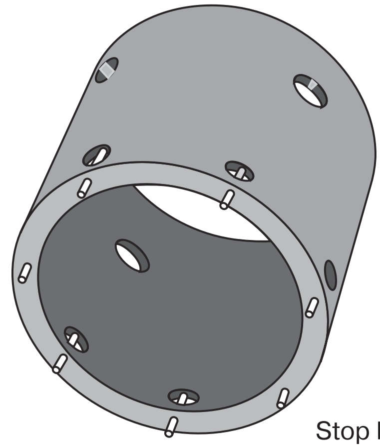
Tools Required
Proper tools make the job of servicing cylinders easier and faster and reduce the possibility of damaging the finely machined surfaces. We recommend that you have the tools shown on this page prior to attempting service on Commercial telescopic cylinders. Tools with an * are required for all cylinders regardless of size. Lifting rings and stop ring wrenches must be ordered to fit the specific sleeve in the cylinder.



Lifting Ring
BC3067 Series

Sleeve or Main O.D.	Eng #	Part Number
3 3/4”	BC3067-1	376-3067-008
4 3/4”	BC3067-2	376-3067-009
5 3/4”	BC3067-3	376-3067-010
6 3/4”	BC3067-4	376-3067-011
7 7/8”	BC3067-5	376-3067-012
9 3/8”	BC3067-6	376-3067-013
11 1/8”	BC3067-7	376-3067-014





Stop Ring Wrench
BA3067 Series

Sleeve or Main O.D.	Sleeve or Plunger O.D.	Eng #	Part Number
3 1/4”	2 3/4”	BA3067-1	376-6067-047
4 1/4”	3 3/4”	BA3067-2	376-6067-048
5 1/4”	4 3/4”	BA3067-3	376-6067-049
6 1/4”	5 3/4”	BA3067-4	376-6067-050
7 1/4”	6 3/4”	BA3067-5	376-6067-051
8 7/16”	7 7/8”	BA3067-6	376-6067-052
9 7/8”	9 3/8””	BA3067-7	376-6067-053

Disassembly

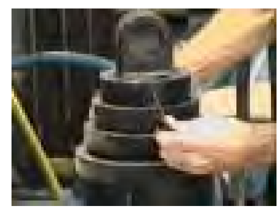
Open the air release valve, remove the port pipe plugs and drain all of the oil out of the cylinder.

We recommend draining the oil from the cylinder before hoisting it to the vertical work stand position. It is easiest to drain oil when the cylinder is in a horizontal position and with the port down and open. Rotate the last plunger so the bleeder hole is on top and open. If you don't drain the oil, oil will squirt out as each tube is removed.

Step 2
Firmly secure the cylinder in place with the rod end up to a sturdy workbench or a suitable stand that has access to an overhead crane.

Step 3
Remove the grease fitting and air release valve with an open end wrench or an adjustable crescent wrench.

Step 4
Remove pipe plugs on double acting telescopic cylinders with an adjustable crescent wrench.

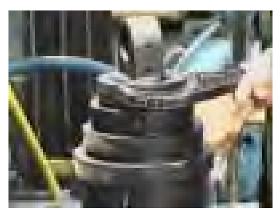


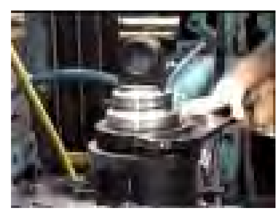
Step 5
Clean head nut thread area, spray with lubricating oil (similar to WD-40).

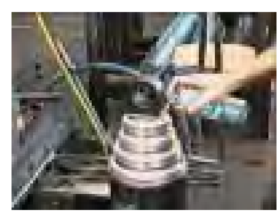
Step 6
Remove set screws from all packing nuts with a 1/8" Allen wrench.

Step 7
Remove all packing nuts with adjustable spanner wrench, G3067-84K-4, Starting with the smallest thru the largest.

If the nut will not move, a sharp blow with a blunt chisel or rod may be required to jar the nut loose. If using a punch to break loose head nut, be careful not to damage threads.







Step 8
Remove and discard old nylon balls, which were in packing nuts.

Step 9
Remove the wiper seal from the packing nut. Discard the old wiper seal.

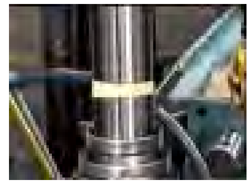
Step 10
Clean the thread and bearing area with a solvent and a clean, lintless rag.

Disassembly

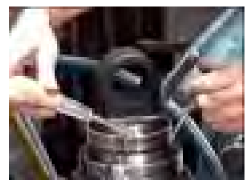
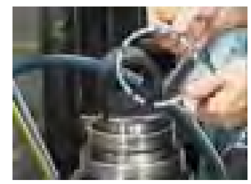
Step 11
Remove all bearing rings with two bearing ring pullers M3067-4.


Step 12
Remove all packing with packing puller V3067-1.

Or extend the plunger or sleeve out about one foot. Wrap masking tape around a clean area on the plunger or sleeve. Push plunger or sleeve back into and past the packing and pull out. Packing will usually pop out, if not, repeat the process.

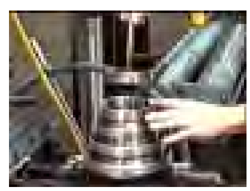
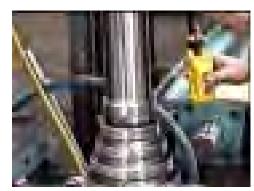



Step 13
Remove wave spring from packing recess with a narrow screwdriver.

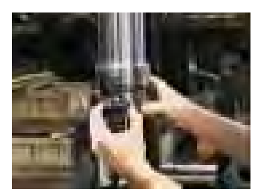
Step 14
Remove stop rings from all stages with stop ring wrenches BA3067 series. If the stop ring will not move, a sharp rap may be required to jar the ring loose. If the sleeve containing the stop ring turns during removal, it should be held with a nylon strap wrench P3067.


Step 15
Removal of the plunger or sleeve will lift out the stop ring and expose the piston bearing ring. Use lifting ring tool series BC3067 to lift out the sleeves.

Step 16
Remove piston bearing ring by hand.

Step 17
Remove piston rings on double acting cylinders with piston ring pliers M3067-3K and remove piston bearing ring or rings by hand.



Step 18
Repeat with remaining sleeves

Assembly

Open the air release valve, remove the port pipe plugs and drain all of the oil out of the cylinder.

All bores in the packing area and plunger outside diameters must be free of tool marks and scratches. Polish with a fine paper, crocus cloth or a abrasive pad. All parts should be clean and free of any contamination.

Start Assembly
Starting with the largest sleeve.

Assemble piston bearings to all sleeves and plunger by hand.
Note: use bronze piston bearing on largest sleeve if piston passes port.

Assemble piston rings on double acting cylinders using piston ring pliers M3067-3K.
Note: stagger cast iron piston rings.

Next, lubricate the piston bearing with grease.

Step 2
Place the sleeve into the assembly using the proper lifting ring in the BC3067 series.

Step 3
Lubricate the stop ring with grease and slide it onto the sleeve with its wrench holes up.

Slide threaded stop ring onto the sleeve and lower into the assembly.

Thread the stop ring into the assembly with the proper stop ring wrench in the BA3067 series. Turn the stop ring wrench counter-clockwise slowly for several turns, until a subtle “click” is heard or a slight settling of the wrench is felt. This indicates that the start points of the internal and external threads are aligned for engagement.

Next, turn the wrench clockwise until the stop ring bottoms out.

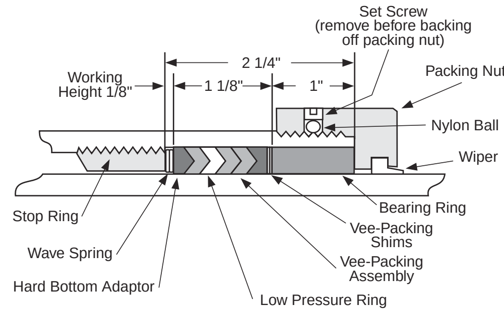
Bottom out stop ring with a sharp blow. If sleeve turns during assembly, it must be held with strap wrench P3067.

Measure stop ring depth. The stop ring should bottom out at a depth of 2 ¼”.

Note: Check if Beveled or Non-beveled Stop Rings and Overlap Collars. Do not use a Beveled Stop Ring with Non-Beveled Overlap Collar or visa versa.

Step 4
Install wave spring with gap edge against top of the cylinder stop ring.

Assembly



Step 5
Remove shims from packing set and measure packing height under finger pressure. Add one shim for each 1/ 32” that the packing measures under 1-1/8”. Measure depth to top of stop ring from top of tube. This dimension should be 2-1/4”, however, it may vary slightly due to seating of the stop ring. Add one shim to the packing set for every 1/32” that this dimension measures over 2-1/4” or remove one shim from the packing set for every 1/32” that this dimension measures under 2-1/4”.

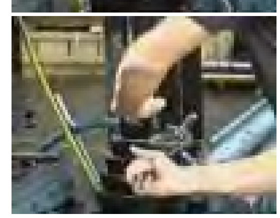
Step 6
Soak packing in hydraulic oil for a few minutes. (Check bottom adapter. Only hard type can be used with the wave spring). Install packing, one ring at a time, in the proper sequence as shown in the sketch. Note: The soft, low pressure ring must be in the second position from the pressure side. Installed packing height need not be checked because wave spring will vary this dimension. Installation of bearing and packing nut will compress wave spring for proper packing pre-load. Pull down tight against tube.

Step 7
Install gland bearing ring with tapped holes showing.

Step 8
Install new wiper seals in all packing nuts.

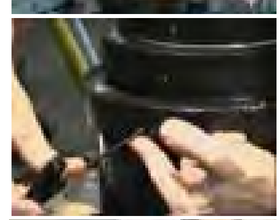
Step 9
Apply anti-seize compound to the sleeve threads.

Step 10
Install packing nut and tighten with the adjustable spanner wrench G3067-84K-4, if packing height is proper packing nut will bottom out.



Step 11
Repeat steps 1 through 10 for remaining sleeves and plunger.

Step 12
Install new nylon balls and set screws into all packing nuts and tighten with 1/ 8” Allen wrench.



Step 13
Install air release or pipe plugs as applicable.

General Air Bleeding Procedure for Double Acting Telescopic Cylinder (Plunger up)

Start with Cylinder in "Retracted Position"

1. Insure all hydraulic plumbing lines and connections are in good working order and properly attached.

2. Locate the extend air purge fitting located on the outside of the plunger head located near the extend port.

3. Locate the retract air purge fitting located on the outside of the plunger head located next to the retract port.

4. Apply and hold hydraulic pressure (a minimum amount is all that is needed for air purge operations) to the retract port. Cylinder should be fully retracted.

5. *Purge air / fluid from the retract fitting located on plunger head until a continuous clear flow of fluid is being displaced that is free of any entrained air.

6. Close this fitting.

7. Apply and hold hydraulic pressure (a minimum amount is all that is needed for air purge operations) to the extend port with the retract side ported to reservoir tank. Allow cylinder to extend as far as possible with the given conditions but a minimum distance of 12 inches is recommended.

8. *Purge air / fluid from the extend air purge fitting located on the outside of the plunger head until a continuous clear flow of fluid is being displaced that is free of any entrained air.

9. Once a clear flow is established close the fitting.

10. Remove Hydraulic pressure from the extend side port.

11. Retract cylinder and let the cylinder rest for several minutes.

12. Repeat steps 5 to 12 a minimum of 5 times or as needed.

*The flow and pressure to expel entrained air on the extend side of the cylinder comes from the compression of any air volume, or entrained air, in the extend side fluid of the cylinder. As the volume of air is reduced, or eliminated, the flow through the purge fitting will decrease, and eventually stop.

This completes the air bleed procedure.

Standard Test Procedure for Hydraulic Cylinders

1) Function Test
Once the Cylinder is placed on the test stand and hydraulic lines attached, the cylinder will be cycled its full stroke a minimum of three (3) full cycles.
The cylinder will be rejected if it functions erratically. Erratic function is excessive chatter, slapstrick, stalling and uncorrectable misstaging.

2) Proof Pressure Test
After the function test is performed the cylinder will be extended fully and pressure held for a minimum of thirty (30) seconds. This pressure will be 2500 psi or a pressure indicated on the assembly print. The cylinder will be rejected for external leakage or structural deformation. If the cylinder is double acting, it will be fully retracted and pressure held for a minimum of thirty (30) seconds. The pressure will be 2500 psi or a pressure indicated on the assembly print. The cylinder will be rejected for external leakage or structural deformation.

3) Internal Bypass Test
This test will be performed on all double acting cylinders and can be done in conjunction with the Proof Pressure Test. The cylinder will be fully extended and pressure held at 2500 psi. The retract line will be removed and piston seal bypass will be determined by the flow out of this cylinder port. Excessive bypass will be a cause for cylinder rejection. The cylinder will be fully retracted and pressure held at 2500 psi. The extend line will be removed and the piston bypass will be determined by the flow out of this cylinder port. The cylinder will be rejected for excessive flow. When making this test the hydraulic line should be completely removed from the cylinder port, and the open line from the valve should be plugged or capped since a slight back pressure in the tank return line would spill oil from the line if not plugged.

Pass/Fail criteria if not noted on Assembly drawing is as follows:
Cast Iron Rings Normal Maximum leakage 1 GPM.
Bypass = 1/2 cubic inch per inch of bore diameter per minute.
Extend bypass would be 1/2 cubic inch per inch of plunger piston ring OD per minute.
Retract bypass would be 1/2 cubic inch per inch of piston ring OD per minute of each stage added together.
Example SD73 Series;
Extend bypass; 1/2 x 5.25 = 2.62 cubic in / min.
Retract bypass; (1/2 x 7.25) + (1/2 x 6.25) + (1/2 x 5.25) = 9.38 cubic in / min.

Soft Seals Maximum leakage 5 drops per minute.

Please Note
Before Installing a New Cylinder in an old application
Has the problem been corrected that caused the original cylinder to fail?
Is the hydraulic fluid clean of all contamination, water, and entrapped air?
Are the hydraulic system relief valve pressures set and operating properly?
Is the mechanism or unit the cylinder is operating in good mechanical condition?

Storage

It pays to keep spare hydraulic cylinders on hand for use when you need them. But, you must know and follow these recommended storage practices or the cylinders can be damaged. Hydraulic cylinders, though often large and unwieldy, are precision machines with finely finished parts and close tolerances. So handle them with care.

For optimum storage life, hydraulic cylinders should be kept in an environment that is protected from excessive moisture and temperature extremes. A hot, dry dessert climate with cold nights, for example, must be accommodated for when choosing the storage area. Daytime heat quickly bakes oil out of sealing materials, which causes leaks and rapid wear when the cylinder is placed in service. Cooling at night causes water condensation and corrosion damage to wear surfaces. Storage areas that allow exposure to rain, snow and extreme cold must likewise be avoided.

It's best to store cylinders indoors if possible. But indoors or out, be sure that plugs or closures are properly installed in all ports to keep out moisture and dirt. Widely varying temperatures and tightly closed ports may cause pressure inside the cylinder to build up to the point where the piston moves far enough to expose the rod to corrosion or contamination. Try to choose a storage location where the cylinders are protected from physical damage. Even a little ding from a falling bar or forklift tine can cause trouble later.

Cylinders, particularly large ones, should be stored closed in a vertical position with the rod end down. Be sure they're blocked securely to keep them from falling. Storing with the rod ends down keeps oil on the seals, which protects them from drying out. This is more critical with fabric and butyl seals than with urethane sealing materials. Storing single acting cylinders with the rod end up can cause port closures to pop open and leak, exposing the sleeves to corrosion damage and contamination. Storing with the rod end down also discourages the temptation to lift a cylinder by the rod eye – a dangerous practice. If horizontal storage cannot be avoided, the rod or cylinder should be rolled into a new position every two months or so to prevent drying, distortion and deterioration of the seals. Don't forget that a cylinder can be a major source of contamination. A small scratch or nick on the sleeve will quickly damage the packing and contaminate the system. Store cylinders carefully and keep them clean.

The following procedures should be followed in order to prevent oxidation and maintain the surfaces of a mounted hydraulic cylinder during idle periods. These idle periods may include; inventory units, demo units, out of service units, etc.

- ·All machined surfaces left exposed should be coated with a light film of grease, if not oxidation will occur.
- ·If oxidation is present, apply a light coat of oil to the surfaces.
- ·Buff surfaces with 320 or 400 grit sandpaper. Do not buff surfaces up and down the length, buff only around the circumference.
- ·If after buffing, the surfaces show evidence of oxidation damage i.e., pitting, the cylinder should be inspected by an authorized service center.
- ·Operation of a hydraulic cylinder with surface damage will shorten the longevity and void any warranty.

Installation

·Cleanliness is an important consideration, and Parker cylinders are shipped with the ports plugs to protect them from contaminants entering the ports. These plugs should not be removed until the piping is to be installed. Before making the connection to the cylinder ports, the piping should be thoroughly cleaned to remove all chips or burrs which might have resulted from threading or flaring operations. One small foreign particle can cause premature failure of the cylinder or other hydraulic system components. If oxidation is present, apply a light coat of oil to the surfaces.
·Proper alignment of the cylinder piston rod and its mating component on the machine should be checked in both the extended and retracted positions. Improper alignment will result in excessive rod gland and/or cylinder bore wear.
·Cylinders operating in an environment where air drying material are present such as fast- drying chemicals, paint, or welding splatter, or other hazardous conditions such as excessive heat, should have shields installed to prevent damage to the piston rod and piston rod seals.

Troubleshooting Hints:

Many of the failures in a hydraulic system show similar symptoms: a gradual or sudden loss of pressure or flow, resulting in loss of power or speed in the cylinders or hydraulic motors. In fact, the cylinders may stall under light loads or may not move at all. Often the loss of power is accompanied by an increase in pump noise, especially as the pump tries to build up pressure.

Any one of the system's components - pump, relief valve, directional valve, or cylinder could be at fault.

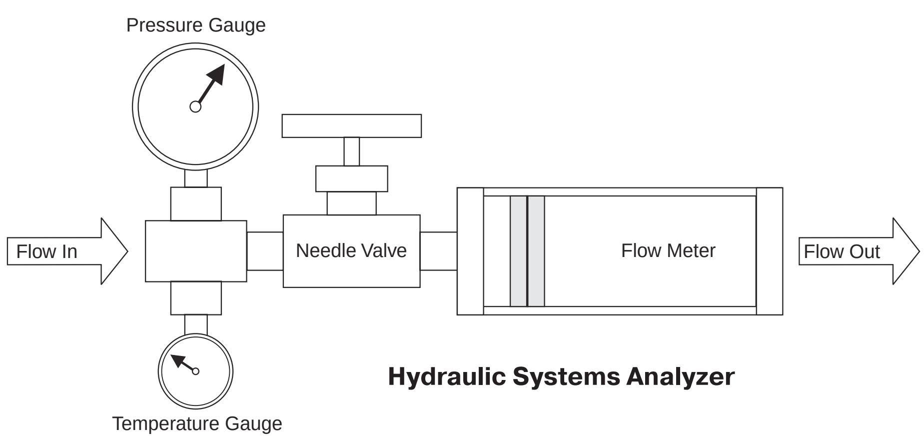
By following an organized step-by-step testing procedure, the problem can be traced to a general area, then if necessary, each component in that area can be tested, repaired or replaced.

Familiarize yourself with the circuitry of the hydraulic system to be tested. Review of the Service Manual is critical to learn the circuitry and location of various components: reservoir, hydraulic pump, relief valve, control valves, cylinders and hydraulic motors. The Service Manual should also provide operating specifications on fluid temperature, relief valve setting and pump delivery at specific RPMs.

Check the obvious. Is there sufficient fluid in the reservoir? Is it dirty? Is the filtering system in proper condition? Are there any bent linkages or pinched hoses? Are quick couplers functioning properly?

Before you start troubleshooting a system, it is helpful to ask questions and find out about the problem:
1. Has the system been working fine and then it just quit and stopped working?
2. Has the system been working fine and then it started to slowly change in the way it works?
3. Does the system work fine when first started and then changes as it is used and as the system heats up?
4. Did the system stop working after something else was fixed or replaced?
5. Did the system ever work or work properly after it was assembled?

When troubleshooting a hydraulic system there are a few tools which will aid in finding and repairing a problem.
1. Pressure Gauge; To measure the System Pressure (psi).
2. Flow Meter; To measure Gallons per Minute (gpm).
3. Temperature Gauge; To measure Heat.
4. Needle Valve; To Load / Restrict the System being tested.
5. And Your Senses;
   A. Seeing; Is that suppose to be BENT?
   B. Hearing; Is it suppose to be that LOUD?
   C. Smell; Is it suppose to SMELL BURNT?
   D. Touch; I can't it's too HOT!
   E. Common; Do I want to get in there while it's WORKING? I DONT THINK SO!



Hydraulic Systems Analyzer

With items 1, 2, 3, 4, and the necessary fittings and hoses, a Hydraulic System Analyzer can be built and most hydraulic system problems can be diagnosed and repaired.

Make sure the items are sized properly for the system being tested, don't use a 200 PSI Gauge in a 3000 PSI System or a 5 GPM Flow Meter or Needle Valve in a 50 GPM System. Verify and make sure that all the components are rated at, or exceed the pressures and flows being tested.

Troubleshooting Hints:

A Hydraulic Analyzer can be used to check the following:
1. Fluid Temperatures, using the temperature gauge provided. Fluid should be flowing through the analyzer for several minutes to obtain an accurate reading.
2. Flow rates, using the flow meter provided. With the needle valve wide open, the monitor will show the rate at minimum pressure loss. The flow rate can be restricted by turning in on the needle valve from wide open to show the flow at various pressure loads.
3. System or operating pressure, by referring to the pressure gauge. To prevent possible component damage, always be sure the needle valve on your analyzer is in the wide open position prior to starting system and if possible, have a relief valve between pump and analyzer.

Example Test for Hydraulic Pump Performance:
1. With system off and needle valve on analyzer in wide open position, install the analyzer in the line with fluid to be flowing in the direction of the arrow on the flow monitor scale.
2. Tighten all fittings to prevent unnecessary leakage.
3. Allow fluid to flow through the analyzer by turning on system.
4. Check the system Service Manual to see what specifications the pump is rated at. Example: 15 gpm @ 1500 psi.
5. With full flow flowing through the analyzer, start turning in the analyzer needle valve, gradually restricting the flow and at the same time, increasing pressure load on the pump. When reaching the rated pressure of the system pump, determine if the pump is operating efficiently (proper flow rate) or if it may need replacing or rebuilding. If the system relief valve is set below test pressure, the relief may have to be increased slightly to test the pump. Be sure to turn the relief valve back to its previous setting when tests have been completed.

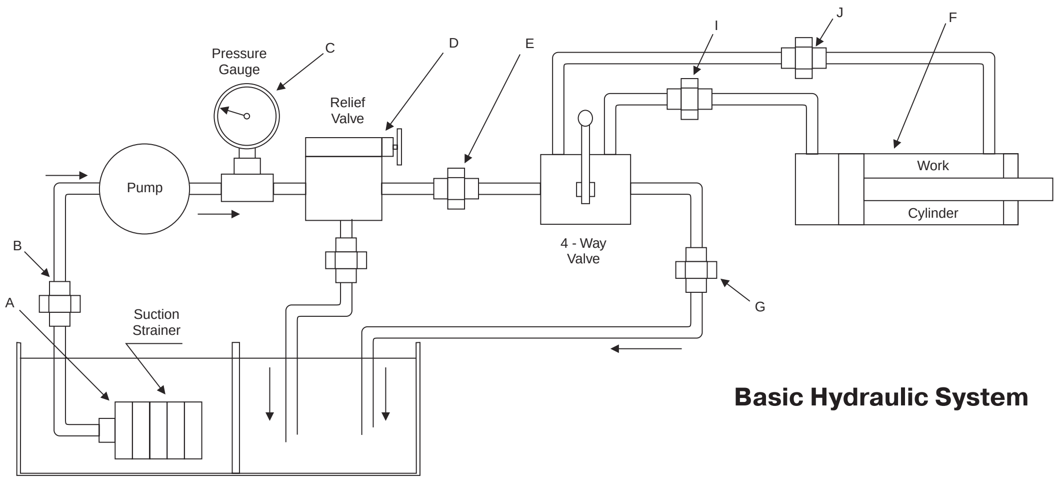
Troubleshooting Heated Fluid:
When analyzing a hydraulic system in which the fluid temperature is higher than normal, it should be kept in mind that hot fluid can produce unusual flow and operating characteristics. A flow monitor with a minimal sensitivity to temperature variation should be used. When fluid gets hot, the viscosity decreases (the fluid gets much thinner). This thinner fluid can pass through much smaller openings or, in other words, more fluid will pass through the same original opening.

When the System Heats Up:
1. Pumps usually slip more fluid through standard clearances. High pressure settings usually cannot be obtained.
2. When the fluid thins down, the parts run closer together and wear faster. Particles of dirt which may not have been a problem with thicker fluid may now be very damaging.
3. Valves, cylinders and actuators will slip more fluid through standard clearances.

All-in-all, excessive heat in a system will not only cause excessive and faster wear, but the system will seem very sluggish because of the lack of fluid supply and operating pressure.

Knowing the potential of your analyzer, the effects of fluid temperature and pressure drop will always insure confidence in analyzing and troubleshooting any service problem areas. The analyzer is only as good as the operator and the less complicated the unit, the more it will be used.

Basic Troubleshooting Steps:



Basic Hydraulic System

Step 1 - Pump Suction Strainer
Pump trouble is most often cavitation of the hydraulic pump inlet caused by restriction due to a dirt build-up on the suction strainer. This can happen on a new as well as on an older system. It produces symptoms such as: increased pump noise, loss of high pressure and / or speed.

If the strainer is not located in the pump suction line it will be found immersed below the oil level in the reservoir, as at Point A. Some operators of hydraulic equipment never give the equipment any attention or maintenance until it fails. Under these conditions, sooner or later, the suction strainer will become sufficiently restricted to cause a breakdown of the whole system and damage to the pump.

The suction strainer should be removed for inspection and cleaned before reinstallation. Wire mesh strainers can best be cleaned with an air hose, blowing from the inside out. They can also be washed in a solvent which is compatible with the reservoir fluid. Kerosene may be used for strainers operating in petroleum based fluid. Do not use gasoline or other explosive or flammable solvents. The strainer should be cleaned even though it may not appear to be dirty. Some clogging materials cannot be seen except by close inspection. If there are holes in the mesh or if there is mechanical damage, the strainer should be replaced.

When reinstalling the strainer, inspect all joints, as at Point B for possible air leaks, particularly at union joints. There must be no air leaks in the suction line. Check the reservoir oil level to be sure it covers the top of the strainer by at least 3” at minimum oil level, which is with all cylinders extended. If it does not cover to this depth there is danger of a vortex forming which may allow air to enter the system when the pump is running.

Step 2 - Pump and Relief Valve
If cleaning the pump suction strainer does not correct the trouble, isolate the pump and relief valve from the rest of the circuit by disconnecting at Point E so that only the pump, relief valve, and pressure gauge remain in the pump circuit. Cap or plug both ends of the plumbing which was disconnected. The pump is now deadheaded into the relief valve. Back out relief valve pressure adjustment. Start the pump and watch for pressure buildup on the gauge while tightening the adjustment on the relief valve. If full pressure can be developed, the pump and relief valve are operating correctly, and the trouble is to be found further down the line. If full pressure cannot be developed in this test, continue with Step 3.

Step 3 - Pump or Relief Valve?
If high pressure cannot be obtained in Step 2 by running the pump against the relief valve, further testing must be conducted to see whether the fault lies in the pump or in the relief valve. Proceed as follows:

If possible, disconnect the reservoir return line from the relief valve at Point H. Attach a short length of hose to the relief valve outlet. Hold the open end of this hose over the reservoir filler opening so the rate of oil flow can be observed. Start the pump and run the relief valve adjustment up and down while observing the flow through the hose. If the pump is bad, there will probably be a full stream of oil when relief valve adjustment is backed off, but this flow will diminish or stop as the adjustment is increased. If a flowmeter is available, the flow can be measured and compared with the pump catalog rating.

If a flowmeter is not available, the rate of flow on small pumps can be measured by discharging the hose into a bucket while timing with the sweep hand on a watch. For example, if a volume of 10 gallons is collected in 15 seconds, the pumping rate is 40 GPM, etc.

If the gauge pressure does not rise above a low value, say 100 PSI, and if the volume of flow does not substantially decrease as the relief valve adjustment is tightened, the relief valve is probably at fault, and should be cleaned or replaced as instructed in Step 5.

If the oil flow substantially decreases as the relief valve adjustment is tightened, and if only a low or moderate pressure can be developed, this indicates trouble in the pump. Proceed to Step 4.

Step 4 - Pump
If a full stream of oil is not obtained in Step 3, or if the stream diminishes as the relief valve adjustment is tightened, the pump is probably at fault. Assuming that the suction strainer has already been cleaned and the inlet plumbing has been examined for air leaks, as in Step 1, the oil is slipping across the pumping elements inside the pump. This can mean a worn-out pump, or too high an oil temperature. High slippage in the pump will cause the pump to run considerably hotter than the oil reservoir temperature. In normal operation, with a good pump, the pump case will probably run about 20° F above the reservoir temperature. If greater than this, excess slippage, caused by wear, may be the cause.

Check also for slipping belts, sheared shaft pin or key, broken shaft, broken coupling, or loosened set screw.

Step 5 - Relief Valve
If the test of Step 3 has indicated the trouble to be in the relief valve, D, the quickest remedy is to replace the valve with another one known to be good. The faulty valve may later be disassembled for inspection and cleaning. Pilot operated relief valves have small orifices which may be blocked with accumulations of dirt. Blow out all passages with an air hose and run a small wire through orifices. Check also for free movement of the spool. In a relief valve with pipe connections in the body, the spool may bind if pipe fittings are over tightened. If possible, test the spool for bind before unscrewing threaded connections from the body, or, screw in fittings tightly during inspection of the valve.

Step 6 - Cylinder
If the pump will deliver full pressure when operating across relief valve in Step 2, both pump and relief valve can be considered good, and the trouble is further downstream. The cylinder should be tested first for worn out or defective seals.

Run the cylinder to one end of its stroke. Disconnect the fluid line which was allowing oil to exhaust from the cylinder. Plug or cap the valve side of this disconnected line to avoid oil spillage caused by any back pressure in the tank return line. Attach a hose to the cylinder fitting where the fluid line was disconnected. Place open end of attached hose into a barrel or bucket. Start the pump and activate the valve to continue to stroke the cylinder the same direction. With the cylinder at the end of its stroke, check for any oil flowing from hose into barrel. If flow is excessive the cylinder may need repaired or replaced. Pistons with metal rings can be expected to have a small amount of leakage across the rings, and even those “leaktight” soft seals may have a small bypass during break in of new seals or after the seals are well worn. After checking, reinstall the lines and run the piston to the opposite end of the barrel and repeat the test. Occasionally a cylinder will leak at one point in its stroke due to a scratch or dent in the barrel. Check suspected positions in mid stroke by installing a positive stop at the suspected position and run the piston rod against it for testing. Once in a while a piston seal may leak intermittently. This is usually caused by a soft packing or O-ring moving slightly or rolling into different positions on the piston, and is more likely to happen on cylinders of large bore.

Step 7 - Directional Control Valve
If the cylinder has been tested (Step 6) and found to have reasonably tight piston seals, the 4-way valve should be checked next. Although it does not often happen, an excessively worn valve spool can slip enough oil to prevent build-up of maximum pressure. Symptoms of this condition are a loss of cylinder speed together with difficulty in building up to full pressure even with the relief valve adjusted to a high setting. This condition would be more likely to occur with high pressure pumps of low volume output, and would develop gradually over a long period of time.

Other Components
Check other components such as by-pass flow controls, hydraulic motors, etc. Solenoid 4-way valves of the pilot operated type with tandem or open center spools may not have sufficient pilot pressure to shift the spool.

Troubleshooting Hints

System Inoperative:

1. Insufficient or No fluid in system.
Refill system with proper grade and type of fluid. Filter new oil being added as recommended. Refill oil reservoir with cylinders in closed position. If refilled while cylinders are extended the reservoir may over flow when or as the cylinders retract. Check for leaks.

2. Pump is not engaged.
Is pump shaft turning?
Check if PTO (power take off) is engaged. Variable control mechanism out of adjustment. Adjust to machine service manual specifications.

3. Slipping or broken pump drive.
Check pump drive mechanism (drive key, flex coupler) for damage.
Check for proper alignment or tension.

4. Pump inlet line plugged.
Drain oil and replace filter or filter element.
Check for clogged oil strainers.
Oil lines dirty or collapsed.
Check if correct inlet hose is used, inner liner may be collapsed. Never use a pressure type hose as a pump inlet suction hose. Check if supply shut off or gate valve is closed. Check in reservoir for other possible obstructions.

5. Pump speed too slow.
Check minimum drive speed.
May be too slow to prime pump.

6. Wrong fluid in system.
Oil viscosity too heavy for pump to pick up a prime.
Drain complete system. Add new fluid of proper viscosity.

7. Air leaks at intake. Pump not priming.
Circuit must be tested at inlet connections.
At pump intake piping joints, test by pouring oil on joints while listening for a change in sound of operation. Determine where air is being drawn into line connection and tighten. At pump shaft, Test by pouring oil on shaft seal while listening for a change in sound of operation. Follow manufacturer's recommendation when changing seals. Air drawn in through intake pipe opening. Check to be certain suction and return lines are well below oil level in reservoir. Add oil to reservoir if necessary.

8.Worn or dirty pump.
Clean, repair or replace. Check alignment.
Check for contaminated oil. Drain and flush system.

9. Pump driven in wrong direction of rotation.
Most pump assemblies will have an arrow showing correct rotation.
On gear type pumps, the pressure port / output will be on the side where the gears come together and mesh. Check to assure correct pump rotation was applied during assembly

10. Leakage.
Check all components, particularly the relief valve for proper settings. Refer to technical manuals.

11. Broken or badly worn components (pump, valves, cylinders, etc.).
Examine and test for internal or external leakage.
Analyze the conditions that brought on the failure and correct them. Repair or replace the faulty components according to technical manual specifications.

12. Excessive load.
Check unit specifications for load limits.

System Develops No Pressure:

1. Pump not delivering fluid.
Follow the remedies mentioned above.

2. Incorrect valve position or setting.
Check and engage valve.
Install pressure gauge and adjust to correct pressure.

3. Vanes in vane pump sticking.
Check for burrs or metal particles that might hold vanes in their slots.
Repair or replace if necessary.
Clean system if contaminants are found.

4. Fluid recirculating back to reservoir and not going to functions.
Mechanical failure of some other part of the system, especially a relief valve.
If contamination is involved, clean and refill with proper fluid.

5. Piston pump or valve broken, or stuck open allowing fluid to return to inlet side.
Disassemble the pump, determine the cause and correct it.
Repair according to technical manual instructions

System Operates Erratically:

1. Air in system.
Check suction side for leaks. Repair.

2. Cold oil.
Allow ample warm-up period.
Operate only at recommended operating temperature ranges.

3. Wrong fluid viscosity.
Oil viscosity too heavy.
Drain complete system. Add new fluid of proper viscosity

4. Pump speed too slow.
Increase engine speed.
Check manual for recommendations.

5. Dirty or damaged components.
Clean or repair as necessary.

6. Restriction in filters or lines.
Clean and/or replace elements or lines.

7. Internal pump parts are sticking.
Dismantle and repair according to technical manual instructions. Look for burrs on parts or metal particles in fluid. If contaminants are the cause, clean and refill with proper fluid.

8. Distance between internal parts has increased due to wear.
Dismantle and repair. If wear is abnormal, determine the cause by checking the operation and maintenance records as well as by examining the pump and system.

System Operates Slowly:

1. Oil viscosity too high, cold oil.
Allow oil to warm up before operating machine.

2. Low pump drive speed.
Increase engine speed (check manual for recommendations). If clutch or belt-driven, check for proper tension.

3. Low oil level.
Check reservoir and add oil as necessary.

4. Air in system.
Check suction side for leaks. repair.

5. Badly worn pump, valves, cylinders, etc.
Repair or replace as needed.

6. Restriction in filters or lines.
Clean and/or replace elements or lines.

7. Improper adjustments.
Check orifices, relief, unloading, flow control valves, etc. Adjust per manual.

8. Oil leaks.
Tighten fittings, replace seals or damaged lines.

System Operates Too Fast:

1. Wrong size or incorrectly adjusted restrictor or flow control.
Replace or adjust as necessary.

2. Engine running too fast.
Reduce engine speed.

Overheating of Oil in System:

1. Oil passing thru relief valve for excessive time.
Return control valve to neutral when not in use. System stalling under load, etc. Fluid viscosity too high.

2. Relief or unloading valve set too high.
Install pressure gauge and adjust to correct pressure.

3. Incorrect oil, low oil, dirty oil.
Use recommended oil, fill reservoir, clean oil, replace filter element.

4. Engine running too fast.
Reduce engine speed.

5. Excessive component internal leakage.
Check stall leakage past pump, valve, motor, cylinder or other components. Repair or replace component as necessary.

6. Restriction in filters or lines.
Check if line I.D.'s are too small causing high velocity. Check if valvings too small, causing high velocity. Clean and/or replace elements or lines.

7. Malfunctioning oil cooler / heat exchanger.
Check if water is shut off, if water cooled.
Check for clogging. Clean repair.

8. Insufficient heat radiation.
Check for proper air circulation around reservoir. Ambient temperature too high for system design. Clean dirt and mud from reservoir and components.

9. Reservoir sized too small.
Increase reservoir size. Add oil cooler or heat exchanger.

10. Reservoir assembled without or insufficient baffling.
Add baffling to allow fluid time to cool.

Foaming of Oil:

1. Incorrect oil, low oil, dirty oil.
Replace, clean or add as needed.

2. Air leaks.
Check suction line and component seals for suction leaks. Repair or replace.

3. Return of tank line not below fluid level.
Repair or replace.

4. Inadequate baffles in reservoir.

5. Lack of anti-foaming additives in oil.
Replace fluid with proper grade.

Noisy Pump:

1. Air leak in intake, or air is being drawn through the inlet line.
Repair or make sure the inlet line is submerged in fluid in the reservoir.
To check for leaks, pour fluid around the joints and listen for a change in sound of operation.

2. Low oil level, incorrect oil, foamy oil.
Check if oil viscosity too high or operating temperature too low. Replace, clean or add proper grade and type of fluid as needed. With rare exception all return lines should be below fluid level in reservoir

3. Pump inlet line or inlet screen is restricted or clogged.
Clean or replace as needed.

4. Reservoir breather vent clogged.
Clean or replace as needed.

5. Worn or damaged pump.
Check and correct cause of parts failure.
Repair or replace as needed.

6. Pump speed too fast.
Operate pump within recommended speed.

7. Drive coupling mis-aligned.
Align unit and check condition of seals and bearings.
Misalignment will cause wear and subsequent high noise level in operation.

8. Relief or unloading valve set too high.
Use reliable gauge to check operating pressure. Relief valve may have been set too high with a damaged pressure gauge.
Check unloading devices to see that they are properly controlling the pump delivery.

Excessive Pump Wear:

1. Abrasive contaminants or sludge in the fluid.
Check for the cause of contaminants.
Replace or repair worn parts according to service manual.
Install or change fluid filter.
Replace fluid with recommended grade and quality.

2. Viscosity of fluid too low or too high.
Replace fluid with proper grade and type.

3. Sustained high pressure above maximum pump rating.
Check for possible relief valve malfunction or other parts failure.

4. Air leaks or restriction in system causing cavitation.
Eliminate any leaks in system.

5. Drive shaft misaligned.
Check and correct according to technical manual specifications.

Leaky Pump or Motor:

1. Damaged or worn shaft seal.
Check and replace.
Check for misalignment.
Check that chemicals in fluid are not destroying packing or seals

2. Loose or damaged parts.
Tighten or replace.

Internal Pump Parts Breakage:

1. Excessive pressure above maximum limits for pump.
Check for parts malfunction and cause. Repair according to machine technical manual

2. Seizure due to lack of fluid.
Check reservoir fluid level, as well as fluid inlet line for restriction.
Check for plugged inlet filter or strainer.

3. Abrasive contaminants in fluid are getting past the filter.
Check for plugged inlet filter or strainer.
Check for malfunctioning filter bypass valve.

4. Excessive torquing of housing bolts.
Replace damaged parts.
Torque to proper specifications.

Load Drops with Control Valve in Neutral:

1. Valve linkage misaligned.
Repair

2. Tie-bolts too tight (stack valves).
Loosen and retighten as necessary.

3. Valve damaged.
Repair or replace.

Control Valve Leaks:

1. Tie-bolts too loose (stack valves).
Tighten as necessary.

2. Seals damaged or worn.
Replace.

Troubleshooting Hints

Relief Valve Noisy:

1. **Relief valve setting too close to operating pressure.**
   Install pressure gauge and adjust to correct pressure.

2. **Worn or scored poppet and seat.**
   Replace.

3. **Spring in relief valve broken.**
   Replace spring and adjust to correct pressure.

Cylinder Seal Leakage:

1. **Slow, Uniform Leakage:**
   A. Poor low-pressure sealability (especially if a lip seal).
   B. Too little initial interference (if squeeze-type seal).
   C. Loss of interference or squeeze due to wear or compression set.
   D. Seal shrinkage after installation (possibly chemically induced, or a result of leaching of plasticizers by solvent action).
   E. Possible omission or failure of static seal(s).
   F. Microscopic debris lodges under seal lip (lint, fiber, etc).
   G. Scored lip due to passage of sharp particle under seal, leaving cut or nick.
   H. Seal lip is nicked or cut during installation (note whether leak starts immediately after seal installation).
   I. Non-repetitive overheating hardens compound (which loses its ability to conform to dynamic surface deviations).
   J. Off-center alignment puts all clearance on one side, all compression on the other (due to bearing wear, excessive side loads, etc).
   K. Check static surfaces of dynamic seal (groove surfaces). They may have problems F, G, or H hidden from view, and without self-cleaning tendency.

2. **Gradually Increasing Leakage:**
   A. Progressive wear.
   B. Increasing compression set.
   C. Progressive tear or erosion from initial nick.
   D. Fine score mark on dynamic surface progressively abrades seal lip.

3. **Sudden Copious Leakage:**
   A. Extruded seal.
   B. Torn seal lip (see 1-D, -E, -F, -G, -H, & -I, and 2-D).
   C. Twisted seal.
   D. Dramatic bearing failure due to excessive side load, shock, etc.
   E. Spiral failure.
   F. Massive infusion of contamination (due to incorrect fluid added to system, or to upstream introduction of dirt or wear debris).
   G. Slow rod leakage builds up behind tight wiper, then dumps . . . giving appearance of catastrophic seal failure. If leak rate continues, look for slow leak or erratic leak causes. If high leak rate continues, look for true catastrophic leak origin.
   H. Reverse-pressure blowout of piston seal due to pressure trap or failure of opposed seal.

4. **Erratic (start-stop) Leakage:**
   A. Cold start-up shrinks seal; friction/fluid heating restores size.
   B. Intermittent eccentric loading.
   C. Fibrous contamination working its way past seal lips.
   D. Unstable seal (twists and returns, cocks, etc.) usually caused by shock loading.
   E. Rod seal leaks slowly, tight wiper periodically dumps accumulated leakage (see 3-G).
   F. Fluid viscosity changes as temperature cycles (e.g., forklift truck alternately entering and leaving cold storage area).

5. **Stick-slip Operation:**
   A. Worn-away, low friction surface treatment.
   B. Breakdown of fluid lubricity due to contamination or deterioration of fluid.
   C. Viscosity change due to temperature.
   D. Excessive burnishing of dynamic surface to finer finish destroys ability of surface to maintain lube film (e.g., may go from 12 RMS to 4 RMS).

6. **Seizing:**
   A. Seal and bearing swell due to incompatible fluid and compound (possibly running hotter than temperature at which fluid is compatible).
   B. Thermal expansion of compound.
   C. Pressure trap between dual squeeze seals or incorrectly installed lip seals.
   D. Wedging of seal or backup device into extrusion gap (if used, it is usually the backup device that extrudes).
   E. In low-pressure systems, shock or other factors cock, cant or misorient the seals in grooves.
   F. Bent rod, cocked head, etc.

7. **Scored Rod or Ram:**
   A. Internally generated contamination.
   B. Externally introduced rod dirt, dirty makeup or disassembly/ reassembly dirt.
   C. Misoriented exclusion devices (wiper/scraper); eccentric installation.
   D. Misaligned (eccentric) loads cock ram into metal-to-metal contact with head.
   E. Wiper in vertical ram forms catch-all pocket.

8. **Drift:**
   A. Inspect valve for leakage and full closure before disassembly. (disconnect return line on valve and inspect visually for leakage).
   B. See problems 1 and 2 as applied to piston seals.
   C. Misapplied cast-iron rings in a “hold” cylinder (right ring in the wrong job).

D. In "retract-mode" creep, check rod seal as well as piston seal.
E. Static internal seal may provide leakage path past piston.

9. Increasing Cylinder Drag:
A. Seal swell caused by improper (incompatible) installation lubricant (e.g., EPR seal lubed with petro-based grease or oil).
B. Packing of contaminants into wiper groove of vertical ram.
C. Thermal expansion of bearings and/or seals.
D. Apparent drag increase due to undetected flow restriction in supply or return line . . . or bypassing of pressure though improperly closing valve . . . or obstructed check valve, etc.
E. Cocked or twisted seal bypassing fluid and wedging into extrusion gap.

10. Increasing Cylinder/Rod Temperature:
A. See causes for problem 9. In their earlier stages, these problems may appear as hotter-running cylinders.
B. Internal leakage "throttling" past seal can cause rapid heating.
C. Decreased lubricity of fluid can boost friction and heating (hotter fluid has lower viscosity, etc.). Contaminated or deteriorated fluid can cause same cycle.
D. Diluted fluid can boost friction, etc.
E. Condensation in reservoirs can emulsify or hit cylinder as slugs of fluid with near-zero lubricity. Also, hot water can swell compounds such as urethanes, increasing friction.

11. Telescopic sleeve undersized, out of round or bulged.
A. Check with micrometers to see if sleeve/tube is within specifications.

Cylinder will not Operate or Move:

1. Pump or PTO is not engaged, system not receiving fluid.
Engage pump, correct pump flow problem.

2. Control valve not engaged.
Engage valve, check for linkage alignment and damage.

3. Pressure too low.
Check pressure at cylinder to make sure it is to circuit requirements.

4. Cylinder bypassing internally.
Check for internal scoring, damaged or worn seals, internal cracks.

5. Cylinder overloaded for rated capacity.
Reduce load.

6. Cylinder too small or not rated for application.
Install correct cylinder.

7. Piston rod broken at piston end.
Disassemble and replace piston rod.

8. Hose quick disconnect not attached.
Check if hose quick disconnect is connected properly

Cylinder not Holding Load or Drifts:

1. Cylinder bypassing internally.
Check for internal scoring, damaged or worn seals, internal cracks.
Pressurize one side of cylinder and disconnect fluid line at opposite port. Observe leakage. One to three cubic inches per minute is considered normal for piston rings. Virtually no leak with soft seals on piston. Replace cylinder barrel or seals as required.

2. Other circuit leaks.
Check for leaks thru operating valve and correct. Correct leaks in connecting lines.

3. Incorrect Valving.
Open center valve with conventional single rod cylinder will creep if restriction on tank port is sufficiently high. Use tandem type valve spool configuration or spool with pump dumped through one cylinder port with the other blocked.
Closed center valve can cause similar results except creep will be according to amount of clearance flow in the valve. Proper notching of valve spool can prevent building up pressure in cylinder lines between cycles. Spools with pressure blocked and cylinder ports completely relaxed will also prevent drift if no moving element is not affected by gravity or vibration.
Pilot operated check valves can positively lock fluid in cylinder lines. Care must be exercised to insure adequate pilot pressure when rod differential may cause intensification.

Cylinder operates erratically or chatters:

1. Telescopic cylinder sleeves mistaging.
Check for tight seals or bearings.

2. Excessive friction due to damaged or improper / misaligned mounting.
Repair or replace as needed.

3. Cylinder sized too close to load requirements. Reduce load or install larger cylinder.

4. Large difference between static and kinetic friction.
Install speed control valves to provide back pressure to control stroke.

Troubleshooting Hints

Oil Spilling Out of Tank:

1. Oil is foaming.
(Refer to Foaming of Oil section)

2. Oil reservoir filled while cylinders were extended.
Fill while cylinders in the retract or closed position.

Foreign Matter Sources in the Circuit:

1. Pipe scale not properly removed.
Lines need cleaned and flushed before installation.

2. Sealing compound (pipe dope, teflon tape) allowed to get inside fittings.
Use care when applying sealants.

3. Improperly screened fill pipes and air breathers.
Repair or replace as required.

4. Burrs inside piping components.
Deburr before installation.

5. Tag ends of packing coming loose.
Check if packing is system compatible.
Replace packing.

6. Seal extrusions from pressure higher than compatible with the seal or gasket.
Replace seal or gasket with compatible item.

7. Human element.
Not protecting components while being repaired. Repaired components not properly protected while stored. (Rust and other contaminants.)
Lines left open and unprotected.

8. Wipers or boots damage or not provided.
Check cylinders or rams.
Add or replace where necessary.

Preventing repeat failures:

When a hydraulic system (pump or cylinder or other major component) has a failure, implementing this 13-step checklist can help prevent repeat failures.

1. Determine cause of failure.

2. Eliminate cause of failure.

3. Retract all cylinders and drain tank.

4. Flush tank. Using diesel fuel under pressure, flush tank thoroughly and wipe with clean cloths.

5. Install new filter elements.
   A. Check to make sure filter is 10 microns or better.
   B. If machine does not have filtration, install a 10 micron filter on the return line.

6. Install new component.

7. Fill the tank with new oil.
   A. Be sure recommended oil is used.
   B. NOTE: You're filling the system, not just the oil supply tank. Pump failure due to lack of oil can result if filling is not done correctly.
   Keep a close check on the oil level as you complete the following steps.

8. Disconnect all lines to cylinders and/or motors at the cylinder or motor. Be sure all implements are securely blocked and all accumulators are bled before dis-con-necting lines. NOTE: It may be necessary to remove, inspect, and flush the fittings that are connected to the pump, valves, and/or cylinders to remove any foreign objects that may have become lodged or stuck inside them.

9. Activate each circuit by moving control valve handle so lines are flushed with new oil. This flushes the lines and valves from pump to all cylinders and motors. Be sure to check oil level, and add new oil if necessary.

10. Connect lines to blind end of cylinders and all fluid motors. Leave rod end disconnected and with engine at one-fourth throttle, activate circuits slowly until cylinder bottoms out. New oil will be put in the blind end of the cylinder and old dirty oil flushed out the rod end. Do this for all cylinders on the machine.

11. Connect lines to rod end of cylinders. Again, check oil level and add new oil as required.

12. Operate all cylinders and motors alternately for 30 minutes at normal operating speed.

13. Change filter element, check oil level and add oil as needed.

The above procedure, if followed, will allow you to install a new pump or cylinder with confidence, knowing that you'll get satisfactory life. Cutting short these steps can cause premature hydraulic component failure; a pump, nor a cylinder will run long on a contaminated system.

In nearly all cases, a replacement component will fail in a shorter time than the original preceding it unless the system is thoroughly cleaned.

In addition, to ensure good service from your equipment, the hydraulic system must be properly maintained, including frequent oil level checks, daily inspection for leaks, filter element and oil changes at recommended intervals (using correct filters and recommended grade of oil), and finally, practicing good operating techniques.

Hydraulic Oil Recommendations

All cylinder 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 Commercial cylinders should meet the following specifications:

These suggestions are intended as a guide only.
Obtain your final oil recommendations from your oil supplier.

Viscosity Recommendations:
Optimum operating viscosity is considered to be about 100 SSU.
* 50 SSU minimum @ operating temperature
  7500 SSU maximum @ starting temperature

* 150 to 225 SSU @ 100˚F. (37.8˚C.) (generally)
  44 to 48 SSU @ 210˚F. (98.9˚C.) (generally)

Approximate SSU		
Oil Grade	**100˚F 37.8˚C**	**210˚F 98.9˚C**
SAE 10	150	43
SAE 20	330	51

Normal Temperatures:
0o F. (-18˚C.) to 100˚F. (37.8˚C.) ambient 100˚F. (37.8˚C.) to 180˚F. (82.2˚C.) system
Be sure the oil you use is recommended for the temperature you expect to encounter.

Other Desirable Properties:
Viscosity Index: 90 minimum
Aniline point: 175 minimum

Additives Usually Recommended:
Rust and Oxidation (R & O) Inhibitors
Foam Depressant

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 manufactures recommendations and the system periodically flushed.

Oil operating temperature should not exceed 200° F. (93° C.) with a maximum of 180o F. (82° C.) generally recommended. 120° F. to 140° F. (50° C. to 60° C.) is generally considered optimum. 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.

Reservoir size should be large enough to hold and cool all the fluid a system will need, yet it should not be waste-fully large. Minimum required capacity can vary anywhere between 1 and 3 times pump output. The reservoir must be able to hold all of the fluid displaced by retracted cylinders when the system is not operating, yet provide space for expansion and foaming.

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

Never use Crank Case Drainings, Kerosene, Fuel Oil, or any Non-Lubricating Fluid, such as Water.

Request for a Quotation - Telescopic Cylinders

Customer Information

Date: ______________________

CAE Name: ____

Customer: __________________ ☐ OEM ☐ MRO/User

Full Address: ____

Contact Name: ____

Telephone: ____

E-mail: ____

Distributor: ____

Distributor Rep: ____

Quote Due Date: ______________ Target Price (each): ____________

Competition: ____

Current Quantity: ______________ Future Quantity: ______________

Product Specifications

Model No. (if known) ____________________________________

Serial No. (if known) ____________________________________

Note: If you provide the model or serial number, it is not necessary to fillout the rest of the form.

Single or Double Acting: ____________________________________

O.D. of body: ____________________________________

O.D. largest moving stage: ____________________________________

Number of moving stages: ____________________________________

Plated or non-plated stage: ____________________________________

☐ Global Shield ☐ chrome ☐ nitride

Any side or eccentric loading possible: ____________________________________

Mounting Type: ____________________________________
(see chart on next page)

Cylinder Orientation:

☐ vertical, plunger up ☐ vertical, plunger down ☐ horizontal

☐ °from vertical ____ ° retracted ____ ° extended

Load: ☐ guided ☐ unguided

Max.Load-Push: ____________ lbf Max. Load-Pull: ____________ lbf

Side Load-Extended: __________ lbf Side Load-Retracted: ________ lbf

System operating pressure (PSI) Normal ____________ Max ________

Is there a relief valve in system ________________ Setting ________

System flow in G.P.M. Min. ______________________ Max ________

System operating temp. (F) Min. __________________ Max ________

Load holding requirements ____________________________________

Environment condition ____________________________________

Fluid Media ____________________________________

Max. Plunger Speed-Extend: ______ inch/sec

Max. Plunger Speed-Retract: ______ inch/sec

Cycle Rate: ______ per minute ________ per day

Market: ____________________________________

Application:

☐ New Application ☐ Existing Application

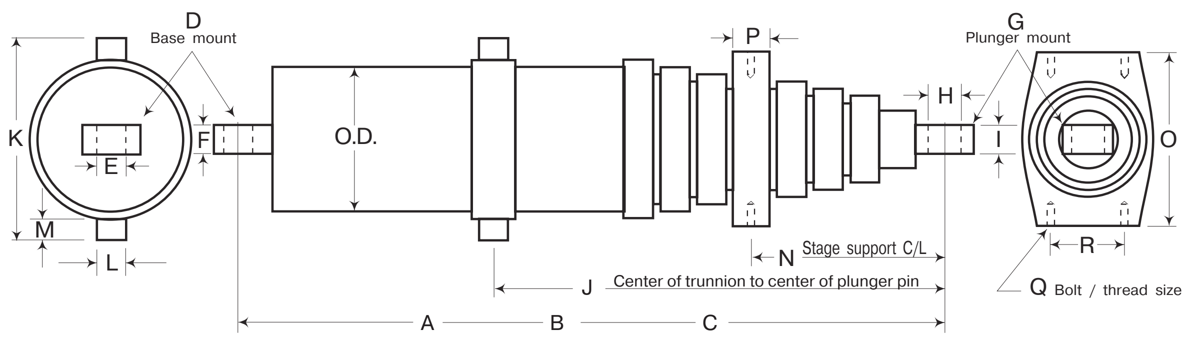
Cylinder Function: ____________________________________

Parker Hannifin Corporation
Cylinder and Accumulator Division
Des Plaines, Illinois

Telescopic Cylinder Application Data Form

Mounting Options

Code Letter	Mount Description	Mount Sketch	Mount Location	Code Letter	Mount Description	Mount Sketch	Mount Location
A	Plain No Mount		Body or Rod	J	Foot / Pad Mount		Body
B	Pin-Eye Drilled Thru Rod		Rod	K	Centerline Mount		Body
C	Pin-Eye Drilled Thru Lug		Body or Rod	L	Double Lug Clevis Mount		Body or Rod
D	Cross Tube		Body or Rod	M	Trunnion Mount		Body
E	Threaded		Body or Rod	N	Rod End Drilled and Tapped		Rod
F	Drilled and Tapped		Body or Rod	O	Ball Mount		Body or Rod
G	Flange Mount at Base		Body	P	Socket Mount		Body or Rod
H	Flange Mount Mid-Body		Body				



A: Total stroke ____________________

B: Closed length ____________________

C: Open length ____________________

D: Base mount type or code ____________________

E: Base pin diameter ____________________

F: Base mount width ____________________

G: Plunger mount type or code ____________________

H: Plunger pin diameter ____________________

I: Plunger mount width ____________________

J: Plunger pin to trunnion C/L (if applicable) ____________________

K: Trunnion overall width ____________________

L: Trunnion lug diameters ____________________

M: Trunnion lug lengths ____________________

Special mounting (if applicable) ____________________

Extend port size and type ____________________

Extended port location ____________________

Retract port size and type ____________________

Retract port location ____________________

Special features or comments ____________________

Email instructions: If you are planning on emailing this form,
please be sure to include your drawing file as a separate attachment.
e-mail: cad.mobile@support.parker.com

Proposal Drawings ________ **Yes** ________ **No**

If yes, $250 drawing charge PO# ____________

Request for a Quotation - Welded Rod Cylinders

Customer Information

Date: ________________________

Parker Rep Name: ____________________

Customer: ____________________ ☐ OEM ☐ MRO/User

Full Address: ____________________

Contact Name: ____________________

Telephone: ____________________

E-mail: ____________________

End Customer Name: ____________________

Quote Due Date: ____________ Target Price (each): ____________

Competition: ____________________

Current Quantity: ____________ Future Quantity: ____________

Product Specifications

Model No. (if known) ____________________

Serial No. (if known) ____________________

Note: If you provide the model or serial number, it is not necessary to fillout the rest of the form.

Bore diameter: ____________________

Cylinder body OD: ____________________

Rod diameter: ____________________

Plated or non-plated stage: ____________________

☐ Global Shield ☐ chrome ☐ nitride

Any side or eccentric loading possible: ____________________

Mounting Type: ____________________
(see chart on next page)

Cylinder Orientation:

☐ vertical, plunger up ☐ vertical, plunger down ☐ horizontal

☐ °from vertical ____ ° retracted ____ ° extended

Load: ☐ guided ☐ unguided

Max.Load-Push: __________ lbf Max. Load-Pull: __________ lbf

Side Load-Extended: __________ lbf Side Load-Retracted: __________ lbf

System operating pressure (PSI) Normal __________ Max ________

Is there a relief valve in system __________ Setting ________

System flow in G.P.M. Min. __________ Max ________

System operating temp. (F) Min. __________ Max ________

Load holding requirements ____________________

Environment condition ____________________

Fluid Media ____________________

Max. Plunger Speed-Extend: ______ inch/sec

Max. Plunger Speed-Retract: ______ inch/sec

Cycle Rate: ______ per minute ________ per day

Market: ____________________

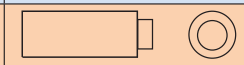
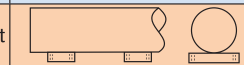
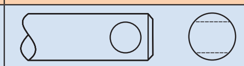
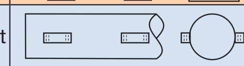
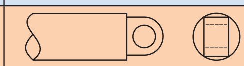
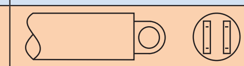
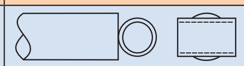
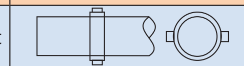
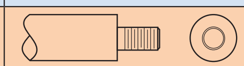
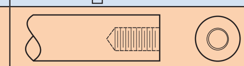
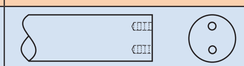
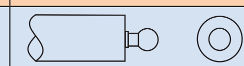
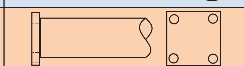
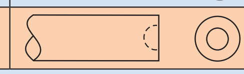
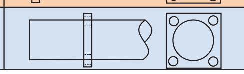
Application:

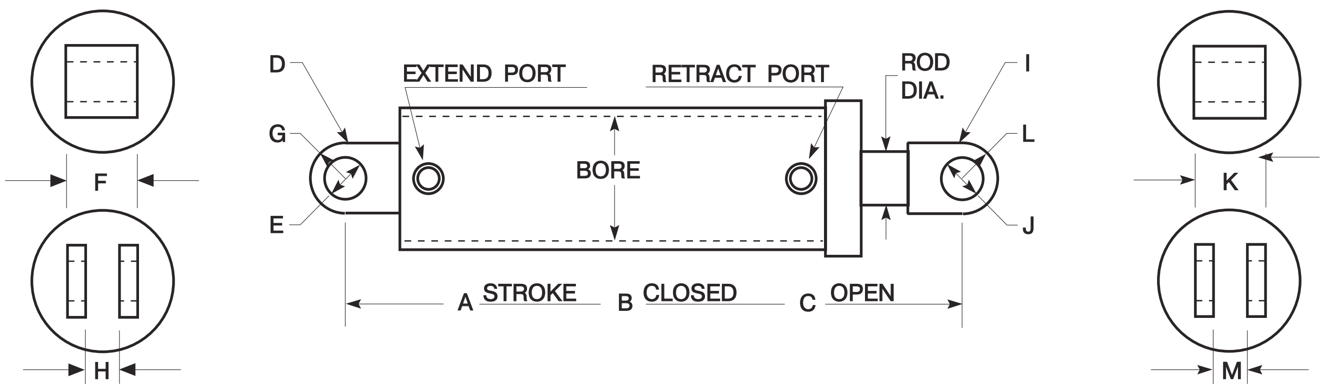
☐ New Application ☐ Existing Application

Cylinder Function: ____________________

Welded Rod Cylinder Application Data Form

Mounting Options

Code Letter	Mount Description	Mount Sketch	Mount Location	Code Letter	Mount Description	Mount Sketch	Mount Location
A	Plain No Mount		Body or Rod	J	Foot / Pad Mount		Body
B	Pin-Eye Drilled Thru Rod		Rod	K	Centerline Mount		Body
C	Pin-Eye Drilled Thru Lug		Body or Rod	L	Double Lug Clevis Mount		Body or Rod
D	Cross Tube		Body or Rod	M	Trunnion Mount		Body
E	Threaded		Body or Rod	N	Rod End Drilled and Tapped		Rod
F	Drilled and Tapped		Body or Rod	O	Ball Mount		Body or Rod
G	Flange Mount at Base		Body	P	Socket Mount		Body or Rod
H	Flange Mount Mid-Body		Body				



A: Total stroke ______________________

B: Closed length ______________________

C: Open length ______________________

D: Base mount type or code ______________________

E: Base pin diameter ______________________

F: Base mount width ______________________

G: Base mount radius ______________________

H: Base Clevis Gap (if applicable) ______________________

I: Plunger mount code ______________________

J: Plunger pin diameter ______________________

K: Plunger mount width ______________________

L: Plunger mount radius ______________________

M: Plunger clevis gap (if applicable) ______________________

Special mounting (if applicable) ______________________

Extend port size and type ______________________

Extended port location ______________________

Retract port size and type ______________________

Retract port location ______________________

Special features or comments ______________________

Email instructions: If you are planning on emailing this form,
please be sure to include your drawing file as a separate attachment.
e-mail: cad.mobile@support.parker.com

Proposal Drawings ________ **Yes** ________ **No**

If yes, $250 drawing charge PO# ____________

Safety Guide for Selecting and Using Hydraulic, Pneumatic Cylinders and Their Accessories

WARNING: ⚠ FAILURE OF THE CYLINDER, ITS PARTS, ITS MOUNTING, ITS CONNECTIONS TO OTHER OBJECTS, OR ITS CONTROLS CAN RESULT IN:

- **Unanticipated or uncontrolled movement of the cylinder or objects connected to it.**
- **Falling of the cylinder or objects held up by it.**
- **Fluid escaping from the cylinder, potentially at high velocity.**

THESE EVENTS COULD CAUSE DEATH OR PERSONAL INJURY BY, FOR EXAMPLE, PERSONS FALLING FROM HIGH LOCATIONS, BEING CRUSHED OR STRUCK BY HEAVY OR FAST MOVING OBJECTS, BEING PUSHED INTO DANGEROUS EQUIPMENT OR SITUATIONS, OR SLIPPING ON ESCAPED FLUID.

Before selecting or using Parker Hannifin Corporation (the Company) cylinders or related accessories, it is important that you read, understand and follow the following safety information. Training is advised before selecting and using the Company's products.

1.0 General Instructions

1.1 Scope – This safety guide provides instructions for selecting and using (including assembling, installing, and maintaining) cylinder products. This safety guide is a supplement to and is to be used with the specific Company publications for the specific cylinder products that are being considered for use.

1.2 Fail Safe – Cylinder products can and do fail without warning for many reasons. All systems and equipment should be designed in a fail-safe mode so that if the failure of a cylinder product occurs people and property won't be endangered.

1.3 Distribution – Provide a free copy of this safety guide to each person responsible for selecting or using cylinder products. Do not select or use the Company's cylinders without thoroughly reading and understanding this safety guide as well as the specific Company publications for the products considered or selected.

1.4 User Responsibility – Due to very wide variety of cylinder applications and cylinder operating conditions, the Company does not warrant that any particular cylinder is suitable for any specific application. This safety guide does not analyze all technical parameters that must be considered in selecting a product. The hydraulic and pneumatic cylinders outlined in this catalog are designed to the Company's design guidelines and do not necessarily meet the design guideline of other agencies such as American Bureau of Shipping, ASME Pressure Vessel Code etc. The user, through its own analysis and testing, is solely responsible for:

- Making the final selection of the cylinders and related accessories.
- Determining if the cylinders are required to meet specific design requirements as required by the Agency(s) or industry standards covering the design of the user's equipment.
- Assuring that the user's requirements are met, OSHA requirements are met, and safety guidelines from the applicable agencies such as but not limited to ANSI are followed and that the use presents no health or safety hazards.
- Providing all appropriate health and safety warnings on the equipment on which the cylinders are used.

1.5 Additional Questions – Call the appropriate Company technical service department if you have any questions or require any additional information. See the Company publication for the product being considered or used, or call 1-847-298-2400, or go to www.parker.com, for telephone numbers of the appropriate technical service department.

2.0 Cylinder and Accessories Selection

2.1 Seals – Part of the process of selecting a cylinder is the selection of seal compounds. Before making this selection, consult the "seal information page(s)" of the publication for the series of cylinders of interest.

The application of cylinders may allow fluids such as cutting fluids, wash down fluids etc. to come in contact with the external area of the cylinder. These fluids may attack the piston rod wiper and or the primary seal and must be taken into account when selecting and specifying seal compounds.

Dynamic seals will wear. The rate of wear will depend on many operating factors. Wear can be rapid if a cylinder is mis-aligned or if the cylinder has been improperly serviced. The user must take seal wear into consideration in the application of cylinders.

2.2 Piston Rods – Possible consequences of piston rod failure or separation of the piston rod from the piston include, but are not limited to are:

- Piston rod and or attached load thrown off at high speed.
- High velocity fluid discharge.
- Piston rod extending when pressure is applied in the piston retract mode.

Piston rods or machine members attached to the piston rod may move suddenly and without warning as a consequence of other conditions occurring to the machine such as, but not limited to:

- Unexpected detachment of the machine member from the piston rod.
- Failure of the pressurized fluid delivery system (hoses, fittings, valves, pumps, compressors) which maintain cylinder position.
- Catastrophic cylinder seal failure leading to sudden loss of pressurized fluid.
- Failure of the machine control system.

Follow the recommendations of the "Piston Rod Selection Chart and Data" in the publication for the series of cylinders of interest. The suggested piston rod diameter in these charts must be followed in order to avoid piston rod buckling.

Piston rods are not normally designed to absorb bending moments or loads which are perpendicular to the axis of piston rod motion. These additional loads can cause the piston rod to fail. If these types of additional loads are expected to be imposed on the piston rod, their magnitude should be made known to our engineering department.

The cylinder user should always make sure that the piston rod is securely attached to the machine member.

On occasion cylinders are ordered with double rods (a piston rod extended from both ends of the cylinder). In some cases a stop is threaded on to one of the piston rods and used as an external stroke adjuster. On occasions spacers are attached to the machine member connected to the piston rod and also used as a stroke adjuster. In both cases the stops will create a pinch point and the user should consider appropriate use of guards. If these external stops are not perpendicular to the mating contact surface, or if debris is trapped between the contact surfaces, a bending moment will be placed on the piston rod, which can lead to piston rod failure. An external stop will also negate the effect of cushioning and will subject the piston rod to impact loading. Those two (2) conditions can cause piston rod failure. Internal stroke adjusters are available with and without cushions. The use of external stroke adjusters should be reviewed with our engineering department.

The piston rod to piston and the stud to piston rod threaded connections are secured with an anaerobic adhesive. The strength of the adhesive decreases with increasing temperature. Cylinders which can be exposed to temperatures above +250°F (+121°C) are to be ordered with a non studded piston rod and a pinned piston to rod joint.

2.3 Cushions – Cushions should be considered for cylinder applications when the piston velocity is expected to be over 4 inches/second.

Cylinder cushions are normally designed to absorb the energy of a linear applied load. A rotating mass has considerably more energy than the same mass moving in a linear mode. Cushioning for a rotating mass application should be reviewed by our engineering department.

2.4 Cylinder Mountings – Some cylinder mounting configurations may have certain limitations such as but not limited to minimum stroke for side or foot mounting cylinders or pressure de-ratings for certain mounts. Carefully review the catalog for these types of restrictions.

Always mount cylinders using the largest possible high tensile alloy steel socket head cap screws that can fit in the cylinder mounting holes and torque them to the manufacturer's recommendations for their size.

2.5 Port Fittings – Hydraulic cylinders applied with meter out or deceleration circuits are subject to intensified pressure at piston rod end.

The rod end pressure is approximately equal to:

$$\frac{\text{operating pressure x effective cap end area}}{\text{effective rod end piston area}}$$

Contact your connector supplier for the pressure rating of individual connectors.

3.0 Cylinder and Accessories Installation and Mounting

3.1 Installation

3.1.1 – Cleanliness is an important consideration, and cylinders are shipped with the ports plugged to protect them from contaminants entering the ports. These plugs should not be removed until the piping is to be installed. Before making the connection to the cylinder ports, piping should be thoroughly cleaned to remove all chips or burrs which might have resulted from threading or flaring operations.

3.1.2 – Cylinders operating in an environment where air drying materials are present such as fast-drying chemicals, paint, or weld splatter, or other hazardous conditions such as excessive heat, should have shields installed to prevent damage to the piston rod and piston rod seals.

3.1.3 – Proper alignment of the cylinder piston rod and its mating component on the machine should be checked in both the extended and retracted positions. Improper alignment will result in excessive rod gland and/or cylinder bore wear. On fixed mounting cylinders attaching the piston rod while the rod is retracted will help in achieving proper alignment.

3.1.4 – Sometimes it may be necessary to rotate the piston rod in order to thread the piston rod into the machine member. This operation must always be done with zero pressure being applied to either side of the piston. Failure to follow this procedure may result in loosening the piston to rod-threaded connection. In some rare cases the turning of the piston rod may rotate a threaded head and loosen it from the cylinder body. Confirm that this condition is not occurring. If it does, re-tighten the head firmly against the cylinder body.

For double rod cylinders it is also important that when attaching or detaching the piston rod from the machine member that the torque be applied to the piston rod end of the cylinder that is directly attaching to the machine member with the opposite end unrestrained. If the design of the machine is such that only the rod end of the cylinder opposite to where the rod attaches to the machine member can be rotated, consult the factory for further instructions.

3.2 Mounting Recommendations

3.2.1 – Always mount cylinders using the largest possible high tensile alloy steel socket head screws that can fit in the cylinder mounting holes and torque them to the manufacturer's recommendations for their size.

3.2.2 – Side-Mounted Cylinders – In addition to the mounting bolts, cylinders of this type should be equipped with thrust keys or dowel pins located so as to resist the major load.

3.2.3 – Tie Rod Mounting – Cylinders with tie rod mountings are recommended for applications where mounting space is limited. Nuts used for this mounting style should be torqued to the same value as the tie rods for that bore size.

3.2.4 – Flange Mount Cylinders – The controlled diameter of the rod gland extension on head end flange mount cylinders can be used as a pilot to locate the cylinders in relation to the machine. After alignment has been obtained, the flanges may be drilled for pins or dowels to prevent shifting.

3.2.5 – Trunnion Mountings – Cylinders require lubricated bearing blocks with minimum bearing clearances. Bearing blocks should be carefully aligned and rigidly mounted so the trunnions will not be subjected to bending moments. The rod end should also be pivoted with the pivot pin in line and parallel to axis of the trunnion pins.

3.2.6 – Clevis Mountings – Cylinders should be pivoted at both ends with centerline of pins parallel to each other. After cylinder is mounted, be sure to check to assure that the cylinder is free to swing through its working arc without interference from other machine parts.

4.0 Cylinder and Accessories Maintenance, Troubleshooting and Replacement

4.1 Storage – At times cylinders are delivered before a customer is ready to install them and must be stored for a period of time. When storage is required the following procedures are recommended.

4.1.1 – Store the cylinders in an indoor area which has a dry, clean and noncorrosive atmosphere. Take care to protect the cylinder from both internal corrosion and external damage.

4.1.2 – Whenever possible cylinders should be stored in a vertical position (piston rod up). This will minimize corrosion due to possible condensation which could occur inside the cylinder. This will also minimize seal damage.

4.1.3 – Port protector plugs should be left in the cylinder until the time of installation.

4.1.4 – If a cylinder is stored full of hydraulic fluid, expansion of the fluid due to temperature changes must be considered. Installing a check valve with free flow out of the cylinder is one method.

4.1.5 – When cylinders are mounted on equipment that is stored outside for extended periods, exposed unpainted surfaces, e.g. piston rod, must be coated with a rust-inhibiting compound to prevent corrosion.

4.2 Cylinder Trouble Shooting

4.2.1 – **External Leakage**

4.2.1.1 – Rod seal leakage can generally be traced to worn or damaged seals. Examine the piston rod for dents, gouges or score marks, and replace piston rod if surface is rough.

Rod seal leakage could also be traced to bearing wear. If clearance is excessive, replace rod bearing and seal. Rod seal leakage can also be traced to seal deterioration. If seals are soft or gummy or brittle, check compatibility of seal material with lubricant used if air cylinder, or operating fluid if hydraulic cylinder. Replace with seal material, which is compatible with these fluids. If the seals are hard or have lost elasticity, it is usually due to exposure to temperatures in excess of 165°F. (+74°C). Shield the cylinder from the heat source to limit temperature to 350°F. (+177°C.) and replace with fluorocarbon seals.

4.2.1.2 – Cylinder body seal leak can generally be traced to a loose head. Torque the head to manufacturer's recommendation for that bore size.

Excessive pressure can also result in cylinder body seal leak. Determine maximum pressure to rated limits. Replace seals and retorque head as in paragraph above. Excessive pressure can also result in cylinder body seal leak. Determine if the pressure rating of the cylinder has been exceeded. If so, bring the operating pressure down to the rating of the cylinder and have the head replaced.

Pinched or extruded cylinder body seal will also result in a leak. Replace cylinder body seal and retorque as in paragraph above.

Cylinder body seal leakage due to loss of radial squeeze which shows up in the form of flat spots or due to wear on the O.D. or I.D. – Either of these are symptoms of normal wear due to high cycle rate or length of service. Replace seals as per paragraph above.

4.2.2 – **Internal Leakage**

4.2.2.1 – Piston seal leak (by-pass) 1 to 3 cubic inches per minute leakage is considered normal for piston ring construction. Virtually no static leak with lipseal type seals on piston should be expected. Piston seal wear is a usual cause of piston seal leakage. Replace seals as required.

4.2.2.2 – With lipseal type piston seals excessive back pressure due to over-adjustment of speed control valves could be a direct cause of rapid seal wear. Contamination in a hydraulic system can result in a scored cylinder bore, resulting in rapid seal wear. In either case, replace piston seals as required.

4.2.2.3 – What appears to be piston seal leak, evidenced by the fact that the cylinder drifts, is not always traceable to the piston. To make sure, it is suggested that one side of the cylinder piston be pressurized and the fluid line at the opposite port be disconnected. Observe leakage. If none is evident, seek the cause of cylinder drift in other component parts in the circuit.

4.2.3 – **Cylinder Fails to Move the Load**

4.2.3.1 – Pneumatic or hydraulic pressure is too low. Check the pressure at the cylinder to make sure it is to circuit requirements.

4.2.3.2 – Piston Seal Leak – Operate the valve to cycle the cylinder and observe fluid flow at valve exhaust ports at end of cylinder stroke. Replace piston seals if flow is excessive.

4.2.3.3 – Cylinder is undersized for the load – Replace cylinder with one of a larger bore size.

4.3 Erratic or Chatter Operation

4.3.1 – Excessive friction at rod bearing or piston bearing due to load misalignment – Correct cylinder-to-load alignment.

4.3.2 – Cylinder sized too close to load requirements – Reduce load or install larger cylinder.

4.3.3 – Erratic operation could be traced to the difference between static and kinetic friction. Install speed control valves to provide a back pressure to control the stroke.

4.4 Cylinder Modifications, Repairs, or Failed Component – Cylinders as shipped from the factory are not to be disassembled and or modified. If cylinders require modifications, these modifications must be done at company locations or by the Company's certified facilities. The Industrial Cylinder Division Engineering Department must be notified in the event of a mechanical fracture or permanent deformation of any cylinder component (excluding seals). This includes a broken piston rod, head, mounting accessory or any other cylinder component. The notification should include all operation and application details. This information will be used to provide an engineered repair that will prevent recurrence of the failure.

It is allowed to disassemble cylinders for the purpose of replacing seals or seal assemblies. However, this work must be done by strictly following all the instructions provided with the seal kits.

Offer of Sale

The items described in this document and other documents and descriptions provided by Parker Hannifin Corporation, its subsidiaries and its authorized distributors ("Seller") are hereby offered for sale at prices to be established by Seller. This offer and its acceptance by any customer ("Buyer") shall be governed by all of the following Terms and Conditions. Buyer's order for any item described in its document, when communicated to Seller verbally, or in writing, shall constitute acceptance of this offer. All goods, services or work described will be referred to as "Products".

1. Terms. All sales of Products by Seller will be governed by, and are expressly conditioned upon Buyer's assent to, these Terms. These Terms are incorporated into any Quote provided by Seller to Buyer. Buyer's order for any Products whether communicated to Seller verbally, in writing, by electronic data interface or other electronic commerce, shall constitute acceptance of these Terms. Seller objects to any contrary or additional terms or conditions of Buyer. Reference in Seller's order acknowledgement to Buyer's purchase order or purchase order number shall in no way constitute an acceptance of any of Buyer's terms or conditions of purchase. Any Quote made by Seller to Buyer shall be considered a firm and definite offer and shall not be deemed to be otherwise despite any language on the face of the Quote. Seller reserves all rights to accept or reject any purported acceptance by Buyer to Seller's Quote if such purported acceptance attempts to vary the terms of the Quote. If Seller ships Products after Buyer issues an acceptance to the Quote, any additional or different terms proposed by Buyer will not become part of the parties' business relationship unless agreed to in a writing that is signed by an authorized representative of Seller, excluding email correspondence. If the transaction proceeds without such agreement on the part of Seller, the business relationship will be governed solely by these Terms and the specific terms in Seller's Quote.

2. Price; Payment. The Products set forth in the Quote are offered for sale at the prices indicated in the Quote. Unless otherwise specifically stated in the Quote, prices are valid for thirty (30) days and do not include any sales, use, or other taxes or duties. Seller reserves the right to modify prices for any reason and at any time by giving ten (10) days prior written notice. Unless otherwise specified by Seller, all prices are F.C.A. Seller's facility (INCOTERMS 2020). All sales are contingent upon credit approval and full payment for all purchases is due thirty (30) days from the date of invoice (or such date as may be specified in the Quote). Under any circumstances, Buyer may not withhold or suspend payment of any amounts due and payable as a deduction, set-off or recoupment of any amount, claim or dispute with Seller. Unpaid invoices beyond the specified payment date incur interest at the rate of 1.5% per month or the maximum allowable rate under applicable law. Seller reserves the right to require advance payment or provision of securities for first and subsequent deliveries if there is any doubt, in Seller's sole determination, regarding the Buyer's creditworthiness or for other business reasons. If the requested advance payment or securities are not provided to Seller's satisfaction, Seller reserves the right to suspend performance or reject the purchase order, in whole or in part, without prejudice to Seller's other rights or remedies, including the right to full compensation. Seller may revoke or shorten any payment periods previously granted in Seller's sole determination. The rights and remedies herein reserved to Seller are cumulative and in addition to any other or further rights and remedies available at law or in equity. No waiver by Seller of any breach by Buyer of any provision of these terms will constitute a waiver by Seller of any other breach of such provision.

3. Shipment; Delivery; Title and Risk of Loss. All delivery dates are approximate, and Seller is not responsible for damages or additional costs resulting from any delay. All deliveries are subject to our ability to procure materials from our suppliers. Regardless of the manner of shipment, delivery occurs and title and risk of loss or damage pass to Buyer, upon placement of the Products with the carrier at Seller's facility. Unless otherwise agreed prior to shipment and for domestic delivery locations only, Seller will select and arrange, at Buyer's sole expense, the carrier and means of delivery. When Seller selects and arranges the carrier and means of delivery, freight and insurance costs for shipment to the designated delivery location will be prepaid by Seller and added as a separate line item to the invoice. Buyer shall be responsible for any additional shipping charges incurred by Seller due to Buyer's acts or omissions. Buyer shall not return or repackage any Products without the prior written authorization from Seller, and any return shall be at the sole cost and expense of Buyer.

4. Warranty. The warranty for the Products is as follows: (i) Goods are warranted against defects in material or workmanship for a period of eighteen (18) months from the date of delivery or 2,000 hours of use, whichever occurs first; (ii) Services shall be performed in accordance with generally accepted practices and using the degree of care and skill that is ordinarily exercised and customary in the field to which the Services pertain and are warranted for a period of six (6) months from the date of completion of the Services; and (iii) Software is only warranted to perform in accordance with applicable specifications provided by Seller to Buyer for ninety (90) days from the date of delivery or, when downloaded by a Buyer or end-user, from the date of the initial download. All prices are based upon the exclusive limited warranty stated above, and upon the following disclaimer: **EXEMPTION CLAUSE; DISCLAIMER OF WARRANTY, CONDITIONS, REPRESENTATIONS: THIS WARRANTY IS THE SOLE AND ENTIRE WARRANTY, CONDITION, AND REPRESENTATION, PERTAINING TO PRODUCTS. SELLER DISCLAIMS ALL OTHER WARRANTIES, CONDITIONS, AND REPRESENTATIONS, WHETHER STATUTORY, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THOSE RELATING TO DESIGN, NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE SOFTWARE IS ERROR-FREE OR FAULT-TOLERANT, OR THAT BUYER'S USE THEREOF WILL BE SECURE OR UNINTERRUPTED, UNLESS OTHERWISE AUTHORIZED IN WRITING BY SELLER, THE SOFTWARE SHALL NOT BE USED IN CONNECTION WITH HAZARDOUS OR HIGH-RISK ACTIVITIES OR ENVIRONMENTS. EXCEPT AS EXPRESSLY STATED HEREIN, ALL PRODUCTS ARE PROVIDED "AS IS".**

5. Claims; Commencement of Actions. Buyer shall promptly inspect all Products upon receipt. No claims for shortages will be allowed unless reported to Seller within ten (10) days of delivery. Buyer shall notify Seller of any alleged breach of warranty within thirty (30) days after the date the non-conformance is or should have been discovered by Buyer. Any claim or action against Seller based upon breach of contract or any other theory, including tort, negligence, or otherwise must be commenced within twelve (12) months from the date of the alleged breach or other alleged event, without regard to the date of discovery.

6. LIMITATION OF LIABILITY. IN THE EVENT OF A BREACH OF WARRANTY, SELLER WILL, AT ITS OPTION, REPAIR OR REPLACE THE NON-CONFORMING PRODUCTS, RE-PERFORM THE SERVICES, OR REFUND THE PURCHASE PRICE PAID WITHIN A REASONABLE PERIOD OF TIME. IN NO EVENT IS SELLER LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES INCLUDING ANY LOSS OF REVENUE OR PROFITS, WHETHER BASED IN CONTRACT, TORT OR OTHER LEGAL THEORY. IN NO EVENT SHALL SELLER'S LIABILITY UNDER ANY CLAIM MADE BY BUYER EXCEED THE PURCHASE PRICE PAID FOR THE PRODUCTS.

7. Confidential Information. Buyer acknowledges and agrees that Confidential Information has been and will be received in confidence and will remain the property of Seller. Buyer further agrees that it will not use Seller's Confidential Information for any purpose other than for the benefit of Seller and shall return all such Confidential Information to Seller within thirty (30) days upon request.

8. Loss to Buyer's Property. Buyer's Property will be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer ordering the Products manufactured using Buyer's Property. Also, Seller shall not be responsible for any loss or damage to Buyer's Property while it is in Seller's possession or control.

9. Special Tooling. Seller may impose a tooling charge for any Special Tooling. Special Tooling shall be and remain Seller's property. In no event will Buyer acquire any interest in the Special Tooling, even if such Special Tooling has been specially converted or adapted for manufacture of Goods for Buyer and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller has the right to alter, discard or otherwise dispose of any Special Tooling or other property owned by Seller in its sole determination at any time.

10. Security Interest. To secure payment of all sums due from Buyer, Seller retains a security interest in all Products delivered to Buyer and, Buyer's acceptance of these Terms is deemed to be a Security Agreement under the Uniform Commercial Code. Buyer authorizes Seller as its attorney to execute and file on Buyer's behalf all documents Seller deems necessary to perfect Seller's security interest.

11. User Responsibility. Buyer, through its own analysis and testing, is solely responsible for making the final selection of the Products and assuring that all performance, endurance, maintenance, safety and warning requirements of the application of the Products are met. Buyer must analyze all aspects of the application and follow applicable industry standards, specifications, and any technical information provided with the Quote or the Products, such as Seller's instructions, guides and specifications. If Seller provides options of or for Products based upon data or specifications provided by Buyer, Buyer is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the Products. In the event Buyer is not the end-user of the Products, Buyer will ensure such end-user complies with this paragraph.

12. Use of Products, Indemnity by Buyer. Buyer shall comply with all instructions, guides and specifications provided by Seller with the Quote or the Products. If Buyer uses or resells the Products in any way prohibited by Seller's instructions, guides or specifications, or Buyer otherwise fails to comply with Seller's instructions, guides and specifications, Buyer acknowledges that any such use, resale, or non-compliance is at Buyer's sole risk. Further, Buyer shall indemnify, defend, and hold Seller harmless from any losses, claims, liabilities, damages, lawsuits, judgments and costs (including attorney fees and defense costs), whether for personal injury, property damage, intellectual property infringement or any other claim, arising out of or in connection with: (a) improper selection, design, specification, application, or any misuse of Products; (b) any act or omission, negligent or otherwise, of Buyer; (c) Seller's use of Buyer's Property; (d) damage to the Products from an external cause, repair or attempted repair by anyone other than Seller, failure to follow instructions, guides and specifications provided by Seller, use with goods not provided by Seller, or opening, modifying, deconstructing, tampering with or repackaging the Products; or (e) Buyer's failure to comply with these Terms, including any legal or administrative proceedings, collection efforts, or other actions arising from or relating to such failure to comply. Seller shall not indemnify Buyer under any circumstance except as otherwise provided in these Terms.

13. Cancellations and Changes. Buyer may not cancel or modify, including but not limited to movement of delivery dates for the Products, any order for any reason except with Seller's written consent and upon terms that will indemnify, defend and hold Seller harmless against all direct, incidental and consequential loss or damage and any additional expense. Seller, at any time, may change features, specifications, designs and availability of Products.

14. Assignment. Buyer may not assign its rights or obligations without the prior written consent of Seller.

15. Force Majeure. Seller is not liable for delay or failure to perform any of its obligations by reason of any events or circumstances beyond its reasonable control. Such circumstances include without limitation: accidents, labor disputes or stoppages, government acts or orders, acts of nature, pandemics, epidemics, other widespread illness, or public health emergency, cyber related disruptions, cyber-attacks, ransomware sabotage, delays or failures in delivery from carriers or suppliers, shortages of materials, sudden increases in the price of raw materials or components, shutdowns or slowdowns affecting the supply of raw materials or components, or the transportation thereof, oil shortages or oil price increases, energy crisis, energy or fuel interruption, war (whether declared or not) or the serious threat of same, riots, rebellions, acts of terrorism, embargoes, fire or any reason whether similar to the foregoing or otherwise. Seller will resume performance as soon as practicable after the event of force majeure has been removed. All delivery dates affected by an event of force majeure shall be tolled for the duration of such event of force majeure and rescheduled for mutually agreed dates as soon as practicable after the event of force majeure ceases to exist. The right to allocate capacity is in the Seller's sole discretion. An event of force majeure shall not include financial distress, insolvency, bankruptcy, or other similar conditions affecting one of the parties, affiliates and/or sub¬contractors. An event of force majeure in the meaning of these Terms means any circumstances beyond Seller's control that permanently or temporarily hinders performance, even where that circumstance was already foreseen. Buyer shall not be entitled to cancel any orders following its claim of an event of force majeure.

16. Waiver and Severability. Failure to enforce any provision of these Terms will not invalidate that provision; nor will any such failure prejudice either party's right to enforce that provision in the future. Invalidation of any provision of these Terms shall not invalidate any other provision herein and, the remaining provisions will remain in full force and effect.

17. Duration. Unless otherwise stated in the Quote, any agreement governed by or arising from these Terms shall: (a) be for an initial duration of one (1) year; and (b) shall automatically renew for successive one-year terms unless terminated by Buyer with at least 180-days written notice to Seller or if Seller terminates the agreement pursuant to Section 19 of these Terms.

18. Termination. Seller may, without liability to Buyer, terminate any agreement governed by or arising from these Terms for any reason and at any time by giving Buyer thirty (30) days prior written notice. Seller may immediately terminate, in writing, if Buyer: (a) breaches any provision of these Terms, (b) becomes or is deemed insolvent, (c) appoints or has appointed a trustee, receiver or custodian for all or any part of Buyer's property,(d) files a petition for relief in bankruptcy on its own behalf, or one is filed against Buyer by a third party, (e) makes an assignment for the benefit of creditors; or (f) dissolves its business or liquidates all or a majority of its assets.

19. Ownership of Rights. Buyer agrees that (a) Seller (and/or its affiliates) owns or is the valid licensee of Seller's IP and (b) the furnishing of information, related documents or other materials by Seller to Buyer does not grant or transfer any ownership interest or license in or to Seller's IP to Buyer, unless expressly agreed in writing. Without limiting the foregoing, Seller retains ownership of all Software supplied to Buyer. In no event shall Buyer obtain any greater right in and to the Software than a right in a license limited to the use thereof and subject to compliance with any other terms provided with the Software. Buyer further agrees that it will not, directly or through intermediaries, reverse engineer, decompile, or disassemble any Software (including firmware) comprising or contained within a Product, except and only to the extent that such activity may be expressly permitted, either by applicable law or, in the case of open source software, the applicable open source license.

20. Indemnity for Infringement of Intellectual Property Rights. Seller is not liable for infringement of any Intellectual Property Rights except as provided in this Section. Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on a third-party claim that one or more of the Products infringes the Intellectual Property Rights of a third party in the country of delivery of the Products by Seller to Buyer. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of any such claim, and Seller having sole control over the defense of the claim including all negotiations for settlement or compromise. If one or more Products is subject to such a claim, Seller may, at its sole expense and option, procure for Buyer the right to continue using the Products, replace or modify the Products to render them non-infringing, or offer to accept return of the Products and refund the purchase price less a reasonable allowance for depreciation. Seller has no obligation or liability for any claim of infringement: (i) arising from information provided by Buyer (including Seller's use of Buyer's Property); or (ii) directed to any Products for which the designs are specified in whole or part by Buyer; or (iii) resulting from the modification, combination or use in a system of any Products. The foregoing provisions of this Section constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for claims of infringement of Intellectual Property Rights.

21. Governing Law. These Terms, the terms of any Quote, and the sale and delivery of all Products are deemed to have taken place in, and shall be governed and construed in accordance with, the laws of the State of Ohio, as applicable to contracts executed and wholly performed therein and without regard to conflicts of laws principles. Buyer irrevocably agrees and consents to the exclusive jurisdiction and venue of the courts of Cuyahoga County, Ohio with respect to any dispute, controversy or claim arising out of or relating to the sale and delivery of the Products.

22. Entire Agreement. These Terms, along with the terms set forth in the Quote, forms the entire agreement between the Buyer and Seller and constitutes the final, complete and exclusive expression of the terms of sale and purchase. In the event of a conflict between any term set forth in the Quote and these Terms, the terms set forth in the Quote shall prevail. All prior or contemporaneous written or oral agreements or negotiations with respect to the subject matter shall have no effect. No modification to these Terms will be binding on Seller unless agreed to in a writing that is signed by an authorized representative of Seller, excluding email correspondence, 'clickwrap' or other purported electronic assent to different or additional terms. Sections 2-25 of these Terms shall survive termination or cancellation of any agreement governed by or arising from these Terms.

23. No 'Wrap' Agreements/No Authority to Bind. Seller's clicking any buttons or any similar action, such as clicking "I Agree" or "Confirm," to utilize Buyer's software or webpage for the placement of orders, is NOT an agreement to Buyer's Terms and Conditions. NO EMPLOYEE, AGENT OR REPRESENTATIVE OF SELLER HAS THE AUTHORITY TO BIND SELLER BY THE ACT OF CLICKING ANY BUTTON OR SIMILAR ACTION ON BUYER'S WEBSITE OR PORTAL.

24. Compliance with Laws. Buyer agrees to comply with all applicable laws, regulations, and industry and professional standards, including those of the United States of America, and the country or countries in which Buyer may operate, including without limitation the U.S. Foreign Corrupt Practices Act ("FCPA"), the U.S. Anti-Kickback Act ("Anti-Kickback Act"), U.S. and E.U. export control and sanctions laws ("Export Laws"), the U.S. Food Drug and Cosmetic Act ("FDCA"), and the rules and regulations promulgated by the U.S. Food and Drug Administration ("FDA"), each as currently amended. Buyer agrees to indemnify, defend, and hold harmless Seller from the consequences of any violation of such laws, regulations and standards by Buyer, its employees or agents. Buyer represents that it is familiar with all applicable provisions of the FCPA, the Anti-Kickback Act, Export Laws, the FDCA and the FDA and certifies that Buyer will adhere to the requirements thereof and not take any action that would make Seller violate such requirements. Buyer represents and agrees that Buyer will not make any payment or give anything of value, directly or indirectly, to any governmental official, foreign political party or official thereof, candidate for foreign political office, or commercial entity or person, for any improper purpose, including the purpose of influencing such person to purchase Products or otherwise benefit the business of Seller. Buyer further represents and agrees that it will not receive, use, service, transfer or ship any Products from Seller in a manner or for a purpose that violates Export Laws or would cause Seller to be in violation of Export Laws. Buyer agrees to promptly and reliably provide Seller all requested information or documents, including end-user statements and other written assurances, concerning Buyer's ongoing compliance with Export Law. (9/22)

06/24 / Catalog HY08-1000

Parker Hannifin Corporation
Cylinder and Accumulator Division
500 South Wolf Road
Des Plaines, IL 60016
phone (847) 298-2400
fax (800) 892-1008
www.parker.com/cylinder-accumulator