Commercial Hydraulics

Welded Cylinders

Telescopic and Piston Rod
Product Information
Data & Application Guide

Catalog HY18-0007/US

Parker Hydraulics

⚠ WARNING

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker Hannifin Corporation, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application and review the information concerning the product or system in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

The products described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by Parker Hannifin Corporation and its subsidiaries at any time without notice.

Offer of Sale

The items described in this document are hereby offered for sale by Parker Hannifin Corporation, its subsidiaries or its authorized distributors. This offer and its acceptance are governed by the provisions stated in the "Offer of Sale".

MOBILE CYLINDER DIVISION PRODUCTS & CAPABILITIES

- **TELESCOPIC CYLINDERS**
  Single Acting
  Double Acting
- **SINGLE STAGE “Rod Type” CYLINDERS**
  Single Acting
  Double Acting
- **BUILD TO CUSTOMER PRINTS OR PER APPLICATION SPECIFICATIONS**
- **BORE SIZES UP TO 20” DIAMETER**
- **STROKE LENGTHS UP TO 500”**
- **OPERATING PRESSURES UP TO 10,000 PSI**
- **VARIOUS OPERATING FLUIDS**
- **BATCH SIZES 1PC TO 100’s**
- **VARIOUS MATERIALS & COATINGS**
  Stainless Steel
  Electroless Nickel
  Nitriding
  Chrome
  Double Chrome
- **TYPICAL OPTIONS**
  Load Holding Valves
  Electro-Hydraulic Transducers
  End of Stroke Hydraulic Cushions
  Protective Rod Boots
  Proximity Switches
  Flow Controls
  Flow Fuses

The code and model numbers of a Commercial Hydraulics Cylinder are references to its size and type. Using these numbers when ordering or inquiring greatly facilitates accurate understanding.

The following are examples of Commercial Hydraulics cylinder code and model numbers.

Single-acting Telescopic	Double-acting Telescopic	Double-acting Piston Rod
S63MB-9-120	**SD96CC-3-199**	**D72LB-11-83**
S=① 6=② 3=③ M=④ B=⑤ 9=⑥ 120=⑦	SD=① 9=② 6=③ C=④ C=⑤ 3=⑥ 199=⑦	D=① 72=② L=④ B=⑤ 11=⑥ 83=⑦

1. **S = Single-acting Telescopic or Displacement Cylinder**
   (Commercial has also used SA, SF, and H as a prefix)
   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 Piston 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**

OUR DESIGN ADVANTAGES INCLUDE:

* *Longer sleeve overlap for improved stability and higher column loading.*
* *Nylon tipped set screws that conform to the shape of the packing nut threads. It is nearly impossible for the packing nut to back off accidentally.*
* *Snap-on, glass-filled bearings that absorb contaminants without damaging cylinder walls.*
* *Threaded steel stop rings for easier servicing and more reliable stopping action.*
* *External packing nuts give added support to the tube exterior while making service procedures easier.*
* *Wave springs and chevron packing for self-compensating seals.*
* *Hytrel rod wipers that resist higher temperatures without extrusion.*
* *Positive manual air bleeder prevents cavitation and “mushy” cylinder action.*
* *Cast steel mountings offer dependable strength. Pin-eye and rod-end are welded into a single unit.*

" S" SERIES SINGLE-ACTING, SINGLE & MULTIPLE STAGE CYLINDERS

Sleeve or Plunger O.D. (in inches)	Effective Area in square inches	Load Capactity lbs @ 2000 p.s.i.	Displacement per inch of stroke in 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

" SD" SERIES DOUBLE-ACTING, MULTIPLE STAGE CYLINDER

Sleeve or Plunger O.D. (in inches)	Bore of Main or Sleeve (in inches)	Effective area (sq. inches) to extend	Effective area (sq. inches) to retract	Load capacity lbs @ 2000 p.s.i. extending	Load capacity lbs @ 2000 p.s.i. retracting	Displacement per inch of stroke (in gallons)* to extend	Displacement per inch of stroke (in 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-8-190 (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.

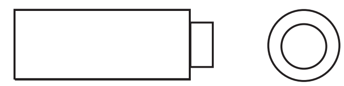
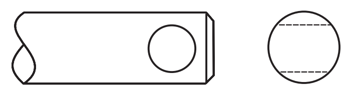
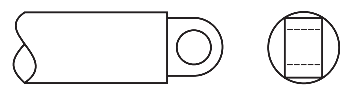
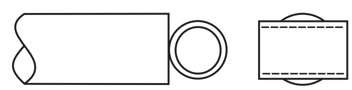
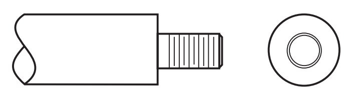
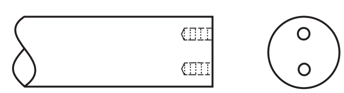
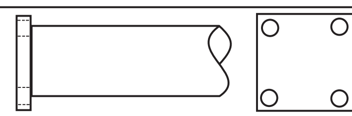
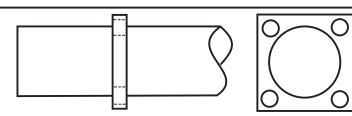
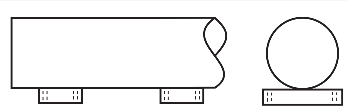
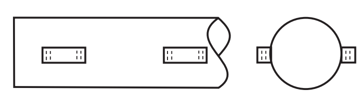
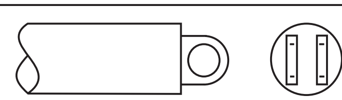
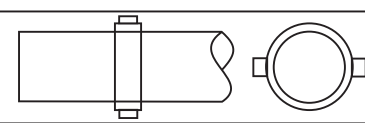
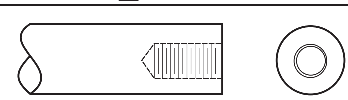
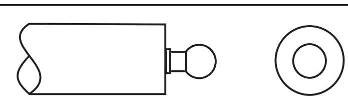
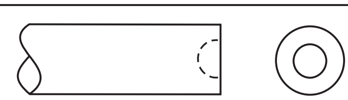
To calculate effective area in square inches: Multiply diameter times diameter times .78
Example: 5 dia. x 5 dia. = 25 x .78 = 19.63 Square inches of area

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 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.= .210
.477

.447 ÷ 3 = .159 gallons per inch of stroke
.159 gallons per inch x 134" of stroke = 21.31 gallons to extend cylinder

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**

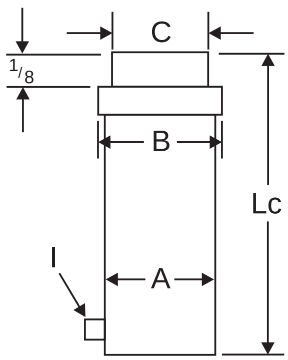
Closed Length Calculations for Single-Acting Single & Multiple Stage Cylinders

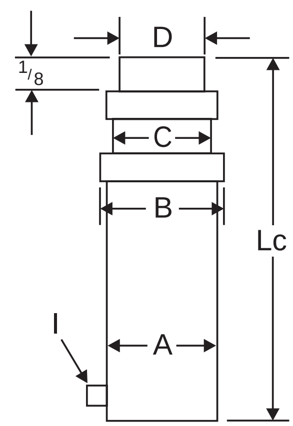
* Closed length (Lc) for S Models is computed by one of the three equations below. Model number and stroke required determines which equation to use. Example: To find Lc for S41 cylinder with 68" stroke. Under S41 column, use equation III, because the stroke is over 50".

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

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

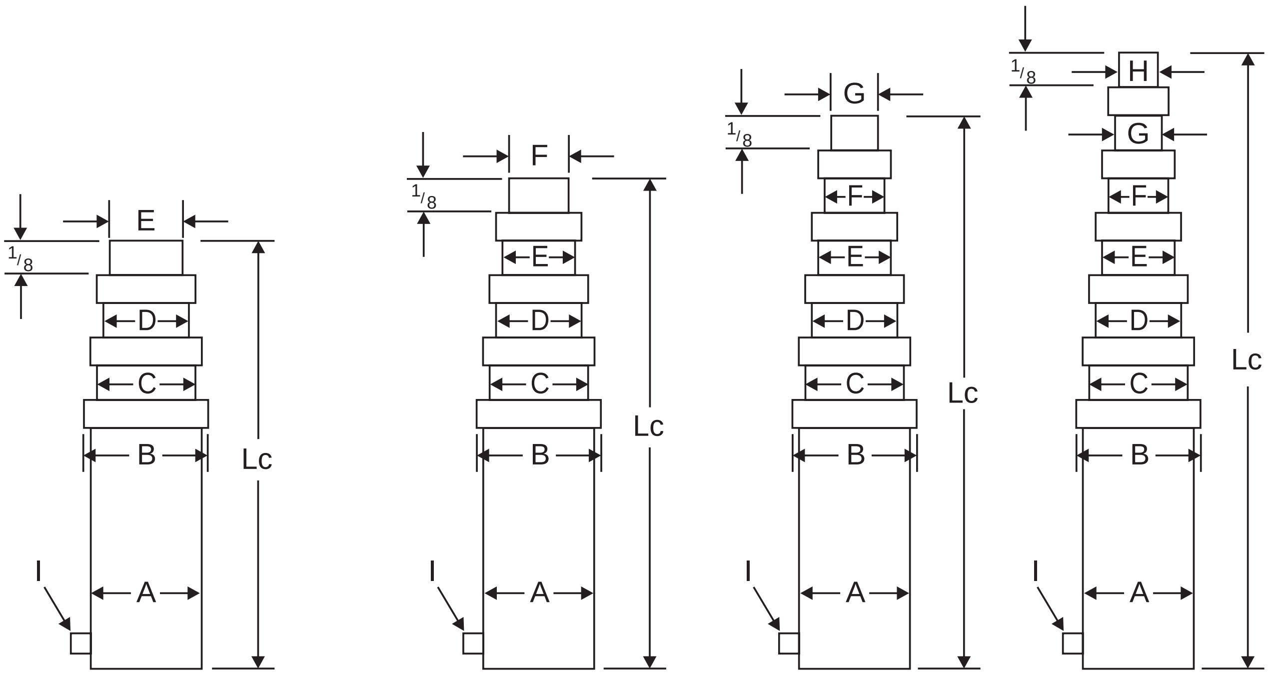
The closed length (Lc) is 77.50". Add Lc 77.50" to the stroke 68" for extended length of 145.50"





		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	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	8	$9\frac{1}{8}$	$10\frac{13}{16}$	A	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	8	$9\frac{1}{8}$	$10\frac{13}{16}$
Largest Packing Nut O.D.	B	$4\frac{3}{8}$	$5\frac{3}{8}$	$6\frac{3}{8}$	$7\frac{3}{8}$	$8\frac{5}{8}$	$9\frac{7}{8}$	$11\frac{3}{4}$	B	$5\frac{3}{8}$	$6\frac{3}{8}$	$7\frac{3}{8}$	$8\frac{5}{8}$	$9\frac{7}{8}$	$11\frac{3}{4}$
1st Sleeve O.D.	C	$2\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$	$9\frac{3}{8}$	C	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$	$9\frac{3}{8}$
2nd Sleeve O.D.	D								D	$2\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$
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	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	1	1	$1\frac{1}{4}$	$1\frac{1}{4}$	I	$\frac{3}{4}$	$\frac{3}{4}$	1	1	$1\frac{1}{4}$	$1\frac{1}{4}$
Max. Stroke at 2000 PSI		71	84	88	95	118	128	190		126	137	138	164	186	265
*To Find Closed Length - Lc	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
Equation I	L_C	Stroke + X up to 35" stroke (O.L. = $1\frac{1}{4}$")							L_C	$\frac{\text{Stroke}}{2} + X$ up to 35" stroke (O.L. = $1\frac{1}{4}$")					
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	$\frac{\text{Stroke}}{2} + X_1$ 36" to 50" stroke (O.L. = 3")					
Equation III	X_2	$\frac{\text{Stroke - 50}}{10}$ (To next largest whole number)							X_2	$\frac{\text{Stroke - 50}}{20}$ (To next largest whole number)					
	L_C	Stroke + X_1 + X_2 over 50" stroke (O.L. = 3" + X_2)							L_C	$\frac{\text{Stroke}}{2} + X_1 + X_2$ over 50" stroke (O.L. = 3" + X_2)					

Closed Length Calculations for Single-Acting Single & Multiple Stage Cylinders



3 STAGE	S53	S63	S73	S83	S93
A	$5\frac{3}{4}$	$6\frac{3}{4}$	8	$9\frac{1}{8}$	$10\frac{13}{16}$
B	$6\frac{3}{8}$	$7\frac{3}{8}$	$8\frac{5}{8}$	$9\frac{7}{8}$	$11\frac{3}{4}$
C	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$	$9\frac{3}{8}$
D	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$
E	$2\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$
F					
G					
H					
I	$\frac{3}{4}$	1	1	$1\frac{1}{4}$	$1\frac{1}{4}$
	181	186	204	224	312
X	7.62	7.88	7.88	8.38	8.50
L_C	$\frac{\text{Stroke}}{3} + X$ O.L. = $1\frac{1}{4}$" up to 50" stroke				
X_1	9.38	9.62	9.62	10.12	10.25
L_C	$\frac{\text{Stroke}}{3} + X_1$ O.L. = 3" 51" to 75" stroke				
X_2	$\frac{\text{Stroke - 75}}{30}$ (To next largest whole number)				
L_C	$\frac{\text{Stroke}}{3} + X_1 + X_2$ O.L. = 3" + X_2 over 75" stroke				

4 STAGE	S64	S74	S84	S94
A	$6\frac{3}{4}$	8	$9\frac{1}{8}$	$10\frac{13}{16}$
B	$7\frac{3}{8}$	$8\frac{5}{8}$	$9\frac{7}{8}$	$11\frac{3}{4}$
C	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$	$9\frac{3}{8}$
D	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$
E	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$
F	$2\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$
G				
H				
I	1	1	$1\frac{1}{4}$	$1\frac{1}{4}$
	238	262	265	352
X	8.81	8.81	9.31	9.44
L_C	$\frac{\text{Stroke}}{4} + X$ O.L. = $1\frac{1}{4}$" up to 70" stroke			
X_1	10.56	10.56	11.06	11.19
L_C	$\frac{\text{Stroke}}{4} + X_1$ O.L. = 3" 71" to 100"			
X_2	$\frac{\text{Stroke - 100}}{40}$ (To next largest whole number)			
L_C	$\frac{\text{Stroke}}{4} + X_1 + X_2$ O.L. = 3" + X_2 over 100" stroke			

5 STAGE	S75	S85	S95
A	8	$9\frac{1}{8}$	$10\frac{13}{16}$
B	$8\frac{5}{8}$	$9\frac{7}{8}$	$11\frac{3}{4}$
C	$6\frac{3}{4}$	$7\frac{7}{8}$	$9\frac{3}{8}$
D	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{7}{8}$
E	$4\frac{3}{4}$	$5\frac{3}{4}$	$6\frac{3}{4}$
F	$3\frac{3}{4}$	$4\frac{3}{4}$	$5\frac{3}{4}$
G	$2\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{3}{4}$
H			
I	1	$1\frac{1}{4}$	$1\frac{1}{4}$
	335	336	410
X	9.75	10.25	10.38
L_C	$\frac{\text{Stroke}}{5} + X$ O.L. = $1\frac{1}{4}$" up to 85" stroke		
X_1	11.50	12.00	12.12
L_C	$\frac{\text{Stroke}}{5} + X_1$ O.L. = 3" 86" to 125" stroke		
X_2	$\frac{\text{Stroke - 125}}{50}$ (To next largest whole number)		
L_C	$\frac{\text{Stroke}}{5} + X_1 + X_2$ O.L. = 3" + X_2 over 125" stroke		

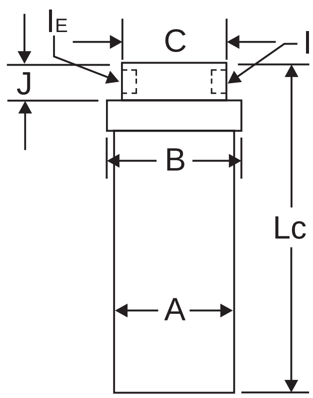
6 STAGE	S86	S96
A	$9\frac{1}{8}$	$10\frac{13}{16}$
B	$9\frac{7}{8}$	$11\frac{3}{4}$
C	$7\frac{7}{8}$	$9\frac{3}{8}$
D	$6\frac{3}{4}$	$7\frac{7}{8}$
E	$5\frac{3}{4}$	$6\frac{3}{4}$
F	$4\frac{3}{4}$	$5\frac{3}{4}$
G	$3\frac{3}{4}$	$4\frac{3}{4}$
H	$2\frac{3}{4}$	$3\frac{3}{4}$
I	$1\frac{1}{4}$	$1\frac{1}{4}$
	T.B.A.	T.B.A.
X	11.19	11.31
L_C	$\frac{\text{Stroke}}{6} + X$ O.L. = $1\frac{1}{4}$" up to 100" stroke	
X_1	12.94	13.06
L_C	$\frac{\text{Stroke}}{6} + X_1$ O.L. = 3" 101" to 150" stroke	
X_2	$\frac{\text{Stroke - 150}}{60}$ (To next largest whole number)	
L_C	$\frac{\text{Stroke}}{6} + X_1 + X_2$ O.L. = 3" + X_2 over 150" stroke	

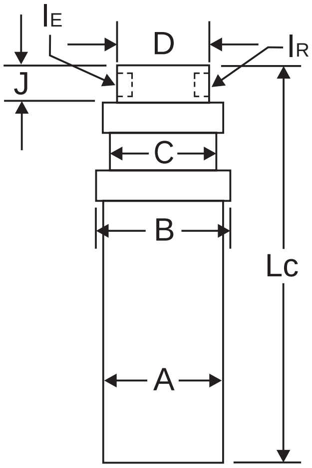
Closed Length Calculations for Double-Acting Single & Multiple Stage Cylinders

* 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”.

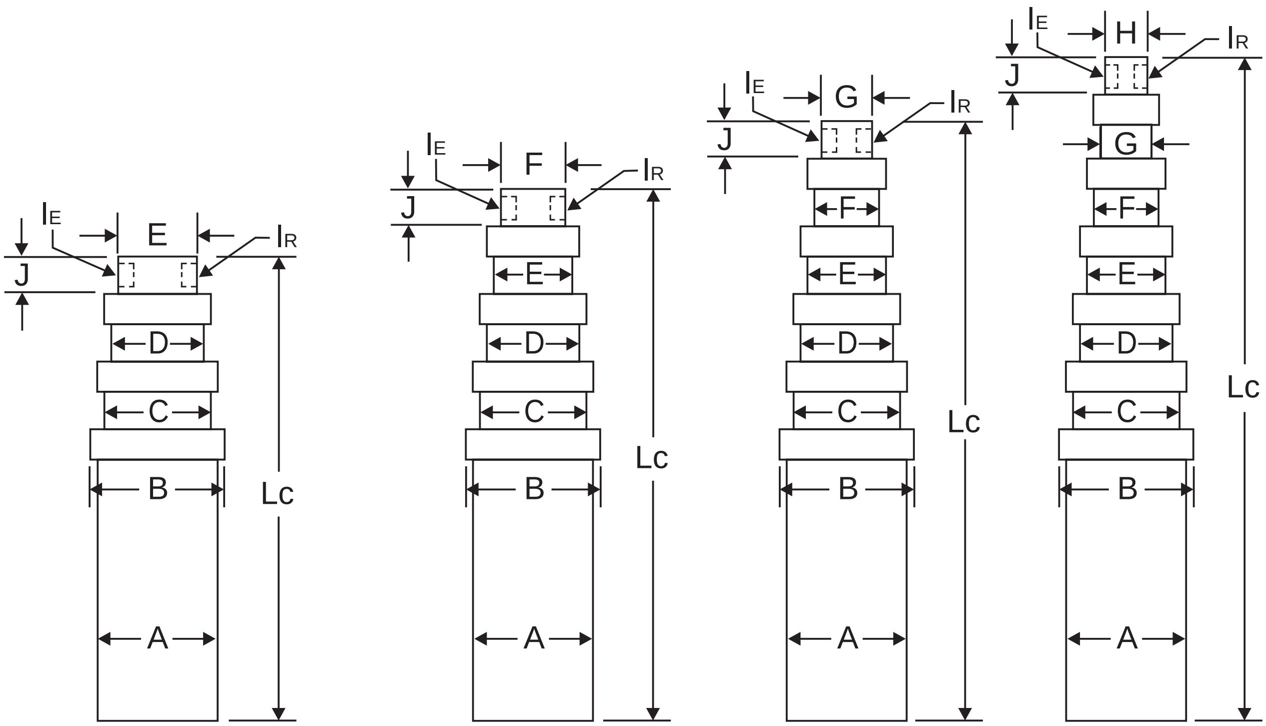
$$Lc = Stroke + X_1 + X_2 = 68" + 12" + \frac{68 - 50)}{4.5} = 68" + 12" + (.666).$$

Use next largest whole number. = 68” + 12” + 1” = 81”.
The closed length (Lc) is 81”. Add Lc 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	$\frac{Stroke}{2} + X$ 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	$\frac{Stroke - 95}{6}$ (To next largest whole number)					
	L_C	$Stroke + X_1$ 46" to 65" stroke (O.L. = 6")							L_C	$\frac{Stroke}{2} + X + X_1$ 95" stroke to max. (O.L. = 6" + X_1)					
Equation III	X_2	$\frac{Stroke - 65}{4.5}$ (To next largest whole number)							X_2	Not Required					
	L_C	$Stroke + X_1 + X_2$ 66" stroke to max.							L_C	Not Required					

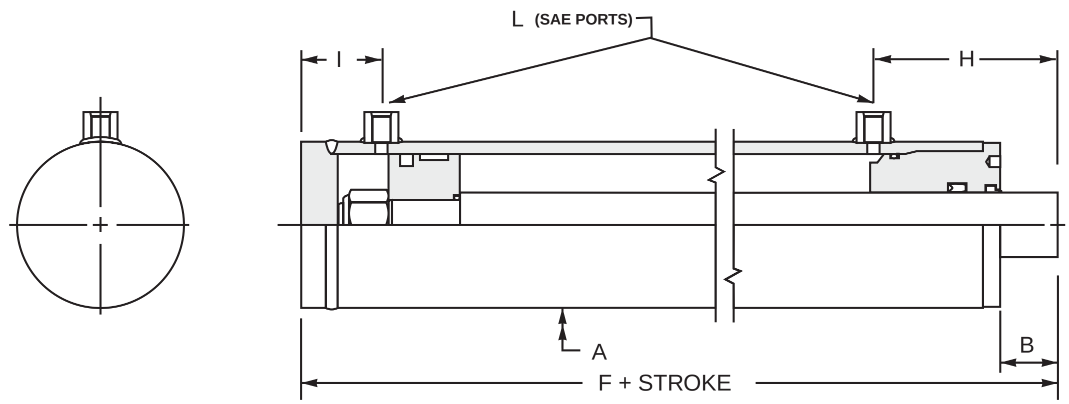


3 STAGE	SD53	SD63	SD73	SD83	SD93
A	5 3/4	6 3/4	8	9 1/8	10 13/16
B	6 3/8	7 3/8	8 5/8	9 7/8	11 3/4
C	4 3/4	5 3/4	6 3/4	7 7/8	9 3/8
D	3 3/4	4 3/4	5 3/4	6 3/4	7 7/8
E	2 3/4	3 3/4	4 3/4	5 3/4	6 3/4
F					
G					
H					
I_E	3/4	1	1	1 1/4	1 1/4
I_R	1/2	3/4	3/4	1	1
J	1 5/8	2 1/8	2 1/8	2 5/8	2 5/8
	215	220	259	289	403
	146	150	175	194	268
X	14.00	14.75	14.75	15.75	15.88
L_C	$\frac{\text{Stroke}}{3} + X$ O.L. = 6" up to 120" stroke				
X_1	$\frac{\text{Stroke - 120}}{5}$ (To next largest whole number)				
L_C	$\frac{\text{Stroke}}{3} + X + X_1$ 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	$\frac{\text{Stroke}}{4} + X$ O.L. = 6" up to 140" stroke			
X_1	$\frac{\text{Stroke - 140}}{6}$ (To next largest whole number)			
L_C	$\frac{\text{Stroke}}{4} + X + X_1$ 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	$\frac{\text{Stroke}}{5} + X$ O.L. = 6" up to 140" stroke		
X_1	$\frac{\text{Stroke - 140}}{8}$ (To next largest whole number)		
L_C	$\frac{\text{Stroke}}{5} + X + X_1$ O.L. = 6" + X_1 140" to 210" stroke		
X_2	$\frac{\text{Stroke - 210}}{3.5}$ (To next largest whole number)		
L_C	$\frac{\text{Stroke}}{5} + X + X_2 + 9$ 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	$\frac{\text{Stroke}}{6} + X$ O.L. = 6" up to 150" stroke	
X_1	$\frac{\text{Stroke - 150}}{10}$ (To next largest whole number)	
L_C	$\frac{\text{Stroke}}{6} + X + X_1$ O.L. = 6" + X_1 150" to 250" stroke	
X_2	Check with Engineering	
L_C	Check with Engineering	



2500 PSI STANDARD DUTY 100 SERIES CYLINDER

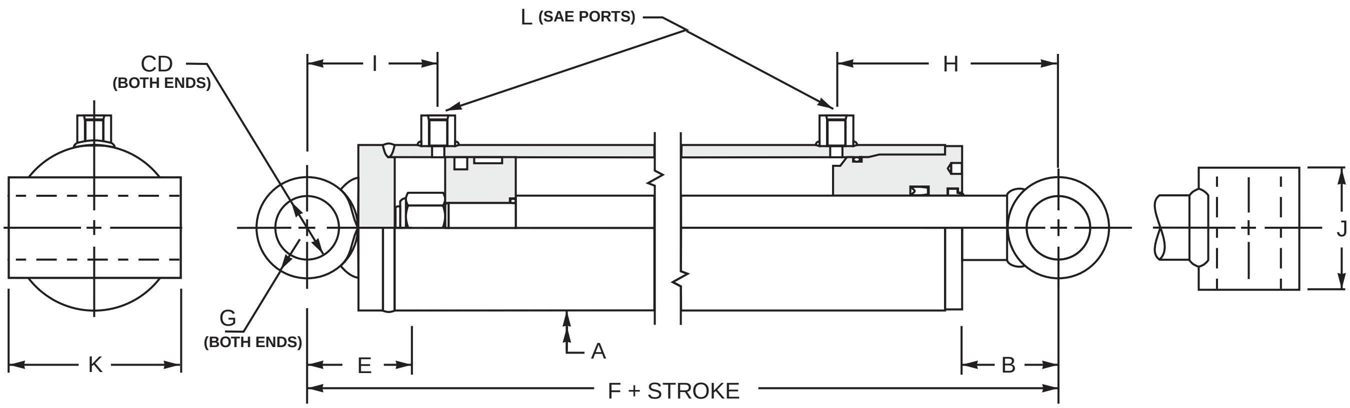
FEATURES

- *COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
- *GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
- *WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
- *INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
- *HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
- *DUCTILE IRON HEAD GLAND & PISTON
- *PISTON UTILIZES WEAR BEARINGS
- *NYLON INSERTED LOCK NUT
- *STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	F	H	I	L	Maximum Stroke	Part#
1.50	.75	2.00	1.38	5.75	3.31	1.31	#4	18	104-**.**
	1.00	2.00	1.50	6.00	3.56	1.31	#4	34	106-**.**
2.00	1.00	2.50	1.38	6.25	3.62	1.38	#6	25	110-**.**
	1.12	2.50	1.50	6.25	3.62	1.38	#6	31	112-**.**
	1.25	2.50	1.50	6.50	3.88	1.38	#6	39	114-**.**
2.50	1.25	3.00	1.50	6.50	3.62	1.62	#6	31	118-**.**
	1.50	3.00	1.56	7.00	4.06	1.69	#6	45	120-**.**
3.00	1.25	3.50	1.56	7.00	4.00	1.75	#8	26	124-**.**
	1.50	3.50	1.44	7.00	3.88	1.88	#8	38	126-**.**
	1.75	3.50	1.44	7.00	3.88	1.88	#8	52	128-**.**
	2.00	3.50	1.44	7.25	4.12	1.88	#8	66	130-**.**
3.50	1.50	4.00	1.56	7.25	4.00	2.00	#8	32	134-**.**
	1.75	4.00	1.56	7.25	4.00	2.00	#8	44	136-**.**
	2.00	4.00	1.56	7.25	4.00	2.00	#8	58	138-**.**
4.00	1.50	4.50	1.44	7.25	3.88	2.12	#8	28	142-**.**
	1.75	4.50	1.50	7.50	3.94	2.31	#8	39	144-**.**
	2.00	4.50	1.50	7.50	3.94	2.31	#8	51	146-**.**
	2.50	4.50	1.50	7.75	4.19	2.31	#8	78	148-**.**
4.50	1.75	5.00	1.38	7.75	3.81	2.44	#8	34	152-**.**
	2.00	5.00	1.38	7.75	3.81	2.44	#8	45	154-**.**
	2.25	5.00	1.38	7.75	3.81	2.44	#8	58	156-**.**
5.00	2.00	5.62	1.50	8.25	3.94	2.81	#8	40	160-**.**
	2.50	5.62	1.50	8.50	4.19	2.81	#8	62	162-**.**
	3.00	5.62	1.50	8.50	4.19	2.81	#8	89	164-**.**

Ordering Information: *** TO COMPLETE PART#; REPLACE (**.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60”, add 1” for every 10” of stroke to the “F” dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



2500 PSI STANDARD DUTY 200 SERIES CYLINDER

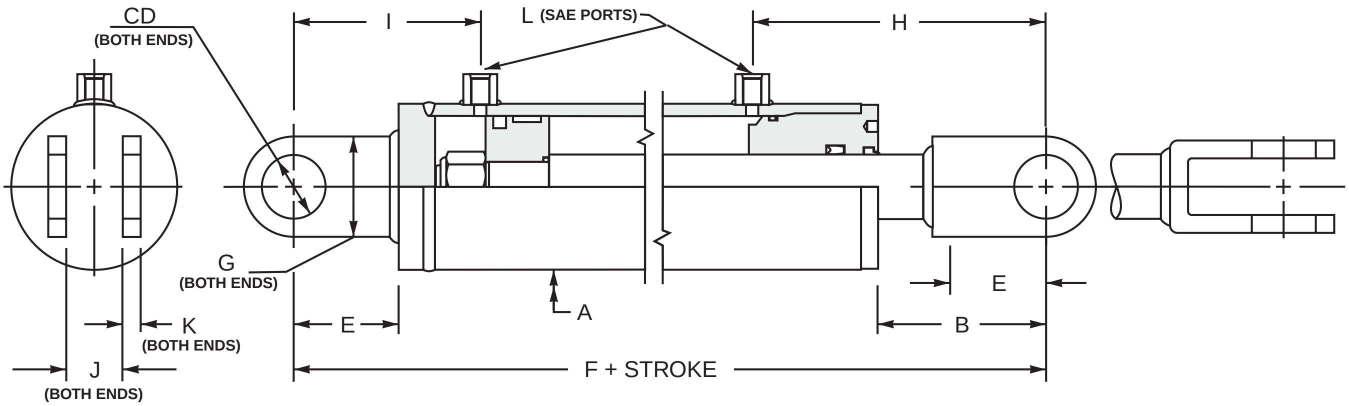
FEATURES

- *COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
- *GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
- *WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
- *INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
- *HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
- *DUCTILE IRON HEAD GLAND & PISTON
- *PISTON UTILIZES WEAR BEARINGS
- *NYLON INSERTED LOCK NUT
- *STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	CD	E	F	G	H	I	J	K	L	Maximum Stroke	Part#
1.50	.75	2.00	1.31	.75	.56	6.25	.62	3.25	1.88	2.50	2.50	#4	18	204-**.**
	1.00	2.00	1.19	.75	.56	6.25	.62	3.25	1.88	2.50	2.50	#4	34	206-**.**
2.00	1.00	2.50	1.44	1.00	.69	7.00	.75	3.69	2.06	2.50	3.00	#6	25	210-**.**
	1.12	2.50	1.56	1.00	.69	7.00	.75	3.69	2.06	2.50	3.00	#6	31	212-**.**
	1.25	2.50	1.31	1.00	.69	7.00	.75	3.69	2.06	2.50	3.00	#6	39	214-**.**
2.50	1.25	3.00	1.69	1.00	.81	7.50	.88	3.81	2.44	2.50	3.25	#6	31	218-**.**
	1.50	3.00	1.50	1.00	.81	7.75	.88	4.00	2.50	2.50	3.25	#6	45	220-**.**
3.00	1.25	3.50	1.50	1.00	.81	7.75	.88	3.94	2.56	2.50	3.75	#8	26	224-**.**
	1.50	3.50	1.38	1.00	.81	7.75	.88	3.81	2.69	2.50	3.75	#8	38	226-**.**
	1.75	3.50	1.38	1.00	.81	7.75	.88	3.81	2.69	2.50	3.75	#8	52	228-**.**
	2.00	3.50	1.38	1.00	.81	8.00	.88	4.06	2.69	2.50	3.75	#8	66	230-**.**
3.50	1.50	4.00	1.44	1.25	.88	8.00	1.00	3.88	2.88	2.75	4.25	#8	32	234-**.**
	1.75	4.00	1.44	1.25	.88	8.00	1.00	3.88	2.88	2.75	4.25	#8	44	236-**.**
	2.00	4.00	1.44	1.25	.88	8.00	1.00	3.88	2.88	2.75	4.25	#8	58	238-**.**
4.00	1.50	4.50	1.56	1.25	.88	8.25	1.00	4.00	3.00	2.75	4.75	#8	28	242-**.**
	1.75	4.50	1.62	1.25	.88	8.50	1.00	4.06	3.19	2.75	4.75	#8	39	244-**.**
	2.00	4.50	1.62	1.25	.88	8.50	1.00	4.06	3.19	2.75	4.75	#8	51	246-**.**
	2.50	4.50	1.62	1.25	.88	8.75	1.00	4.31	3.19	2.75	4.75	#8	78	248-**.**
4.50	1.75	5.00	1.50	1.25	.88	8.75	1.00	3.94	3.31	2.75	5.25	#8	34	252-**.**
	2.00	5.00	1.50	1.25	.88	8.75	1.00	3.94	3.31	2.75	5.25	#8	45	254-**.**
	2.25	5.00	1.50	1.25	.88	8.75	1.00	3.94	3.31	2.75	5.25	#8	58	256-**.**
5.00	2.00	5.62	1.88	1.50	1.12	9.75	1.25	4.31	3.94	2.75	6.00	#8	40	260-**.**
	2.50	5.62	1.88	1.50	1.12	10.00	1.25	4.56	3.94	2.75	6.00	#8	62	262-**.**
	3.00	5.62	1.88	1.50	1.12	10.00	1.25	4.56	3.94	4.25	6.00	#8	89	264-**.**

Ordering Information: * TO COMPLETE PART#; REPLACE (.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60”, add 1” for every 10” of stroke to the “F” dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



2500 PSI STANDARD DUTY 300 SERIES CYLINDER

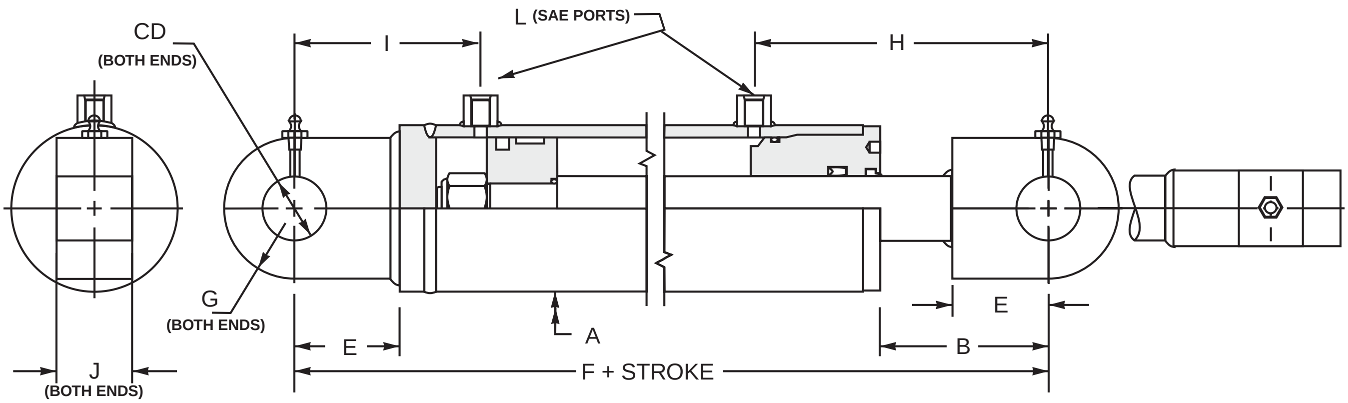
FEATURES

* COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
* GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
* WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
* INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
* HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
* DUCTILE IRON HEAD GLAND & PISTON
* PISTON UTILIZES WEAR BEARINGS
* NYLON INSERTED LOCK NUT
* STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	CD	E	F	G	H	I	J	K	L	Maximum Stroke	Part#
1.50	.75	2.00	3.00	.75	1.62	9.00	1.75	4.94	2.94	1.06	.38	#4	18	304-**.**
	1.00	2.00	2.88	.75	1.62	9.00	1.75	4.94	2.94	1.06	.38	#4	34	306-**.**
2.00	1.00	2.50	3.88	1.00	2.00	10.25	2.00	5.62	3.38	1.25	.50	#6	25	310-**.**
	1.12	2.50	3.50	1.00	2.00	10.25	2.00	5.62	3.38	1.25	.50	#6	31	312-**.**
	1.25	2.50	3.25	1.00	2.00	10.25	2.00	5.62	3.38	1.25	.50	#6	39	314-**.**
2.50	1.25	3.00	3.25	1.00	2.00	10.25	2.00	5.38	3.62	1.25	.50	#6	31	318-**.**
	1.50	3.00	3.06	1.00	2.00	10.25	2.00	5.56	3.44	1.25	.50	#6	45	320-**.**
3.00	1.25	3.50	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	26	324-**.**
	1.50	3.50	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	38	326-**.**
	1.75	3.50	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	52	328-**.**
	2.00	3.50	3.06	1.00	2.00	10.25	2.00	5.75	3.25	1.25	.50	#8	66	330-**.**
3.50	1.50	4.00	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	32	334-**.**
	1.75	4.00	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	44	336-**.**
	2.00	4.00	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	58	338-**.**
4.00	1.50	4.50	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	28	342-**.**
	1.75	4.50	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	39	344-**.**
	2.00	4.50	3.06	1.00	2.00	10.25	2.00	5.50	3.50	1.25	.50	#8	51	346-**.**
	2.50	4.50	3.25	1.00	2.00	11.25	2.00	5.94	4.06	1.25	.50	#8	78	348-**.**
4.50	1.75	5.00	3.38	1.25	2.00	11.75	2.50	5.81	4.44	1.62	.75	#8	34	352-**.**
	2.00	5.00	3.38	1.25	2.00	11.75	2.50	5.81	4.44	1.62	.75	#8	45	354-**.**
	2.25	5.00	3.38	1.25	2.00	11.75	2.50	5.81	4.44	1.62	.75	#8	58	356-**.**
5.00	2.00	5.62	4.25	1.50	2.50	13.50	3.00	6.69	5.31	2.12	1.00	#8	40	360-**.**
	2.50	5.62	4.25	1.50	2.50	13.75	3.00	6.94	5.31	2.12	1.00	#8	62	362-**.**
	3.00	5.62	4.25	1.50	2.50	13.75	3.00	6.94	5.31	2.12	1.00	#8	89	364-**.**

Ordering Information: *** TO COMPLETE PART#; REPLACE (**.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60", add 1" for every 10" of stroke to the "F" dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



2500 PSI STANDARD DUTY 400 SERIES CYLINDER

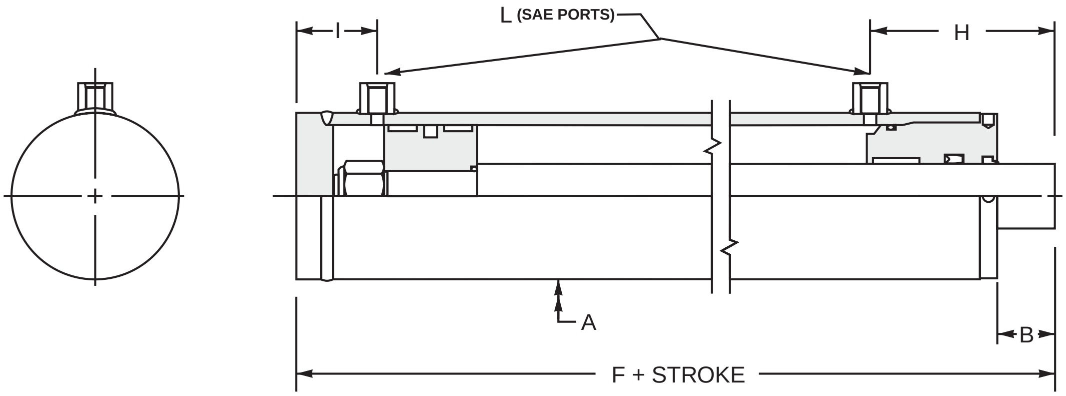
FEATURES

* COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
* GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
* WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
* INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
* HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
* DUCTILE IRON HEAD GLAND & PISTON
* PISTON UTILIZES WEAR BEARINGS
* NYLON INSERTED LOCK NUT
* STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	CD	E	F	G	H	I	J	L	Maximum Stroke	Part#
1.50	.75	2.00	2.12	.75	1.50	8.00	.75	4.06	2.81	.75	#4	18	404-**.**
	1.00	2.00	2.00	.75	1.50	8.00	.75	4.06	2.81	1.00	#4	34	406-**.**
2.00	1.00	2.50	2.62	1.00	2.00	9.50	1.00	4.88	3.38	1.00	#6	25	410-**.**
	1.12	2.50	2.75	1.00	2.00	9.50	1.00	4.88	3.38	1.25	#6	31	412-**.**
	1.25	2.50	2.50	1.00	2.00	9.50	1.00	4.88	3.38	1.25	#6	39	414-**.**
2.50	1.25	3.00	2.75	1.00	2.00	9.75	1.00	4.88	3.62	1.25	#6	31	418-**.**
	1.50	3.00	2.56	1.00	2.00	10.00	1.00	5.06	3.69	1.50	#6	45	420-**.**
3.00	1.25	3.50	2.81	1.00	2.00	10.25	1.00	5.25	3.75	1.25	#8	26	424-**.**
	1.50	3.50	2.69	1.00	2.00	10.25	1.00	5.12	3.88	1.50	#8	38	426-**.**
	1.75	3.50	2.69	1.00	2.00	10.25	1.00	5.12	3.88	1.75	#8	52	428-**.**
	2.00	3.50	2.69	1.00	2.00	10.50	1.00	5.38	3.88	2.00	#8	66	430-**.**
3.50	1.50	4.00	3.06	1.25	2.50	11.25	1.25	5.50	4.50	1.50	#8	32	434-**.**
	1.75	4.00	3.06	1.25	2.50	11.25	1.25	5.50	4.50	1.75	#8	44	436-**.**
	2.00	4.00	3.06	1.25	2.50	11.25	1.25	5.50	4.50	2.00	#8	58	438-**.**
4.00	1.50	4.50	3.19	1.25	2.50	11.50	1.25	5.62	4.62	1.50	#8	28	442-**.**
	1.75	4.50	3.25	1.25	2.50	11.75	1.25	5.69	4.81	1.75	#8	39	444-**.**
	2.00	4.50	3.25	1.25	2.50	11.75	1.25	5.69	4.81	2.00	#8	51	446-**.**
	2.50	4.50	3.25	1.25	2.50	12.00	1.25	5.94	4.81	2.50	#8	78	448-**.**
4.50	1.75	5.00	3.12	1.25	2.50	12.00	1.25	5.56	4.94	1.75	#8	34	452-**.**
	2.00	5.00	3.12	1.25	2.50	12.00	1.25	5.56	4.94	2.00	#8	45	454-**.**
	2.25	5.00	3.12	1.25	2.50	12.00	1.25	5.56	4.94	2.50	#8	58	456-**.**
5.00	2.00	5.62	3.25	1.50	2.50	12.50	1.50	5.69	5.31	2.00	#8	40	460-**.**
	2.50	5.62	3.25	1.50	2.50	12.75	1.50	5.94	5.31	2.50	#8	62	462-**.**
	3.00	5.62	3.25	1.50	2.50	12.75	1.50	5.94	5.31	3.00	#8	89	464-**.**

Ordering Information: *** TO COMPLETE PART#; REPLACE (**.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60", add 1" for every 10" of stroke to the "F" dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



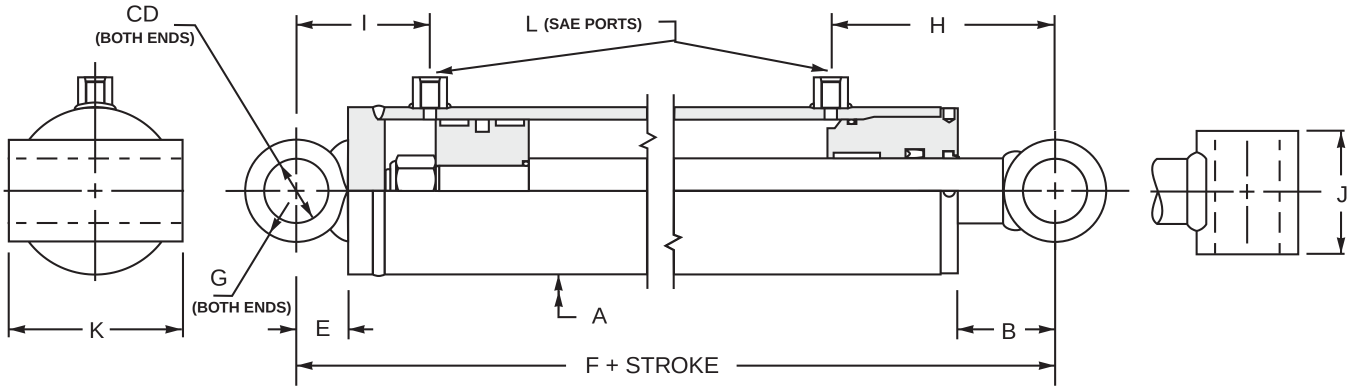
3000 PSI HEAVY DUTY 600 SERIES CYLINDER

FEATURES

* PISTON AND HEAD GLAND HAVE INCREASED BEARING SURFACE AREA
* COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
* GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
* WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
* INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
* HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
* DUCTILE IRON HEAD GLAND & PISTON
* PISTON UTILIZES WEAR BEARINGS
* NYLON INSERTED LOCK NUT
* STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	F	H	I	L	Maximum Stroke	Part#
3.00	1.75	3.50	1.56	8.25	3.94	1.94	#6	47	604-**.**
	2.00	3.50	1.56	8.25	3.94	1.94	#6	53	606-**.**
3.50	1.75	4.00	1.44	8.25	3.88	2.00	#8	40	610-**.**
	2.00	4.00	1.50	8.50	3.94	2.19	#8	52	612-**.**
4.00	2.00	4.62	1.50	9.25	4.56	2.31	#8	46	616-**.**
	2.50	4.62	1.50	9.25	4.56	2.31	#8	72	618-**.**
	3.00	4.62	1.62	10.00	5.44	2.56	#8	99	620-**.**
4.50	2.00	5.12	1.50	9.50	4.62	2.50	#10	40	624-**.**
	2.50	5.12	1.50	9.75	4.62	2.75	#10	64	626-**.**
	3.00	5.12	1.50	9.75	4.62	2.75	#10	90	628-**.**
	3.50	5.12	1.50	10.00	5.38	2.62	#10	115	630-**.**
5.00	2.00	5.62	1.50	9.25	4.44	2.44	#12	36	634-**.**
	2.50	5.62	1.62	10.25	5.00	2.69	#12	57	636-**.**
	3.00	5.62	1.62	10.25	5.00	2.69	#12	82	638-**.**
	3.50	5.62	1.50	10.00	4.88	2.56	#12	108	640-**.**
	4.00	5.62	1.62	10.25	5.56	2.69	#12	130	642-**.**
5.50	2.50	6.12	1.44	10.25	4.81	2.75	#12	52	646-**.**
	3.00	6.12	1.56	10.25	4.94	2.62	#12	75	648-**.**
	3.50	6.12	1.56	10.25	4.94	2.62	#12	100	650-**.**
	4.00	6.12	1.69	10.50	5.06	2.75	#12	124	652-**.**
	4.50	6.12	1.56	11.00	5.50	3.38	#12	144	654-**.**
6.00	2.50	6.75	1.62	10.50	5.00	2.81	#12	48	658-**.**
	3.00	6.75	1.50	10.25	4.88	2.69	#12	70	660-**.**
	3.50	6.75	1.50	10.25	4.88	2.69	#12	94	662-**.**
	4.00	6.75	1.62	10.50	5.00	2.81	#12	120	664-**.**
7.00	2.50	8.00	1.69	11.25	5.62	2.75	#16	40	668-**.**
	3.00	8.00	1.69	11.25	5.62	2.75	#16	60	670-**.**
	3.50	8.00	1.69	11.25	5.62	2.75	#16	82	672-**.**
	4.00	8.00	1.56	11.75	5.50	3.38	#16	107	674-**.**
8.00	3.50	9.00	1.50	13.00	5.69	3.44	#16	71	678-**.**
	4.00	9.00	1.50	13.00	5.69	3.44	#16	94	680-**.**
	4.50	9.00	1.50	13.00	5.69	3.44	#16	118	682-**.**

Ordering Information: * TO COMPLETE PART#; REPLACE (.**) WITH STROKE REQUIRED**
* For stroke lengths longer than 60”, add 1” for every 10” of stroke to the “F” dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



3000 PSI HEAVY DUTY 700 SERIES CYLINDER

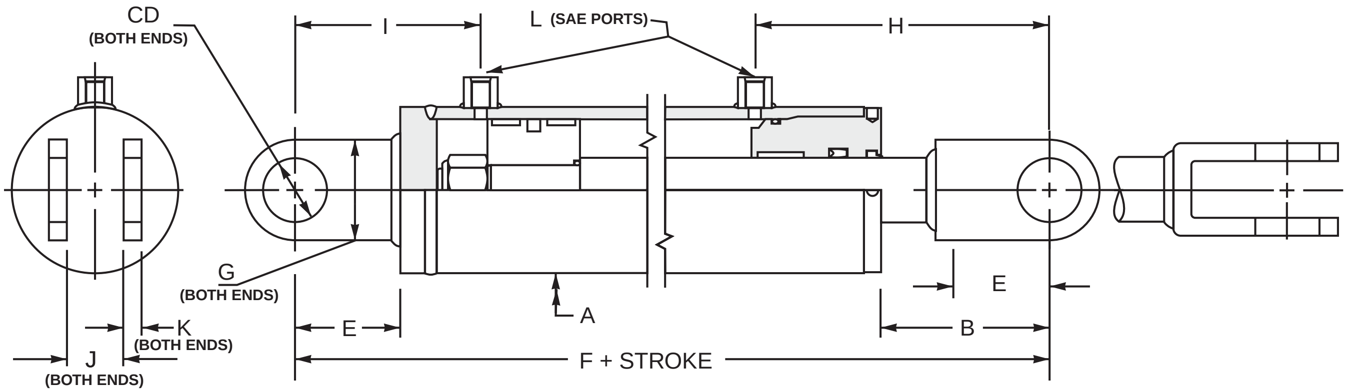
FEATURES

- *PISTON AND HEAD GLAND HAVE INCREASED BEARING SURFACE AREA
- *COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
- *GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
- *WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
- *INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
- *HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
- *DUCTILE IRON HEAD GLAND & PISTON
- *PISTON UTILIZES WEAR BEARINGS
- *NYLON INSERTED LOCK NUT
- *STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	CD	E	F	G	H	I	J	K	L	Maximum Stroke	Part#
3.00	1.75	3.50	1.50	1.00	.81	9.00	.88	3.88	2.75	2.75	3.75	#6	47	704-**.**
	2.00	3.50	1.50	1.00	.81	9.00	.88	3.88	2.75	2.75	3.75	#6	53	706-**.**
3.50	1.75	4.00	1.56	1.25	.88	9.25	1.00	4.00	2.88	3.25	4.25	#8	40	710-**.**
	2.00	4.00	1.62	1.25	.88	9.50	1.00	4.06	3.06	3.25	4.25	#8	52	712-**.**
4.00	2.00	4.62	2.12	1.50	1.12	11.00	1.25	5.19	3.44	3.00	4.75	#8	46	716-**.**
	2.50	4.62	2.12	1.50	1.12	11.00	1.25	5.19	3.44	3.00	4.75	#8	72	718-**.**
	3.00	4.62	2.00	1.50	1.12	11.50	1.25	5.81	3.69	4.25	4.75	#8	99	720-**.**
4.50	2.00	5.12	1.88	1.50	1.12	11.00	1.25	5.00	3.62	3.00	5.50	#10	40	724-**.**
	2.50	5.12	2.12	1.50	1.12	11.50	1.25	5.25	3.88	3.00	5.50	#10	64	726-**.**
	3.00	5.12	2.12	1.50	1.12	11.50	1.25	5.25	3.88	4.25	5.50	#10	90	728-**.**
	3.50	5.12	2.12	1.50	1.12	11.75	1.25	6.00	3.75	4.25	5.50	#10	115	730-**.**
5.00	2.00	5.62	2.25	1.75	1.25	11.25	1.38	5.19	3.69	3.25	6.00	#12	36	734-**.**
	2.50	5.62	2.12	1.75	1.25	12.00	1.38	5.50	3.94	3.25	6.00	#12	57	736-**.**
	3.00	5.62	2.12	1.75	1.25	12.00	1.38	5.50	3.94	4.75	6.00	#12	82	738-**.**
	3.50	5.62	2.00	1.75	1.25	11.75	1.38	5.38	3.81	4.75	6.00	#12	108	740-**.**
	4.00	5.62	2.12	1.75	1.25	12.00	1.38	6.06	3.94	4.75	6.00	#12	130	742-**.**
5.50	2.50	6.12	2.19	1.75	1.25	12.25	1.38	5.56	4.00	3.25	7.00	#12	52	746-**.**
	3.00	6.12	2.06	1.75	1.25	12.00	1.38	5.44	3.88	4.75	7.00	#12	75	748-**.**
	3.50	6.12	2.06	1.75	1.25	12.00	1.38	5.44	3.88	4.75	7.00	#12	100	750-**.**
	4.00	6.12	2.19	1.75	1.25	12.25	1.38	5.56	4.00	4.75	7.00	#12	124	752-**.**
	4.50	6.12	2.06	1.75	1.25	12.75	1.38	6.00	4.62	5.50	7.00	#12	144	754-**.**
6.00	2.50	6.75	2.25	2.00	1.38	12.50	1.50	5.62	4.19	3.50	7.00	#12	48	758-**.**
	3.00	6.75	2.12	2.00	1.38	12.25	1.50	5.50	4.06	3.50	7.00	#12	70	760-**.**
	3.50	6.75	2.12	2.00	1.38	12.25	1.50	5.50	4.06	4.75	7.00	#12	94	762-**.**
	4.00	6.75	2.25	2.00	1.38	12.50	1.50	5.62	4.19	5.50	7.00	#12	120	764-**.**
7.00	2.50	8.00	2.81	2.50	1.62	14.00	1.75	6.75	4.38	5.00	8.25	#16	40	768-**.**
	3.00	8.00	2.81	2.50	1.62	14.00	1.75	6.75	4.38	5.00	8.25	#16	60	770-**.**
	3.50	8.00	2.81	2.50	1.62	14.00	1.75	6.75	4.38	5.00	8.25	#16	82	772-**.**
	4.00	8.00	2.69	2.50	1.62	14.50	1.75	6.62	5.00	5.00	8.25	#16	107	774-**.**
8.00	3.50	9.00	2.88	3.00	1.88	16.25	2.00	7.06	5.31	5.00	9.25	#16	71	778-**.**
	4.00	9.00	2.88	3.00	1.88	16.25	2.00	7.06	5.31	5.00	9.25	#16	94	780-**.**
	4.50	9.00	2.88	3.00	1.88	16.25	2.00	7.06	5.31	5.00	9.25	#16	118	782-**.**

Ordering Information: * TO COMPLETE PART#; REPLACE (.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60”, add 1” for every 10” of stroke to the “F” dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



3000 PSI HEAVY DUTY 800 SERIES CYLINDER

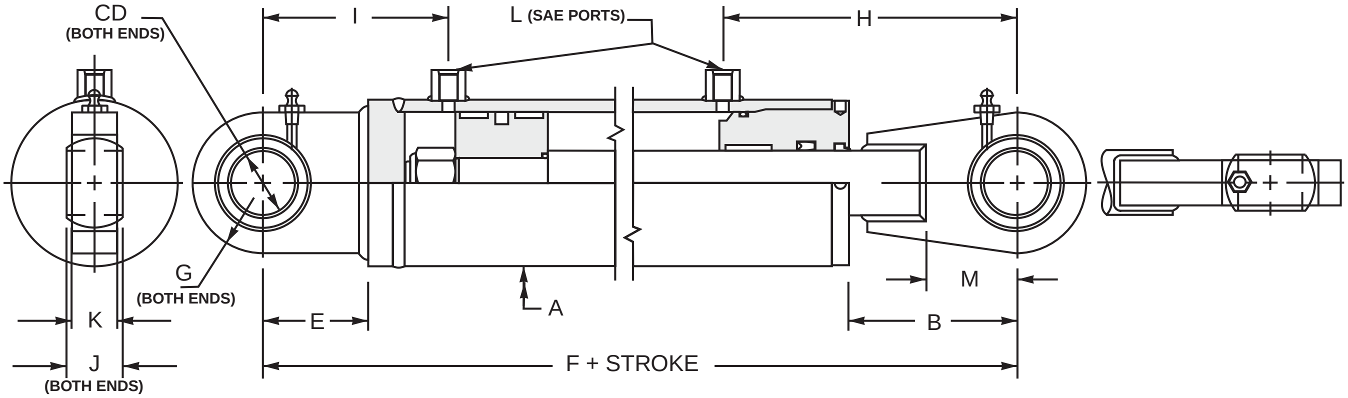
FEATURES

- *PISTON AND HEAD GLAND HAVE INCREASED BEARING SURFACE AREA
- *COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
- *GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
- *WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
- *INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
- *HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
- *DUCTILE IRON HEAD GLAND & PISTON
- *PISTON UTILIZES WEAR BEARINGS
- *NYLON INSERTED LOCK NUT
- *STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	CD	E	F	G	H	I	J	K	L	Maximum Stroke	Part#
3.00	1.75	3.50	3.31	1.00	2.00	12.00	2.00	5.75	3.94	1.25	.50	#6	47	804-**.**
	2.00	3.50	3.31	1.00	2.00	12.00	2.00	5.75	3.94	1.25	.50	#6	53	806-**.**
3.50	1.75	4.00	3.81	1.25	2.00	12.50	2.50	4.50	4.50	1.62	.75	#8	40	810-**.**
	2.00	4.00	3.50	1.25	2.00	12.50	2.50	5.94	4.69	1.62	.75	#8	52	812-**.**
4.00	2.00	4.62	4.25	1.50	2.00	14.00	3.00	7.31	4.31	1.62	1.00	#8	46	816-**.**
	2.50	4.62	4.25	1.50	2.00	14.00	3.00	7.31	4.31	1.62	1.00	#8	72	818-**.**
	3.00	4.62	4.12	1.50	2.00	14.50	3.00	7.94	4.56	1.62	1.00	#8	99	820-**.**
4.50	2.00	5.12	4.25	1.50	2.00	14.25	3.00	7.38	4.50	1.62	1.00	#10	40	824-**.**
	2.50	5.12	4.00	1.50	2.00	14.25	3.00	7.12	4.75	1.62	1.00	#10	64	826-**.**
	3.00	5.12	4.00	1.50	2.00	14.25	3.00	7.12	4.75	1.62	1.00	#10	90	828-**.**
	3.50	5.12	4.00	1.50	2.00	14.50	3.00	7.88	4.62	1.62	1.00	#10	115	830-**.**
5.00	2.00	5.62	4.25	1.75	2.25	14.25	3.50	7.19	4.69	2.12	1.00	#12	36	834-**.**
	2.50	5.62	4.12	1.75	2.25	15.00	3.50	7.50	4.94	2.12	1.00	#12	57	836-**.**
	3.00	5.62	4.12	1.75	2.25	15.00	3.50	7.50	4.94	2.12	1.00	#12	82	838-**.**
	3.50	5.62	4.25	1.75	2.25	15.00	3.50	7.62	4.81	2.12	1.00	#12	108	840-**.**
	4.00	5.62	4.12	1.75	2.25	15.00	3.50	8.06	4.94	2.12	1.00	#12	130	842-**.**
5.50	2.50	6.12	4.44	1.75	2.25	15.50	3.50	7.81	5.00	2.12	1.25	#12	52	846-**.**
	3.00	6.12	4.56	1.75	2.25	15.50	3.50	7.94	4.88	2.12	1.25	#12	75	848-**.**
	3.50	6.12	4.56	1.75	2.25	15.50	3.50	7.94	4.88	2.12	1.25	#12	100	850-**.**
	4.00	6.12	4.44	1.75	2.25	15.50	3.50	7.81	5.00	2.12	1.25	#12	124	852-**.**
	4.50	6.12	4.56	1.75	2.25	16.25	3.50	8.50	5.63	2.12	1.25	#12	144	854-**.**
6.00	2.50	6.75	4.62	2.00	2.50	16.00	4.00	8.00	5.31	2.62	1.25	#12	48	858-**.**
	3.00	6.75	4.50	2.00	2.50	15.75	4.00	7.88	5.19	2.62	1.25	#12	70	860-**.**
	3.50	6.75	4.50	2.00	2.50	15.75	4.00	7.88	5.19	2.62	1.25	#12	94	862-**.**
	4.00	6.75	4.62	2.00	2.50	16.00	4.00	8.00	5.31	2.62	1.25	#12	120	864-**.**
7.00	2.50	8.00	5.19	2.50	3.00	17.75	5.00	9.12	5.75	2.62	1.25	#16	40	868-**.**
	3.00	8.00	5.19	2.50	3.00	17.75	5.00	9.12	5.75	2.62	1.25	#16	60	870-**.**
	3.50	8.00	5.19	2.50	3.00	17.75	5.00	9.12	5.75	2.62	1.25	#16	82	872-**.**
	4.00	8.00	5.06	2.50	3.00	18.25	5.00	9.00	6.38	2.62	1.25	#16	107	874-**.**
8.00	3.50	9.00	6.50	3.00	4.00	22.00	6.00	10.69	7.44	3.12	1.50	#16	71	878-**.**
	4.00	9.00	6.50	3.00	4.00	22.00	6.00	10.69	7.44	3.12	1.50	#16	94	880-**.**
	4.50	9.00	6.50	3.00	4.00	22.00	6.00	10.69	7.44	3.12	1.50	#16	118	882-**.**

Ordering Information: * TO COMPLETE PART#; REPLACE (.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60”, add 1” for every 10” of stroke to the “F” dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.



3000 PSI HEAVY DUTY 900 SERIES CYLINDER

FEATURES

- *PISTON AND HEAD GLAND HAVE INCREASED BEARING SURFACE AREA
- *COLD DRAWN (HIGH IMPACT) 75,000 MIN. YIELD D.O.M. TUBING
- *GROUND & POLISHED, HARD CHROME PLATED RODS (75,000 min. yeild)
- *WELDED STYLE CONSTRUCTION CERTIFIED TO A.W.S. B2.1
- *INTERNALLY THREADED HEAD DESIGN WITH BUTTRESS THREADS
- *HIGHEST QUALITY SEAL CONFIGURATIONS COMPATIBLE WITH PETROLEUM BASE FLUIDS
- *DUCTILE IRON HEAD GLAND & PISTON
- *PISTON UTILIZES WEAR BEARINGS
- *NYLON INSERTED LOCK NUT
- *STANDARD PAINT; GREY PRIMER

Bore	Rod	A	B	CD	E	F	G	H	I	J	K	L	M	Maximum Stroke	Part#
3.00	1.75	3.50	3.81	1.25	2.00	12.50	1.50	6.19	3.94	1.093	.94	#6	2.00	47	904-**.**
	2.00	3.50	3.81	1.25	2.00	12.50	1.50	6.19	3.94	1.093	.94	#6	2.00	53	906-**.**
3.50	1.75	4.00	3.94	1.25	2.00	12.75	1.50	6.38	4.00	1.093	.94	#8	2.00	40	910-**.**
	2.00	4.00	3.75	1.25	2.00	12.75	1.50	6.19	4.19	1.093	.94	#8	2.00	52	912-**.**
4.00	2.00	4.62	4.00	1.50	2.50	14.25	1.88	7.06	4.81	1.312	1.12	#8	2.25	46	916-**.**
	2.50	4.62	4.00	1.50	2.50	14.25	1.88	7.06	4.81	1.312	1.12	#8	2.25	72	918-**.**
	3.00	4.62	4.12	1.50	2.50	15.00	1.88	7.94	5.06	1.312	1.12	#8	2.25	99	920-**.**
4.50	2.00	5.12	4.00	1.50	2.50	14.50	1.88	7.12	5.00	1.312	1.12	#10	2.25	40	924-**.**
	2.50	5.12	4.00	1.50	2.50	14.75	1.88	7.12	5.25	1.312	1.12	#10	2.25	64	926-**.**
	3.00	5.12	4.00	1.50	2.50	14.75	1.88	7.12	5.25	1.312	1.12	#10	2.25	90	928-**.**
	3.50	5.12	4.00	1.50	2.50	15.00	1.88	7.88	5.12	1.312	1.12	#10	2.25	115	930-**.**
5.00	2.00	5.62	4.50	1.75	2.50	14.75	2.00	7.44	4.94	1.531	1.31	#12	2.50	36	934-**.**
	2.50	5.62	4.62	1.75	2.50	15.75	2.00	8.00	5.19	1.531	1.31	#12	2.50	57	936-**.**
	3.00	5.62	4.62	1.75	2.50	15.75	2.00	8.00	5.19	1.531	1.31	#12	2.50	82	938-**.**
	3.50	5.62	4.50	1.75	2.50	15.50	2.00	7.88	5.06	1.531	1.31	#12	2.50	108	940-**.**
	4.00	5.62	4.62	1.75	2.50	15.75	2.00	8.56	5.19	1.531	1.31	#12	2.50	130	942-**.**
5.50	2.50	6.12	4.69	1.75	2.50	16.00	2.00	8.06	5.25	1.531	1.31	#12	2.50	52	946-**.**
	3.00	6.12	4.56	1.75	2.50	15.75	2.00	7.94	5.12	1.531	1.31	#12	2.50	75	948-**.**
	3.50	6.12	4.56	1.75	2.50	15.75	2.00	7.94	5.12	1.531	1.31	#12	2.50	100	950-**.**
	4.00	6.12	4.69	1.75	2.50	16.00	2.00	8.06	5.25	1.531	1.31	#12	2.50	124	952-**.**
	4.50	6.12	4.56	1.75	2.50	16.50	2.00	8.50	5.88	1.531	1.31	#12	2.50	144	954-**.**
6.00	2.50	6.75	4.88	2.00	2.75	16.50	2.38	8.25	5.56	1.750	1.50	#12	2.75	48	958-**.**
	3.00	6.75	4.75	2.00	2.75	16.25	2.38	8.12	5.44	1.750	1.50	#12	2.75	70	960-**.**
	3.50	6.75	4.75	2.00	2.75	16.25	2.38	8.12	5.44	1.750	1.50	#12	2.75	94	962-**.**
	4.00	6.75	4.88	2.00	2.75	16.50	2.38	8.25	5.56	1.750	1.50	#12	2.75	120	964-**.**
7.00	2.50	8.00	5.69	2.50	3.25	18.50	3.00	9.62	6.00	2.188	1.88	#16	3.25	40	968-**.**
	3.00	8.00	5.69	2.50	3.25	18.50	3.00	9.62	6.00	2.188	1.88	#16	3.25	60	970-**.**
	3.50	8.00	5.69	2.50	3.25	18.50	3.00	9.62	6.00	2.188	1.88	#16	3.25	82	972-**.**
	4.00	8.00	5.56	2.50	3.25	19.00	3.00	9.50	6.62	2.188	1.88	#16	3.25	107	974-**.**
8.00	3.50	9.00	6.50	3.00	4.25	22.25	3.75	10.69	7.69	2.625	2.25	#16	4.25	70	978-**.**
	4.00	9.00	6.50	3.00	4.25	22.25	3.75	10.69	7.69	2.625	2.25	#16	4.25	94	980-**.**
	4.50	9.00	6.50	3.00	4.25	22.25	3.75	10.69	7.69	2.625	2.25	#16	4.25	118	982-**.**

Ordering Information: * TO COMPLETE PART#; REPLACE (.**) WITH STROKE REQUIRED**

* For stroke lengths longer than 60”, add 1” for every 10” of stroke to the “F” dimension.
* Other port sizes and locations available upon request.
* Consult factory for longer stroke and or higher pressure requirements.
* Maximum stroke based on full load at full extension.

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)

Other Desirable Properties:

Viscosity Index: 90 minimum
Aniline point: 175 minimum

Additives Usually Recommended:

Rust and Oxidation (R & O) Inhibitors
Foam Depressant

Approximate SSU at . . .

Oil Grade	100° F. (37.8° C.)	210° F. (98.9° C.)
SAE 10	150	43
SAE 20	330	51

Normal Temperatures:

0° 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 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 180° 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 wastefully 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.

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 ruined. Hydraulic cylinders, though often large and unwieldy, are precision machines with finely finished parts and close tolerances. And they're expensive. 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 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 like wise 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. However, overtightening of port plugs should be avoided. 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 toppling. 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 shred packing and contaminate the system. Store cylinders carefully and keep them clean.

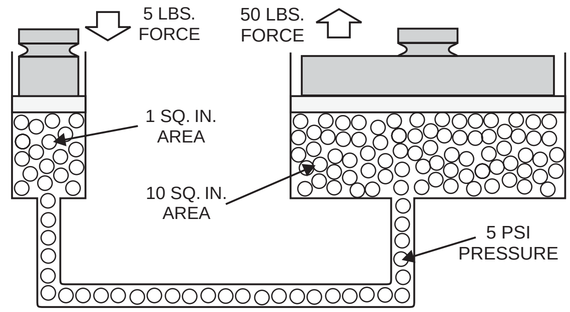
The following procedures should be followed in order to prevent oxidation and maintain the surfaces of a mounted hydraulic cylinder during idle periods. These idle periods may include; inventory units, demo units, out of service units, etc.

· All machined surfaces left expose 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 for evaluation.
· Operation of a hydraulic cylinder with surface damage will shorten the longevity and preclude any warranty express or implied.

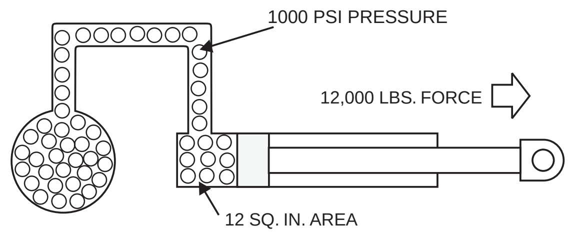
INSTALLATION

·Cleanliness is an important consideration, and Parker 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, 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.

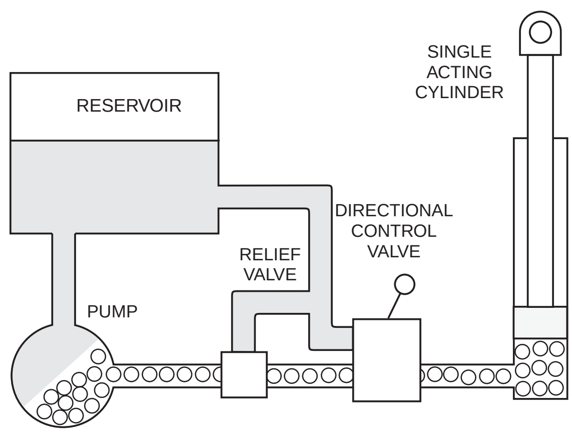
The basis for all hydraulic systems is expressed by Pascal's law which states that the pressure exerted anywhere upon an enclosed liquid is transmitted undiminished, in all directions, to the interior of the container. This principle allows large forces to be generated with relatively little effort. As illustrated, a 5 pound force exerted against a 1 inch square area creates an internal pressure of 5 psi. This pressure, acting against the 10 square inch area develops 50 pounds of force.



In a basic hydraulic circuit, the force exerted by a cylinder is dependent upon the cylinder bore size and the pump pressure. (There is no force generated unless there is resistance to the movement of the piston). With 1000 psi pump pressure exerted against a 12 square inch piston area (approximately 4” dia.), a force of 12,000 pounds is developed by the cylinder. The speed at which the piston will move is dependent upon the flow rate (gpm) from the pump and the cylinder area. Hence, if pump delivery is 1 gallon per minute (231 cu. in./min.) the cylinder piston will move at a rate of 19.25 in./min. (231 cu. in. ÷ 12 sq. in./min.).

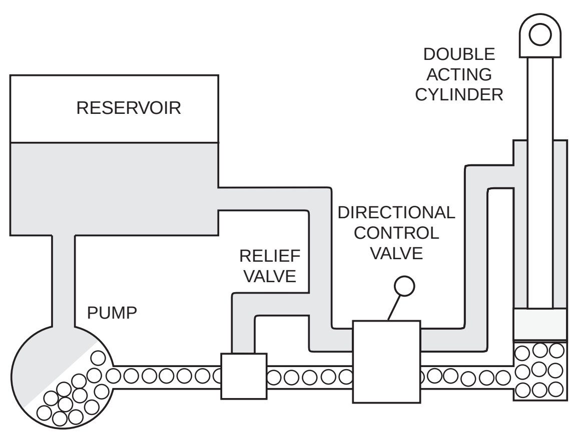


The simplest hydraulic circuit consists of a reservoir, pump, relief valve, 3-way directional control valve, single acting cylinder, connectors and lines. This system is used where the cylinder piston is returned by mechanical force. With the control valve in neutral, pump flow passes through the valve and back to the reservoir. With the valve shifted, oil is directed to the piston side of the cylinder, causing the piston to move, extending the rod. If the valve is returned to neutral, the oil is trapped in the cylinder, holding it in a fixed position, while pump flow is returned to the reservoir. Shifting the valve in the opposite direction permits the oil to pass through the valve back to the reservoir. The relief valve limits the system pressure to a pre-set amount. Relief valves are commonly incorporated into the directional control valve.



A hydraulic system using a double acting cylinder and a 4-way valve differs from a single acting cylinder system in that the cylinder can exert force in both directions. With the control valve in neutral, flow is returned to the reservoir. When shifted in one direction, oil is directed to the piston side of the cylinder, causing the cylinder to extend. Oil from the rod side passes through the valve back to the reservoir. If the valve is shifted to neutral, oil in the cylinder is trapped, holding it in a fixed position. When the valve is shifted in the opposite position, oil is directed to the rod side of the cylinder, causing the cylinder to retract. Oil from the piston side passes through the valve back to the reservoir.

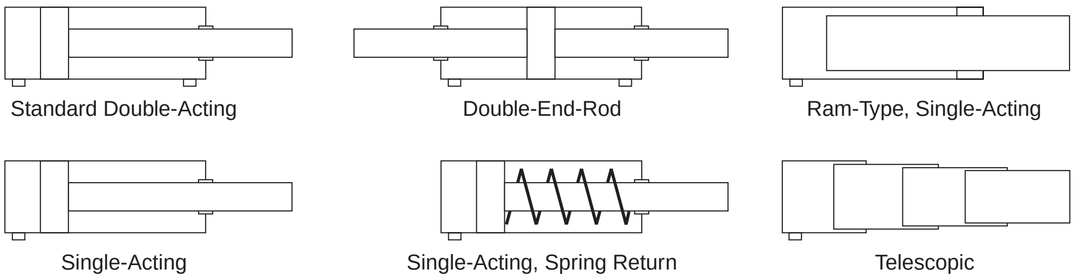
Cylinder extend force is the result of pressure (psi) times the piston area (minus any force resulting from the pressure acting against the rod side of the piston). Retract force is a result of the pressure (psi) times the area difference between the rod and the piston (minus any force resulting from pressure acting against the piston side of the cylinder).



All of the systems described above are open center systems due to the oil flowing through the control valve back to the tank. Most systems are this type. Closed center systems use control valves with the inlet port blocked and variable displacement pumps. With the control valve in neutral, the pump is “de-stroked” to zero flow.

The function of a cylinder in a fluid power system is to convert energy in the fluid stream into an equivalent amount of mechanical energy. Its power is delivered in a straight-line, push-pull motion.

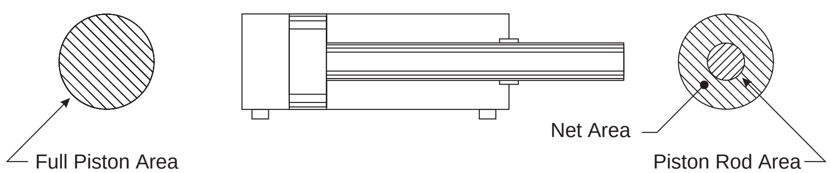
Graphic Symbols: Following diagram illustrates standard ANSI (American National Standards Institute) graphic symbols for use in circuit diagrams. Six of the more often used are shown:



Standard ANSI (American National Standards Institute) Graphic Symbols for Use in Circuit Diagrams.

The standard double-acting cylinder with piston rod out one end, is used in the majority of applications. It develops force in both directions of piston travel. The double-end-rod type is a variation of the standard cylinder but having a piston rod extending out both end caps. It is occasionally used where it is necessary to have equal area on both sides of the piston, such as a steering application, or where one of rod extensions is to be used for mounting a cam for actuation of a limit switch, or for mounting a stroke limiting stop. The single-acting cylinder develops force in one direction, and is retracted by the reactive force from the load or an internal or external spring. The single-acting ram is a construction often used on fork lift mast raise, or a refuse body tailgate raise, or a high tonnage press cylinders. The telescoping cylinder is built in both single-acting and double-acting types. Its purpose is to provide a long stroke with a relatively short collapsed length. The single-acting telescopic is a construction often used to raise dump trucks and dump trailers. The double-acting telescopic is a construction often used in garbage bodies to pack and eject the load.

Force Produced by a Cylinder: A standard double-acting cylinder has three significant internal areas. The full piston area when exposed to fluid pressure, produces force to extend the piston rod. The amount of this force, in pounds, is calculated by multiplying piston square inch area times gauge pressure, in PSI.

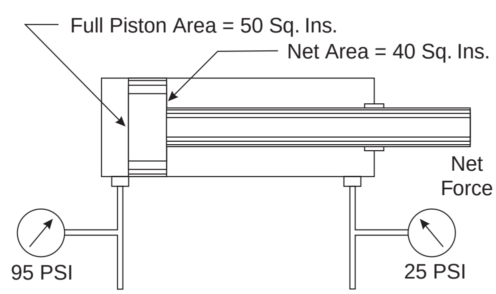


Significant Areas in a Double-Acting Cylinder, Single-End-Rod Type.

The “net” area on the front side of the piston is less than full piston area because part of the piston surface is covered by the rod. Net area is calculated by subtracting rod area from full piston area. Because net area is always less than piston area, cylinder force for rod retraction is always less than can be developed for extension when working at the same pressure.

Cylinder Force Against a Load: The force which a cylinder can exert against a load is determined by making two calculations. First, extension force is calculated according to piston area and PSI pressure against it. Then, the opposing force on the opposite side of the piston is calculated the same way. Net force against a load is the difference between the two.

Caution! It is incorrect, on a single-end-rod cylinder to calculate cylinder net force as piston area times ΔP (pressure drop, psid) across the piston. This is true only for double-end-rod cylinders which have equal areas on both sides of the piston.



Cylinder Force Against a Load.

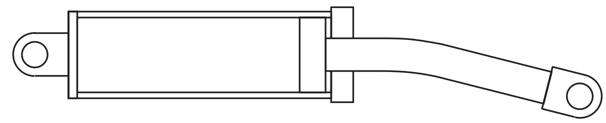
Example: The extension force is 95 PSI x 50 sq. in. = 4750 lbs. The opposing force on the rod side is 25 PSI x 40 sq. in. = 1000 lbs. Therefore, the net force which the cylinder can exert against a load in its extension direction is 4750 - 1000 = 3750 lbs. In making cylinder force calculation we sometimes assume that the opposite side of the piston is at atmospheric pressure, and that the counter-force is zero. On some kinds of loads this can lead to serious error.

Note: Most designers try to eliminate back pressure to get full extend force, but there will always be back pressure.

Standard catalog cylinder models are not designed to take any appreciable side load on the piston rod. They must be mounted so the rod is not placed in a bind at any part of the stroke. If the direction of the load changes during the stroke, hinge mounting must be used on both the rod end and rear end. Use guides on the mechanism, if necessary, to assure that no side load is transmitted to the cylinder rod or piston.

Rod Buckling

Column failure or buckling of the rod may occur if the cylinder stroke is too long relative to the rod diameter. The exact ratio of rod length to rod diameter at which column failure will occur cannot be accurately calculated, but the “Column Strength” table in this manual shows suggested safe ratios for normal applications.

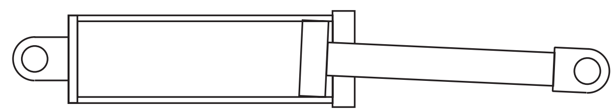


Tension and Compression Failures

All standard cylinders have been designed with sufficiently large piston rods so failure will never occur either in tension or compression, provided the cylinder is operated within the manufacturers pressure rating.

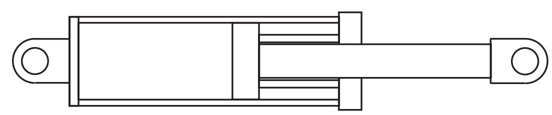
Rod Bearing Failure

Rod bearing failures usually occur when the cylinder is at maximum extension. Failures occur more often on hinge or trunnion mount cylinders, in which the rear support point is located considerably behind the rod bearing. If space permits, it is wise to order cylinders with longer stroke than actually required, and not permit the piston to approach to the front end while under full load.



Stop Collar

On those application where it is necessary to let the piston “bottom out” on the front end, the cylinder may be ordered with a stop collar. The stop collar should be especially considered on long strokes if the distance between support exceeds 10 times the rod diameter, if the maximum thrust is required at full extension, and if the cylinder has a rear flange, clevis, tang, or trunnion mounting.

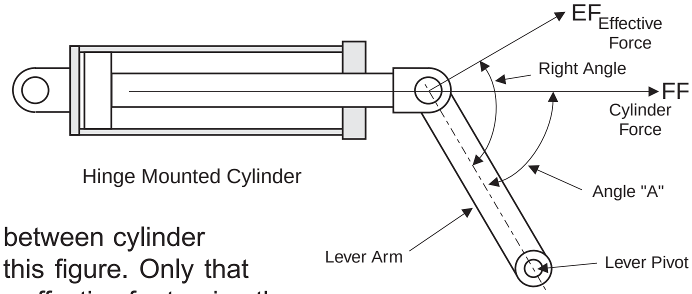


MINIMUM PISTON ROD DIAMETER

Figures in body of chart are suggested minimum rod diameters, in inches.

Load, Pounds	Exposed Length of Piston Rod, Inches / Rod Diameter, Inches							
	10"	20"	40"	60"	70"	80"	100"	120"
1,000			3/4	1				
1,500			13/16	1-1/16				
2,000		5/8	7/8	1-1/8	1-1/4	1-3/8		
3,000		11/16	15/16	1-3/16	1-3/8	1-1/2		
4,000		3/4	1	1-1/4	1-7/16	1-9/16	1-7/8	
6,000	13/16	7/8	1-1/8	1-3/8	1-9/16	1-5/8	1-7/8	
8,000	15/16	1	1-3/16	1-1/2	1-5/8	1-3/4	2	2-1/4
10,000	1	1-1/8	1-5/16	1-9/16	1-3/4	1-7/8	2-1/8	2-3/8
15,000	1-3/16	1-1/4	1-7/16	1-3/4	1-3/4	2	2-1/4	2-1/2
20,000	1-3/8	1-7/16	1-5/8	1-7/8	2	2-1/8	2-7/16	2-3/4
30,000	1-11/16	1-3/4	1-7/8	2-1/8	2-1/4	2-3/8	2-11/16	3
40,000	2	2	2-1/8	2-3/8	2-1/2	2-5/8	2-7/8	3-1/4
60,000	2-3/8	2-7/16	2-1/2	2-3/4	2-3/4	2-7/8	3-1/4	3-1/2
80,000	2-3/4	2-3/4	2-7/8	3	3	3-1/4	3-1/2	3-3/4
100,000	3-1/8	3-1/8	3-1/4	3-3/8	3-1/2	3-1/2	3-3/4	4
150,000	3-3/4	3-3/4	3-7/8	4	4	4-1/8	4-3/8	4-1/2
200,000	4-3/8	4-3/8	4-3/8	4-1/2	4-3/4	4-3/4	4-7/8	5
300,000	5-3/8	5-3/8	5-3/8	5-1/2	5-1/2	5-1/2	5-3/4	6

Cylinder Working a Rotating Lever:



A cylinder working a hinged lever can exert its maximum force on the lever only when the lever axis and cylinder axis are at right angles. When Angle "A" is greater or less than a right angle, only part of the cylinder force is effective on the lever. The cylinder force is found by multiplying the full cylinder force times the sine (sin) of the least angle between cylinder and lever axes. Cylinder Force, FF, is horizontal in this figure. Only that portion, EF, which is at right angles to the lever axis is effective for turning the lever. The value of EF varies with the acute angle "A" between the cylinder and lever axis.

Example: Find the effective force exerted by a 3-inch bore cylinder against a lever when the cylinder is operating at 3000 PSI and when its axis is at an angle of 55 degrees with the lever axis.

First , find the full force developed by the cylinder: FF (full force) = 7.07 (piston area) x 3000 PSI = 21,210 lbs.

Next, find the effective force at 55^0: EF (effective force) = 21,210 x 819 (sin 55^0) = 17,371 lbs.

Since maximum cylinder force is delivered in the right angle position, the hinge points for the cylinder and lever should be located, if possible, so the right angle falls close to the lever position which requires the greatest torque (force).

Note: The working angles on a hinged units, such as a dump truck, refuse body packer blade, or a crane, are constantly changing, it may be necessary to construct a rough model on a sheet of paper, to exact scale, with cardboard arms and thumbtack hinge pins. This will show the point at which the greatest cylinder thrust is needed. An exact calculation can then be made for this condition.

POWER FACTOR TABLE

Trigonometric Sines and Cosines

Angle, Degrees	Sine (sin)	Cosine (cos)	Angle, Degrees	Sine (sin)	Cosine (cos)	Angle, Degrees	Sine (sin)	Cosine (cos)
1	0.0175	0.9998	31	0.5150	0.8572	61	0.8746	0.4848
2	0.0349	0.9994	32	0.5299	0.8480	62	0.8829	0.4695
3	0.0523	0.9986	33	0.5446	0.8387	63	0.8910	0.4540
4	0.0698	0.9976	34	0.5592	0.8290	64	0.8988	0.4384
5	0.0872	0.9962	35	0.5736	0.8192	65	0.9063	0.4226
6	0.1045	0.9945	36	0.5878	0.8090	66	0.9135	0.4067
7	0.1219	0.9925	37	0.6018	0.7986	67	0.9205	0.3907
8	0.1392	0.9903	38	0.6157	0.7880	68	0.9272	0.3746
9	0.1564	0.9877	39	0.6293	0.7771	69	0.9336	0.3584
10	0.1736	0.9848	40	0.6428	0.7660	70	0.9397	0.3420
11	0.1908	0.9816	41	0.6561	0.7547	71	0.9455	0.3256
12	0.2079	0.9781	42	0.6691	0.7431	72	0.9511	0.3090
13	0.2250	0.9744	43	0.6820	0.7314	73	0.9563	0.2924
14	0.2419	0.9703	44	0.6947	0.7193	74	0.9613	0.2756
15	0.2588	0.9659	45	0.7071	0.7071	75	0.9659	0.2588
16	0.2756	0.9613	46	0.7193	0.6947	76	0.9703	0.2419
17	0.2924	0.9563	47	0.7314	0.6820	77	0.9744	0.2250
18	0.3090	0.9511	48	0.7431	0.6691	78	0.9781	0.2079
19	0.3256	0.9455	49	0.7547	0.6561	79	0.9816	0.1908
20	0.3420	0.9397	50	0.7660	0.6428	80	0.9848	0.1736
21	0.3584	0.9336	51	0.7771	0.6293	81	0.9877	0.1564
22	0.3746	0.9272	52	0.7880	0.6157	82	0.9903	0.1392
23	0.3907	0.9205	53	0.7986	0.6018	83	0.9925	0.1219
24	0.4067	0.9135	54	0.8090	0.5878	84	0.9945	0.1045
25	0.4226	0.9063	55	0.8192	0.5736	85	0.9962	0.0872
26	0.4384	0.8988	56	0.8290	0.5592	86	0.9976	0.0698
27	0.4540	0.8910	57	0.8387	0.5446	87	0.9986	0.0523
28	0.4695	0.8829	58	0.8480	0.5299	88	0.9994	0.0349
29	0.4848	0.8746	59	0.8572	0.5150	89	0.9998	0.0175
30	0.5000	0.8660	60	0.8660	0.5000	90	1	0

Cylinders on Cranes and Beams:

Example 1: Calculation to find cylinder force required to handle 15,000 lbs. when the beam is in the position shown.

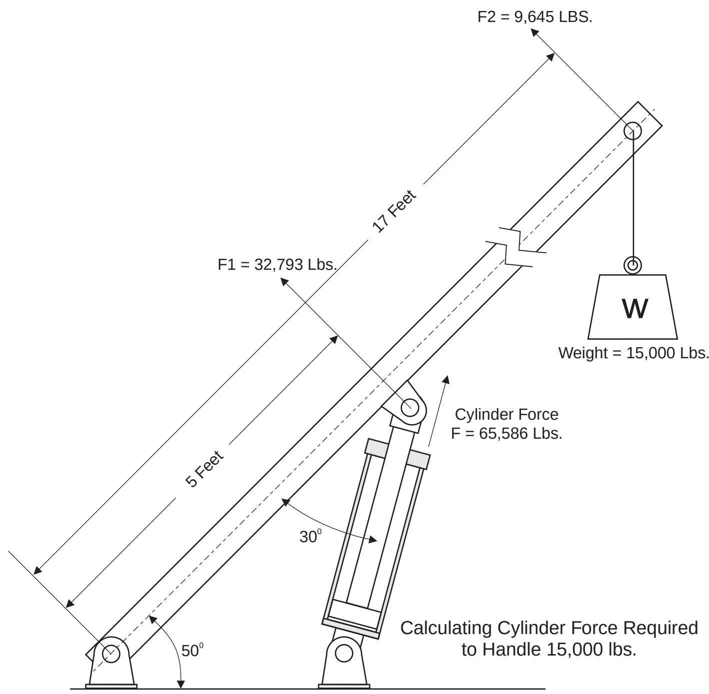
First find the force F2 at right angles to the beam which must be present to support the 15,000 lb. load.

$F2 = W \times \cos 50^0 = 15,000 \times .643 = 9,645$ lbs.

Next, find the force F1, also at right angles to the beam, which must be produced by the cylinder to support the 15,000 lb. load. This is calculated by proportion. F1 will be greater than F2 in the same ratio that arm lenght 17 feet is greater than arm lenght 5 feet.

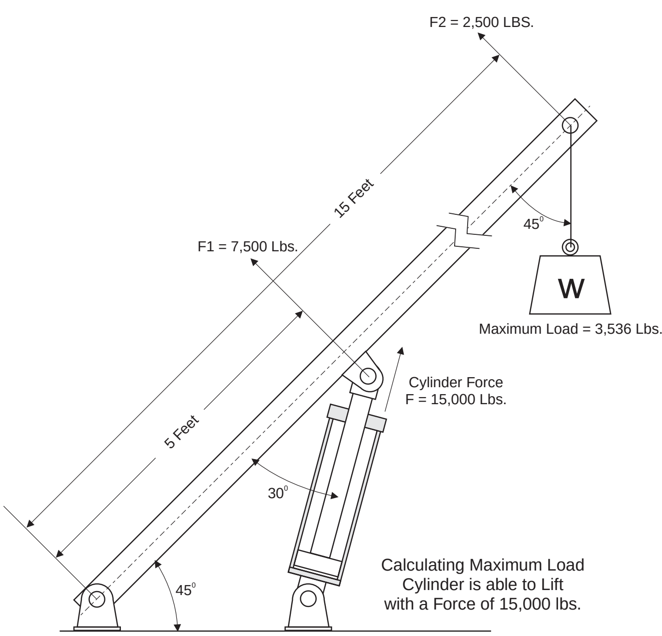
Arm length ratio of 17 ÷ 5 = 3.4.
Therefore, F1 = 9,645 x 3.4 = 32,793 lbs.

Finally, calculate the cylinder force, at an angle of 30^0 to the beam, which will produce a force of 32,793 lbs. at its rod hinge point at right angles to the beam.



Calculating Cylinder Force Required to Handle 15,000 lbs.

F (cylinder force) = $F1 \div \sin 30^0 = 32,793 \div .500 = 65,586$ lbs.



Calculating Maximum Load Cylinder is able to Lift with a Force of 15,000 lbs.

Example 2: Calculation to find maximum load that can be lifted with a cylinder force of 15,000 lbs. when the beam is in the position shown.

First, translate the cylinder thrust, F, of 15,000 lbs. into 7,500 lbs. at right angles to the beam using power factor of 0.500 (sin) from the power factor table, for a 30^o angle.

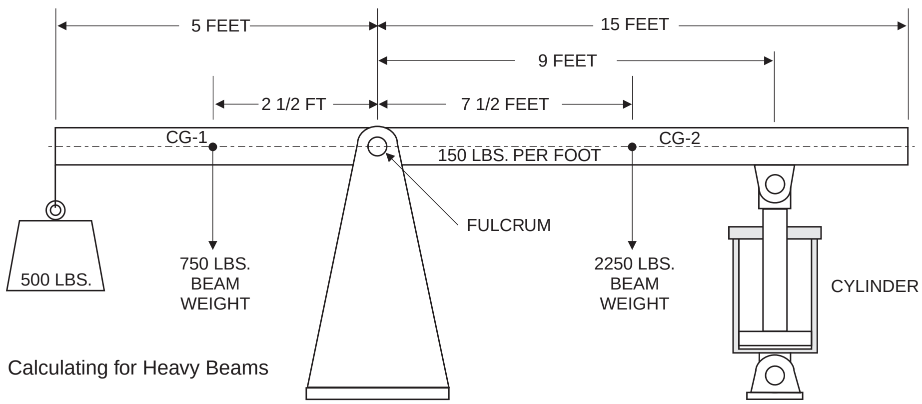
Next, translate this to F2, 2,500 lbs. at the end of beam where the weight is suspended. This is done with simple proportion by the length of each arm from the base pivot point. F2 is 1/3rd F1 since the lever arm is 3 times as long.

Finally, find the maximum hanging load that can be lifted, at a 45^o angle between beam and load weight, using sin (power factor) for 45^o:

$W = F2 \div \sin 45^0 = 2500 \div 0.707 = 3535$ lbs.

Calculations for a Heavy Beam:

On a heavy beam it is necessary to calculate not only for concentrated loads such as the suspended weights and cylinder thrust, but to figure in the weight of the beam itself. If the beam is uniform, so many pounds per foot of length, the calculation is relatively easy. In the example shown in figure "B", the beam has a uniform weight of 150 lbs. per foot, is partially counterbalanced by a weight of 500 lbs. on the left side of the fulcrum, and must be raised by the force of a cylinder applied at a point 9 feet from the right side of the fulcrum.



Calculating for Heavy Beams

The best method of solution is to use the principle of moments. A moment is a torque force consisting of (so many) pounds applied at a lever distance of (so many) feet or inches. The solution here is to find how much cylinder thrust is needed to just balance the beam. Then, by increasing the hydraulic cylinder thrust 5 to 10% to take care of friction losses, the cylinder would be able to raise the beam.

Using the principle of moments, it is necessary to calculate all of the moment forces which are trying to turn the beam clockwise, then calculate all the moment forces trying to turn the beam counter-clockwise, then subtract the two. In this case they must be equal to balance the beam.

Clockwise moment due to the 15 feet of beam on the right side of the fulcrum: This can be considered as a concentrated weight acting at its center of gravity 7 1/2 feet from the fulcrum. Moment = 150 (lbs. per foot) x 15 feet x 7 1/2 feet = 16,875 foot pounds.

Counter-clockwise moment due to the 5 feet of beam on the left side of the fulcrum: 150 (lbs. per foot) x 5 feet x 2 1/2 feet (CG distance) = 1875 foot pounds.

Counter-clockwise moment due to hanging weight of 500 pounds: 500 x 5 feet = 2500 foot lbs.

Subtracting counter-clockwise from clockwise moments: 16,875 - 1875 - 2500 = 12,500 foot pounds that must be supplied by the cylinder for balance condition. To find cylinder thrust: 12,500 foot pounds ÷ 9 feet (distance from fulcrum) = 1388.8 pounds.

Remember when working with moments, that only the portion of the total force which is at right angles to the beam is effective as a moment force. If the beam is at an angle to the cylinder or to the horizontal, then the effective portion of the concentrated of distributed weight, and the cylinder thrust, can be calculated with the power factors (refer to chart).

The great advantage telescopic cylinders have over conventional rod-type cylinders is their ability to provide an exceptionally long stroke from a compact initial package. The collapsed length of typical telescopic cylinders varies between 20% to 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 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 seems to be 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. These 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. Zero-leakage, 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, zero leakage seals on the piston, which in turn 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.

In some instances a double-acting telescoping cylinder can be designed where both ports are located in the stationary main barrel. Cylinder size (diameter and stroke) and the number of moving stages determine whether this is possible. If it is, the more-complicated internal passages for oil flow require a double wall and or a special trombone type telescopic design.

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 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.

Constant-Thrust / Constant-Speed

A special telescopic cylinder - known as a *constant-trust/constant-speed cylinder* - is configured so that all moving stages will extend at the same time, providing an overall constant speed as well as a constant push force throughout its stroke when extending or retracting. This type of cylinder has been used to drive a drill head in underground mining, where such performance parameters are necessary and space is at a premium. The more-complicated design accomplishes the required action by trapping oil internally, matching extend and retract areas, and limiting the number of moving stages.

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:

$F = A \times P$
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, of course.

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 always should be provided with 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 Catch 22 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 flow from plunger is dead 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.

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.

Manufacturer's of telescopic cylinders can (and have) altered their designs to suit a variety of special application considerations. Their application engineers should be eager to provide assistance in selecting or designing the right cylinder for your specific application, and advising about circuitry to operate it safely and efficiently.

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)

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

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, 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.

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 (in^3) per Revolution
RPM = Pump revolutions per minute

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

$$\text{Flow rate (gpm)} = \frac{\text{Velocity (ft/s)} \times \text{Area (in}^2\text{)}}{0.3208}$$

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:

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

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

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

Overall Efficiency = Mech. Eff. x Volumetric Eff.

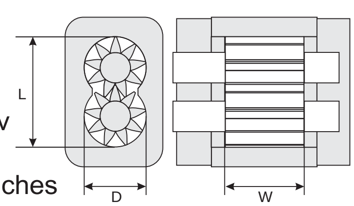
Theoretical Flow = RPM x CIR ÷ 231
Theoretical Pressure = T x 6.28 ÷ CIR
Input HP = PSI x GPM ÷ 1714
Output HP = T x RPM ÷ 63025

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 = Inch Pound ÷ 12

Inch Pound = Foot Pound 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.

Motor Efficiencies:

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 (in^3) 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 10^0 use the degree of the angle. Grades greater than 10^0 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

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 feet/second
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 fooot 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 ÷ in^2
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

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

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

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

Note:
Isothermal operatiion 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 = Intial 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 and, T_2, P_2 and V_2 are final conditions.

Note:
Adiabatic operatiion 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

Intial Gas Volume - Compressed **Gas =** Usual Oil

<u>Reservoir Cooling:</u>

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 Farenheit

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

<u>Reservoir Heating:</u>

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.

<u>Energy Formulas:</u>

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

Formulae in SI Metric Units

Familiar fluid power formulae in English units are shown in the left column. When the industry converts to SI (International) units, these formulae 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, foot-lbs.	T = Torque, Nm (Newton-meters)
RPM = Speed, 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 dm^3/min ÷ 600**
HP = Horsepower	Kw = Powers in kilowatts
PSI = Gauge pressure, lbs/sq. inch	Bars = System pressure
GPM = Flow, 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, square inches	A = Piston area, sq. centimeters
PSI = Gauge pressure, lbs/sq. inch	Bars = Gauge pressure
Travel Speed of a Hydraulic Cylinder Piston	
S = V ÷ A	**S = V ÷ 6A**
S = Travel speed, inches/minute	S = Travel speed, meter/sec
V = Vol. of oil to cyl., cu.in/min	V = Oil flow dm^3/minute
A = Piston area, square inches	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 = dm^3/min ÷ 6A**
V = Velocity, feet per second	V = Oil velocity, meters/second
GPM = Oil flow, gallons/minute	dm^3/min = Oil flow, cu.dm/minute
A = Inside area of pipe, sq. inches	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

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 (sq. in.)
1 square centimeter = 0.155 sq. in.
1 square decimeter = 15.5 sq. in.
= 0.10764 square feet (sq. ft.)

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 ounce (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 kilowat (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 pound-inches (lb.-in.)

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

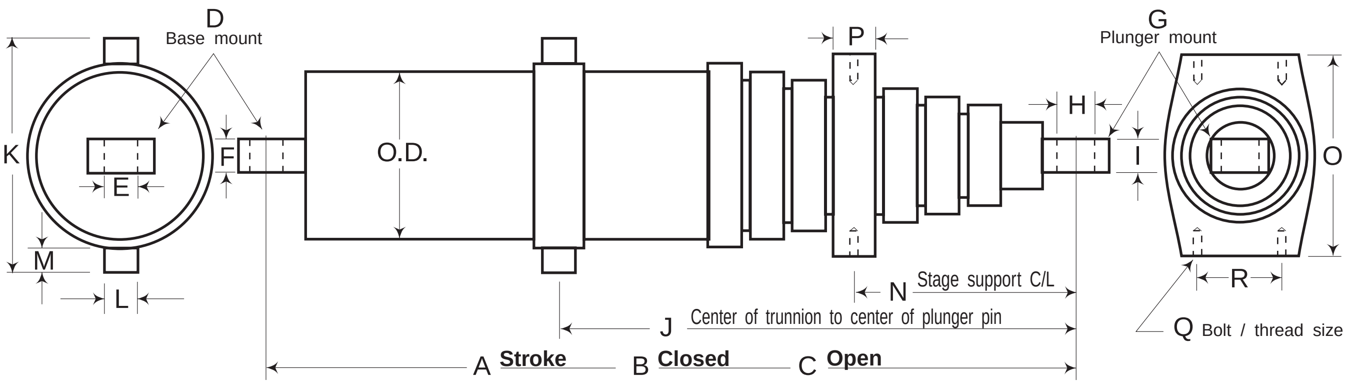
FRACTIONS, DECIMALS AND MILLIMETERS

Inches Fractions	Inches Decimals	M M
-	0.0004	0.01
-	0.004	0.1
-	0.01	0.25
1/64	0.01562	0.397
-	0.0197	0.5
-	0.0295	0.75
1/32	0.03125	0.794
-	0.0394	1
3/64	0.04688	1.191
-	0.059	1.5
1/16	0.0625	1.588
5/64	0.07812	1.984
-	0.0787	2
3/32	0.09375	2.381
-	0.0984	2.5
7/64	0.10938	2.778
-	0.1181	3
1/8	0.125	3.175
-	0.1378	3.5
9/64	0.14062	3.572
5/32	0.15625	3.969
-	0.1575	4
11/64	0.17188	4.366
-	0.177	4.5
3/16	0.1875	4.763
-	0.1969	5
13/64	0.20312	5.159
-	0.2165	5.5
7/32	0.21875	5.556
15/64	0.23438	5.953
-	0.2362	6
1/4	0.25	6.35
-	0.2559	6.5
17/64	0.26562	6.747
-	0.2756	7
9/32	0.28125	7.144
-	0.2953	7.5
19/64	0.29688	7.541
5/16	0.3125	7.938
-	0.315	8
21/64	0.32812	8.334
-	0.335	8.5
11/32	0.34375	8.731
-	0.3543	9
23/64	0.35938	9.128
-	0.374	9.5
3/8	0.375	9.525
25/64	0.39062	9.922
-	0.3937	10
13/32	0.40625	10.319
-	0.413	10.5
27/64	0.42188	10.716
-	0.4331	11
7/16	0.4375	11.113
29/64	0.45312	11.509
15/32	0.46875	11.906
-	0.4724	12
31/64	0.48438	12.303
-	0.492	12.5
1/2	0.5	12.7
-	0.5118	13
33/64	0.51562	13.097
17/32	0.53125	13.494
35/64	0.54688	13.891
-	0.5512	14
9/16	0.5625	14.288
-	0.571	14.5
37/64	0.57812	14.684
-	0.5906	15
19/32	0.59375	15.081
39/64	0.60938	15.478
5/8	0.625	15.875
-	0.6299	16
41/64	0.64062	16.272
-	0.6496	16.5
21/32	0.65625	16.669
-	0.6693	17
43/64	0.67188	17.066
11/16	0.6875	17.463
45/64	0.70312	17.859
-	0.7087	18
23/32	0.71875	18.256
-	0.7283	18.5
47/64	0.73438	18.653
-	0.748	19
3/4	0.75	19.05
49/64	0.76562	19.447

Inches Fractions	Inches Decimals	M M
25/32	0.78125	19.844
-	0.7874	20
51/64	0.79688	20.241
13/16	0.8125	20.638
-	0.8268	21
53/64	0.82812	21.034
27/32	0.84375	21.431
55/64	0.85938	21.828
-	0.8661	22
7/8	0.875	22.225
57/64	0.89062	22.622
-	0.9055	23
29/32	0.90625	23.019
59/64	0.92188	23.416
15/16	0.9375	23.813
-	0.9449	24
61/64	0.95312	24.209
31/32	0.96875	24.606
-	0.9843	25
63/64	0.98438	25.003
1	1	25.4
-	1.0236	26
1-1/32	1.0312	26.194
1-1/16	1.062	26.988
-	1.063	27
1-3/32	1.094	27.781
-	1.1024	25
1-1/8	1.125	28.575
-	1.1417	29
1-5/32	1.156	29.369
-	1.1811	30
1-3/16	1.1875	30.163
1-7/32	1.219	30.956
-	1.2205	31
1-1/4	1.25	31.75
-	1.2598	32
1-9/32	1.281	32.544
-	1.2992	33
1-5/16	1.312	33.338
-	1.3386	34
1-11/32	1.344	34.131
1-3/8	1.375	34.925
-	1.3779	35
1-13/32	1.406	35.719
-	1.4173	36
1-7/16	1.438	36.513
-	1.4567	37
1-15/32	1.469	37.306
-	1.4961	38
1-1/2	1.5	38.1
1-17/32	1.531	38.894
-	1.5354	39
1-9/16	1.562	39.688
-	1.5748	40
1-19/32	1.594	40.481
-	1.6142	41
1-5/8	1.625	41.275
-	1.6535	42
1-21/32	1.6562	42.069
1-11/16	1.6875	42.863
-	1.6929	43
1-23/32	1.719	43.656
-	1.7323	44
1-3/4	1.75	44.45
-	1.7717	45
1-25/32	1.781	45.244
-	1.811	46
1-13/16	1.8125	46.038
1-27/32	1.844	46.831
-	1.8504	47
1-7/8	1.875	47.625
-	1.8898	48
1-29/32	1.9062	48.419
-	1.9291	49
1-15/16	1.9375	49.213
-	1.9685	50
1-31/32	1.969	50.006
2	2	50.8
-	2.0079	51
2-1/32	2.0312	51.594
-	2.0472	52
2-1/16	2.062	52.388
-	2.0866	53
2-3/32	2.094	53.181
2-1/8	2.125	53.975
-	2.126	54
2-5/32	2.156	54.769

Inches Fractions	Inches Decimals	M M
-	2.165	55
2-3/16	2.1875	55.563
-	2.2047	56
2-7/32	2.219	56.356
-	2.244	57
2-1/4	2.25	57.15
2-9/32	2.281	57.944
-	2.2835	58
2-5/16	2.312	58.738
-	2.3228	59
2-11/32	2.344	59.531
-	2.3622	60
2-3/8	2.375	60.325
-	2.4016	61
2-13/32	2.406	61.119
2-7/16	2.438	61.913
-	2.4409	62
2-15/16	2.469	62.706
-	2.4803	63
2-1/2	2.5	63.5
-	2.5197	64
2-17/32	2.531	64.294
-	2.559	65
2-9/16	2.562	65.088
2-19/32	2.594	65.881
-	2.5984	66
2-5/8	2.625	66.675
-	2.638	67
2-21/32	2.656	67.469
-	2.6772	68
2-11/16	2.6875	68.263
-	2.7165	69
2-23/32	2.719	69.056
2-3/4	2.75	69.85
-	2.7559	70
2-25/32	2.781	70.643
-	2.7953	71
2-13/16	2.8125	71.437
-	2.8346	72
2-27/32	2.844	72.231
-	2.874	73
2-7/8	2.875	73.025
2-29/32	2.9062	73.819
-	2.9134	74
2-15/16	2.9375	74.613
-	2.9527	75
2-31/32	2.969	75.406
-	2.9921	76
3	3	76.2
3-1/32	3.0312	76.994
-	3.0315	77
3-1/16	3.062	77.788
-	3.0709	78
3-3/32	3.094	75.581
-	3.1102	79
3-1/8	3.125	79.375
-	3.1495	80
3-5/32	3.156	80.169
3-3/16	3.1875	80.963
-	3.189	81
3-7/32	3.219	81.756
-	3.2283	82
3-1/4	3.25	82.55
-	3.2677	83
3-9/32	3.281	83.344
-	3.3071	84
3-5/16	3.312	84.137
3-11/32	3.344	84.931
-	3.3464	85
3-3/8	3.375	85.725
-	3.3858	86
3-13/32	3.406	86.519
-	3.4252	87
3-7/16	3.438	87.313
-	3.4646	88
3-15/32	3.469	88.106
3-1/2	3.5	88.9
-	3.5039	89
3-17/32	3.531	89.694
-	3.5433	90
3-9/16	3.562	90.487
-	3.5827	91
3-19/32	3.594	91.281
-	3.622	92
3-5/8	3.625	92.075
3-21/32	3.656	92.869
-	3.6614	93

Inches Fractions	Inches Decimals	M M
3-11/16	3.6875	93.663
-	3.7008	94
3-23/32	3.719	94.456
-	3.7401	95
3-3/4	3.75	95.25
-	3.7795	96
3-25/32	3.781	96.044
3-13/16	3.8125	96.838
-	3.8189	97
3-27/32	3.844	97.631
-	3.8583	98
3-7/8	3.875	98.425
-	3.8976	99
3-29/32	3.9062	99.219
-	3.937	100
3-15/16	3.9375	100.013
3-31/32	3.969	100.806
-	3.9764	101
4	4	101.6
4-1/16	4.062	103.188
4-1/8	4.125	104.775
-	4.1338	105
4-3/16	4.1875	106.363
4-1/4	4.25	107.95
4-5/16	4.312	109.538
-	4.3307	110
4-3/8	4.375	111.125
4-7/16	4.438	112.716
4-1/2	4.5	114.3
-	4.5275	115
4-9/16	4.562	115.88
4-5/8	4.625	117.475
4-11/16	4.6875	119.063
-	4.7244	120
4-3/4	4.75	120.65
4-13/16	4.8125	122.238
4-7/8	4.875	123.825
-	4.9212	125
4-15/16	4.9375	125.413
5	5	127
-	5.1181	130
5-1/4	5.25	133.35
5-1/2	5.5	139.7
-	5.5118	140
5-3/4	5.75	146.05
-	5.9055	150
6	6	152.4
6-1/4	6.25	158.75
-	6.2992	160
6-1/2	6.5	165.1
-	6.6929	170
6-3/4	6.75	171.45
7	7	177.8
-	7.0866	180
-	7.4803	190
7-1/2	7.5	190.5
-	7.874	200
8	8	203.2
-	8.2677	210
8-1/2	8.5	215.9
-	8.6614	220
9	9	228.6
-	9.055	230
-	9.4488	240
9-1/2	9.5	241.3
-	9.8425	250
10	10	254.01
-	10.2362	260
-	10.6299	270
11	11	279.401
-	11.0236	280
-	11.4173	290
-	11.811	300
12	12	304.801
13	13	330.201
-	13.7795	350
14	14	335.601
15	15	381.001
-	15.748	400
16	16	406.401
17	17	431.801
-	17.7165	450
18	18	457.201
19	19	482.601
-	19.685	500
20	20	508.001



Cylinder application ____________________

Single- or Double-acting ____________ System operating pressure Normal ____ Max. ____

O.D. of body ____________ Is there a relief valve in system ____ Setting ____

O.D. largest moving stage ____________ System flow in G.P.M Min. ____ Max. ____

Number of moving stages ____________ System operating temp. Normal ____ Max. ____

Chrome or non-chrome stages ____________ Fluid type ____________

Mounting conditions ___Vert. ___Horz. ___Incline angle Load holding requirements ____________

Any side or eccentric loading possible ____________ Environmental condition ____________

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 ____________

N : Plunger pin to stage support (if applicable) ____________

O : Stage support width ____________

P : Stage support thickness ____________

Q : Stage support bolt & thread size ____________

R : Stage support bolt locations & C/L's ____________

Special mounting (if applicable) ____________________

Extend port size and type ____________ Extend port location ____________

Retract port size and type ____________ Retract port location ____________

Special features or comments ____________________

Requested by: Firm ____________________ Current Quan. ____________

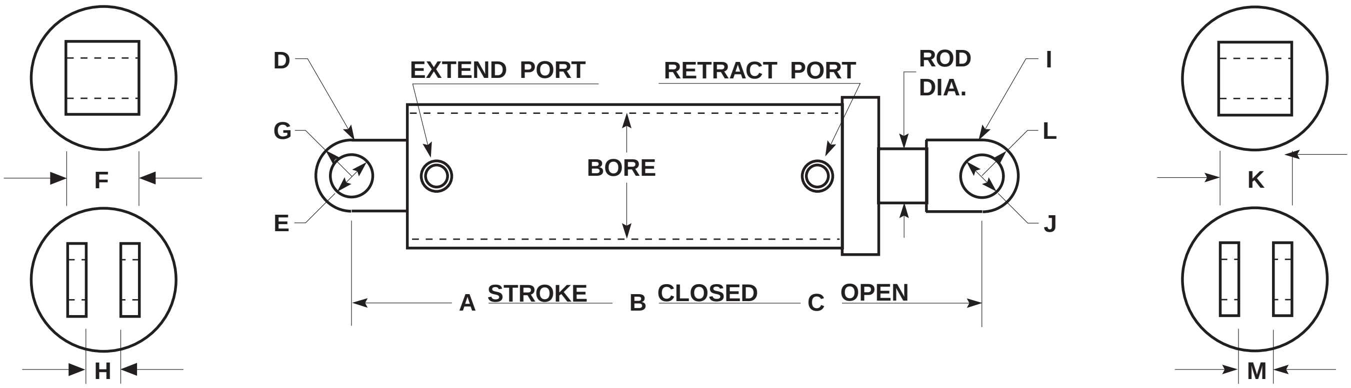
Address ____________________ Future Quan. ____________

City ____________ State ____ Zip ____

Phone ____________ Fax ____________

Contact ____________________

Phone: (800) 848-5575 * 330-480-8431 * Fax (800) 694-3392 * 330-480-8432



Cylinder application ____

Single- or Double-acting ____ | System operating pressure Normal ____ Max. ____

Bore ____ | Is there a relief valve in system ____ Setting ____

Rod diameter ____ | System flow in G.P.M Min. ____ Max. ____

Head & gland design ____ | System operating temp. Normal ____ Max. ____

Piston design ____ | Fluid type ____

Mounting conditions ____Vert. ____Horz. ____Incline angle | Load holding requirements ____

Any side or eccentric loading possible ____ | Environmental condition ____

A : Total stroke ____

B : Closed length ____

C : Open length ____

D : Base mount type or code ____ | I : Plunger mount type or code ____

E : Base pin diameter ____ | J : Plunger pin diameter ____

F : Base mount width ____ | K : Plunger mount width ____

G : Base mount radius ____ | L : Plunger mount radius ____

H Base Clevis Gap (if applicable) ____ | M : Plunger clevis gap (if applicable) ____

Special mounting (if applicable) ____

Extend port size and type ____ | Extend port location ____

Retract port size and type ____ | Retract port location ____

Special features or comments ____

Requested by: Firm ____ | Current Quan. ____

Address ____ | Future Quan. ____

City ____ State ____ Zip ____

Phone ____ Fax ____

Contact ____

Phone: (800) 848-5575 * 330-480-8431 * Fax (800) 694-3392 * 330-480-8432

Offer of Sale

The items described in this document are hereby offered for sale at prices to be established by Parker Hannifin Corporation, its subsidiaries and its authorized distributors. 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 Parker Hannifin Corporation, its subsidiary or an authorized distributor (“Seller’] verbally or in writing, shall constitute acceptance of this offer.

1. Terms and Conditions of Sale: All descriptions, quotations, proposals, offers, acknowledgments, acceptances and sales of Seller’s products are subject to and shall be governed exclusively by the terms and conditions stated herein. Buyer’s acceptance of any offer to sell is limited to these terms and conditions. Any terms or conditions in addition to, or inconsistent with those stated herein, proposed by Buyer in any acceptance of an offer by Seller, are hereby objected to No such additional, different or inconsistent terms and conditions shall become part of the contract between Buyer and Seller unless expressly accepted in writing by Seller. Seller’s acceptance of any offer to purchase by Buyer is expressly conditional upon Buyer’s assent to all the terms and conditions stated herein, including any terms in addition to, or inconsistent with those contained in Buyer’s offer. Acceptance of Seller’s products shall in all events constitute such assent.

2. Payment: Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer’s receipt of the shipment.

3. Delivery: Unless otherwise provided on the face hereof, delivery shall be made F.O.B. Seller’s plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller’s delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

4. Warranty: Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of 18 months from the date of shipment from Parker Hannifin Corporation. THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTIBILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED.

NOTWITHSTANDING THE FOREGOING, THERE ARE NO WARRANTIES WHATSOEVER ON ITEMS BUILT OR ACQUIRED WHOLLY OR PARTIALLY, TO BUYER’S DESIGNS OR SPECIFICATIONS.

5. Limitation Of Remedy: SELLER’S LIABILITY ARISING FROM OR IN ANY WAY CONNECTED WITH THE ITEMS SOLD OR THIS CONTRACT SHALL BE LIMITED EXCLUSIVELY TO REPAIR OR REPLACEMENT OF THE ITEMS SOLD OR REFUND OF THE PURCHASE PRICE PAID BY BUYER, AT SELLER’S SOLE OPTION. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOST PROFITS ARISING FROM OR IN ANY WAY CONNECTED WITH THIS AGREEMENT OR ITEMS SOLD HEREUNDER, WHETHER ALLEGED TO ARISE FROM BREACH OF CONTRACT, EXPRESS OR IMPLIED WARRANTY, OR IN TORT, INCLUDING WITHOUT LIMITATION, NEGLIGENCE, FAILURE TO WARN OR STRICT LIABILITY.

6. Changes, Reschedules and Cancellations: Buyer may request to modify the designs or specifications for the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order, however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification or cancellation shall be at Seller’s discretion, and shall be upon such terms and conditions as Seller may require.

7. Special Tooling: A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller’s property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

8. Buyer’s Property: Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer’s property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller’s possession or control.

9. Taxes: Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the items sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

10. Indemnity For Infringement of Intellectual Property Rights: Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Part 10. Seller will defend and indemnify Buyer against allegations of infringement of U.S. patents, U.S. trademarks, copyrights, trade dress and trade secrets (hereinafter ‘Intellectual Property Rights’). 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 an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller’s obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it noninfringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller’s sole and exclusive liability and Buyer’s sole and exclusive remedy for infringement of Intellectual Property Rights.
If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret or any similar right.

11. Force Majeure: Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller’s obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter ‘events of Force Majeure]. Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials and any other cause beyond Seller’s control.

12. Entire Agreement/Governing Law: The terms and conditions set forth herein, together with any amendments, modifications and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder or this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

PD4099 9/88

Parker Hannifin Corporation
6035 Parkland Blvd.
Cleveland, Ohio 44124-4141
Telephone: (216) 896-3000
Fax: (216) 896-4000
www.parker.com

Parker Hannifin Corporation

About Parker Hannifin Corporation

Parker Hannifin is a leading global motion-control company dedicated to delivering premier customer service. A Fortune 500 corporation listed on the New York Stock Exchange (PH), our components and systems comprise over 1,400 product lines that control motion in some 1,000 industrial and aerospace markets. Parker is the only manufacturer to offer its customers a choice of hydraulic, pneumatic, and electromechanical motion-control solutions. Our Company has the largest distribution network in its field, with over 7,500 distributors serving nearly 400,000 customers worldwide.

Parker's Charter

To be a leading worldwide manufacturer of components and systems for the builders and users of durable goods. More specifically, we will design, market and manufacture products controlling motion, flow and pressure. We will achieve profitable growth through premier customer service.

Product Information

North American customers seeking product information, the location of a nearby distributor, or repair services will receive prompt attention by calling the Parker Product Information Center at our toll-free number: 1-800-C-PARKER (1-800-272-7537). In Europe, call 00800-C-PARKER-H (00800-2727-5374).

The Aerospace Group is a leader in the development, design, manufacture and servicing of control systems and components for aerospace and related high-technology markets, while achieving growth through premier customer service.

The Climate & Industrial Controls Group designs, manufactures and markets system-control and fluid-handling components and systems to refrigeration, air-conditioning and industrial customers worldwide.

The Fluid Connectors Group designs, manufactures and markets rigid and flexible connectors, and associated products used in pneumatic and fluid systems.

The Seal Group designs, manufactures and distributes industrial and commercial sealing devices and related products by providing superior quality and total customer satisfaction.

The Hydraulics Group designs, produces and markets a full spectrum of hydraulic components and systems to builders and users of industrial and mobile machinery and equipment.

The Filtration Group designs, manufactures and markets quality filtration and clarification products, providing customers with the best value, quality, technical support, and global availability.

The Automation Group is a leading supplier of pneumatic and electromechanical components and systems to automation customers worldwide.

The Instrumentation Group is a global leader in the design, manufacture and distribution of high-quality critical flow components for worldwide process instrumentation, ultra-high-purity, medical and analytical applications.

Commercial Hydraulics

Mobile Cylinder Div.
P.O. Box 239
Youngstown, OH 44501-0239
Tel: (330) 746-8011
Fax: (330) 746-1148
www.parker.com

Catalog HY18-0007/US
5M, 3/02