Section C – Hydraulic and Pneumatic Cylinders

Schrader Bellows offers you the widest range of Hydraulic and Pneumatic Cylinder Modifications and Options...all available to meet your particular cylinder design requirements of today...and tomorrow. We have a section that lets you “customize” cylinders to fit your application and help reduce your operating costs. At Schrader Bellows we’re ready to give you any and all the technical assistance you need to provide you with the modified standard cylinder design you need to meet your requirements.

Custom Modifications and Innovations

Cylinder Parts Identification and Seal Kit Data

Application Engineering Data

C

Feature	Hydraulic Series					Pneumatic Series	
	PL-2	PH-2	PH-3	CHE	SHM	PA-2	NC9
Extreme High Temperature Seals	●	●	●			●	
Non-Lube (N)* (1)						●	●
High Water Content Fluids	●	●	●		●		
Special Piston Rod Ends (1)	●	●	●	●	●	●	●
Rod End Threads 2 X Std. Length (1)	●	●	●	●	●	●	●
Port Relocation (2)	●	●	●		●	●	●
Extra Ports (2)	●	●	●		●	●	●
SAE “O” Ring Ports (2)	●	●	●	●	●	●	●
Oversize Port (2)	●	●	●		●	●	●
Mounting Combinations (2)	●	●	●	●	●	●	●
Stroke Adjusters (2)	●	●	●		●	●	
Spring Return (2)	●	●	●		●	●	●
Spring Extend (1)	●	●	●		●	●	
Water Service (2)	●	●	●		●	●	●
Hi-Load Piston (1)		●	●		●		
Fluorocarbon Seals (2)	●	●	●	●	●	●	●
Rod End Boots (2)	●	●	●		●	●	
Manifold Ports (2)	●	●	●		●	●	
Metallic Rod Wiper (2)	●	●	●		●	●	
Gland Drain (2)	●	●	●		●		
Air Bleeds (2)	●	●	●		●		
Thrust Key (2)	●	●	●	●	●	●	●
Spherical Bearings (1)	●	●			●	●	●
EPS-5, 6 & 7 and CLS-1 & 4 Proximity Switches (2)	●	●	●		●	●	●
Flange Coupling Piston Rod End (2)	●	●	●	●		●	●

*Modification suffix ie: PN.
(1) See Catalog Section for details.
(2) See Application Engineering Section for details.

Dual Axis Knuckle

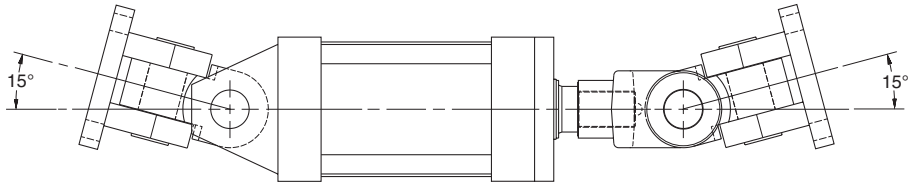
Using a Dual Axis Knuckle permits increased angular movement from the cylinder center line. Clevis or Eye mounted cylinders often require movement beyond the plane that two pivot pins allow. Spherical bearing mounts permit angular movement up to 4.5° within the pivoting plane. A Dual Axis Knuckle, with two pin holes 90° apart, installed at the cap and rod end of a mounting style MP1 cylinder adds two pivot points, thereby providing up to 30° movement in another plane at each end.

Dual Axis Knuckle Benefits

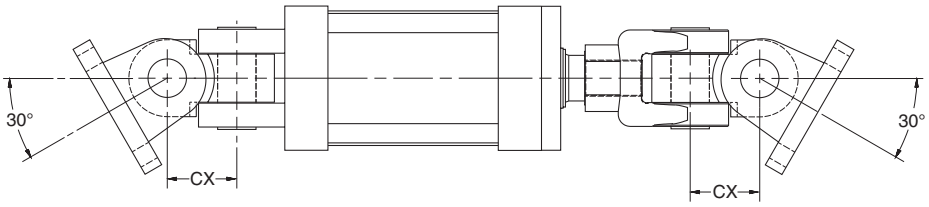
- Increased angular movement range compared to spherical bearing mount.
- Significantly higher dynamic load rating than spherical bearing mount.
- Reduced bearing loads and wear that results from misalignment.
- Allows faster assembly of pivoting cylinders to the machine.

Maximum Achievable Angular Movement from Cylinder Centerline*

Inboard Pin -
15° maximum movement for cylinder misalignment only.

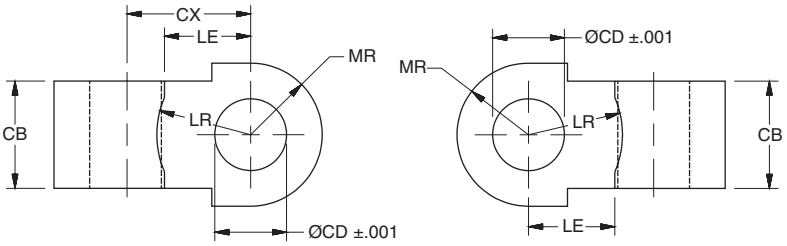


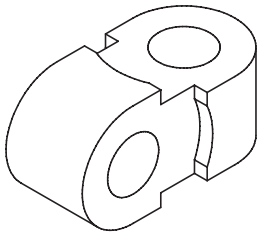
Outboard Pin -
30° maximum movement when applying force to a load moving in a curved plane.



*Maximum movement is achieved with cast clevis brackets. Movement is reduced when using fabricated clevis brackets.

Dual Axis Knuckle Dimensions and Usage





Part Number	Pin Ø	Load Capacity (lb)	CB	CD Ø	CX	LE	LR	MR	Mating Parts		MP1 Mount Usage by Series & Bore	
									Clevis Bracket	Rod Clevis	PA-2 & PL-2	PH-2
0952670000	0.500	4380	0.75	0.503	0.88	0.54	0.63	0.50	0960160050	0509400000, 0509410000	1.50, 2.00, 2.50	1.50
0952680000	0.750	12370	1.25	0.753	1.19	0.80	0.94	0.75	0960160075	0509420000, 1332840000	3.25, 4.00, 5.00	2.00, 2.50
0952690000	1.000	20500	1.50	1.003	1.69	1.05	1.22	1.00	0960160100	0509430000, 0509440000, 1332850000	6.00, 7.00, 8.00	3.25
0952700000	1.375	30500	2.00	1.378	2.38	1.44	1.69	1.38	0960160138	0509450000, 1332860000	10.00	4.00
0952710000	1.750	49500	2.50	1.753	3.06	1.81	2.19	1.75	0960160175	0509460000	12.00	5.00
0952720000	2.000	68000	2.50	2.003	3.63	2.09	2.44	2.00	0960160200	0509470000, 0509480000	14.00	6.00

Extreme High Temperature Seal Option – Up to 400° F

For Series PH-2, PH-3, PA-2 and PL-2 Cylinders

When your customer demands a long life cylinder with outstanding heat resistance, look no further than Schrader Bellows' new Extreme High Temperature Seal option.

Filled PTFE piston seals, rod seals, and wiperseal provide maximum resistance to extreme heat (up to 400° F) with excellent service life.

PTFE seals are mechanically energized to maintain uniform contact to dynamic sealing surfaces for positive leak-free performance across the entire operating pressure range. Static seals are fluorocarbon for a complete heat resistant assembly.

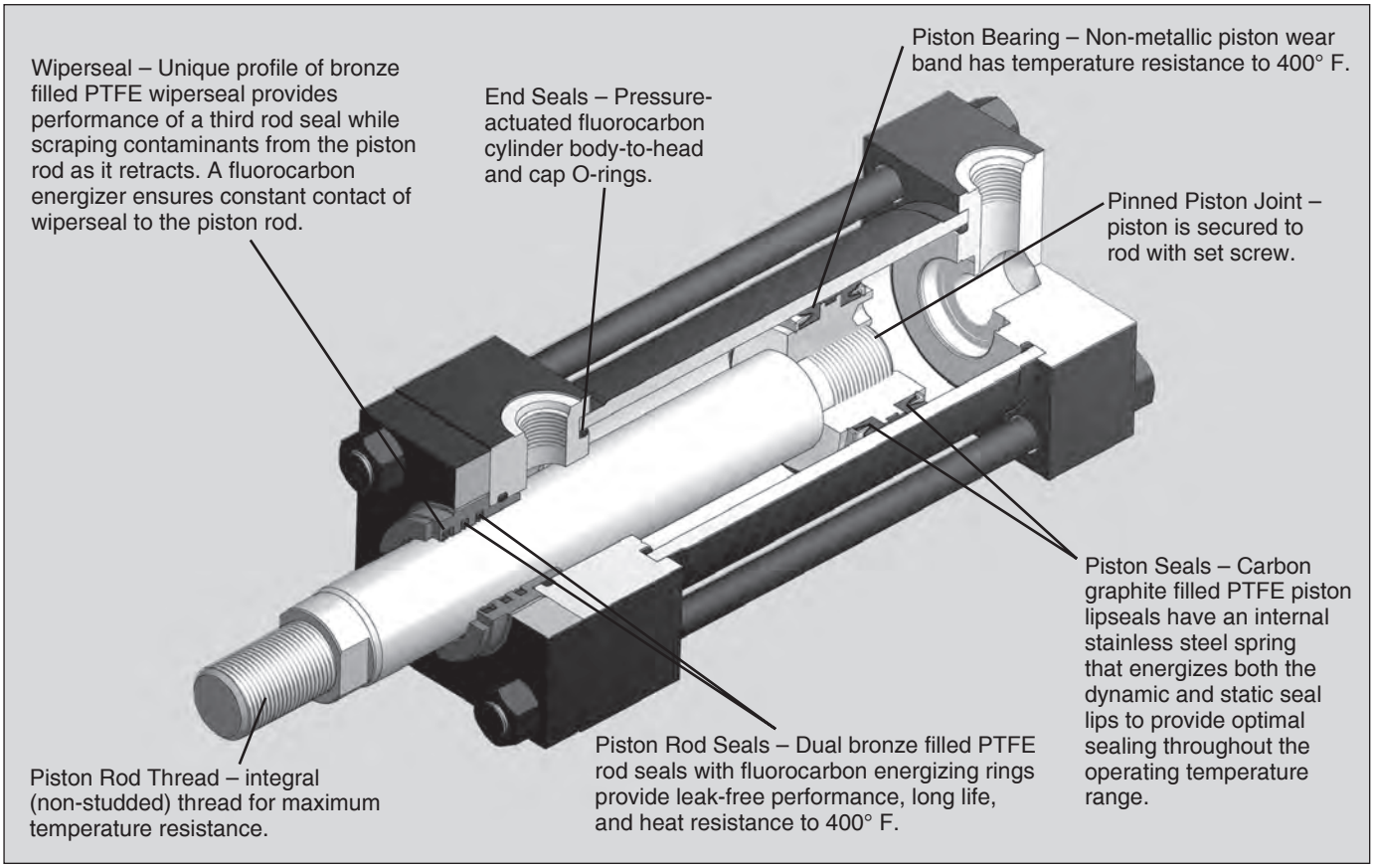
Customer Value Proposition:

Schrader Bellows' Extreme High Temperature Seal Option will provide OEM's and End Users an increase in machine productivity through improved resistance to heat degradation as compared to typical fluorocarbon seals. With a maximum continuous temperature rating of 400° F, the Extreme High Temperature Seal Option will allow longer service life in applications that require the use of alternative fluid types and demand superior heat resistance.

Schrader Bellows' innovative seal design utilizes PTFE materials that are constantly energized to provide excellent seal performance and long life. Customers utilizing this design will realize a reduction in machine downtime due to seal failure associated with high temperature exposure.

Product Features:

- Operating temperature to 400° F
- Broad range of fluid compatibility
- Available bore sizes: 1-1/2" through 8"; rod diameters 1" through 5"
- Stainless steel spring loads both dynamic and static piston seal lips
- No additional delivery time



Schrader Bellows®

Cylinder End-of-Stroke Proximity Sensors

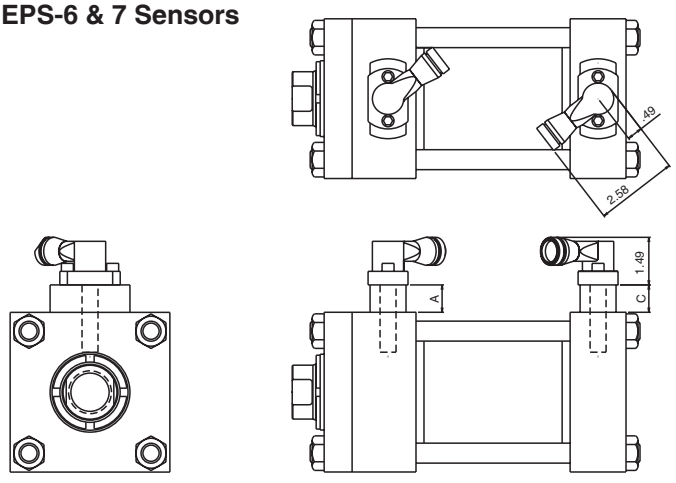
For Series PA-2, PL-2, PH-2, PH-3 and SHM Cylinders

"EPS" Style Inductive Sensors
For General Industrial AC and DC Applications

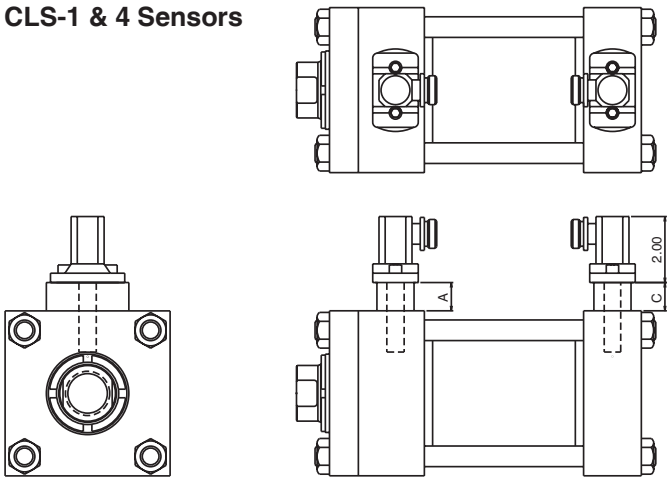
"CLS" Style Magnetic Sensors
For Extreme Temperature Applications

All Sensors Are:
Non-Contacting
Water Resistant
Weld-Field Immune
Shock and Vibration Resistant
Flange-Mounted to Cylinder End Caps

EPS-6 & 7 Sensors



CLS-1 & 4 Sensors



Series and Parallel Wiring

When Schrader Bellows EPS-6 or 7 proximity switches are used as inputs to programmable controllers the preferred practice is to connect each switch to a separate input channel of the PC. Series or parallel operations may then be accomplished by the internal PC programming.

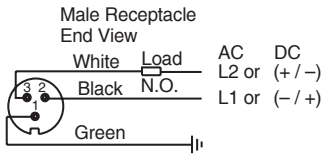
Schrader Bellows EPS-6 or 7 switches may be hard wired for series operation, but the voltage drop through the switches (see specifications) must not reduce the available voltage below what is needed to actuate the load.

Schrader Bellows EPS-6 or 7 switches may also be hard wired for parallel operation. However, the leakage current of each switch will pass through the load. The total of all leakage currents must not exceed the current required to actuate the load. In most cases, the use of two or more EPS-6 or 7 switches in parallel will require the use of a bypass (shunt) resistor.

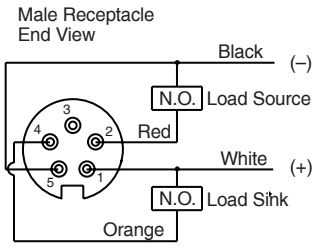
Series	A max.	C max.
PH-2, PH-3 1.5"-8" bores	.86"	1.75"
PL-2	1.55"	1.05"
PA-2	1.55"	1.30"
SHM	1.19"	1.05"

Connector Pin Numbering

3-Pin Mini



5-Pin Mini



Specifications

Style:	EPS-7	EPS-6	CLS-1	CLS-4
Code Designator:	H	D	F	B
Description:	Economical, General Purpose, 2 wire device, primarily for AC applications, not suitable for 24 VDC applications. Also for automotive industry applications.	Economical, General Purpose, 3 wire, DC sensor, dual output: sinking and sourcing	Functional replacement for AB (Mechanical) Limit Switches in many applications, or where customer needs NC contacts, zero leakage, zero voltage drop, higher or lower load current than EPS-style.	Functional replacement for AB (Mechanical) Limit Switches in many High Temperature applications, or where customer needs NC contacts, zero leakage, zero voltage drop, higher or lower load current than EPS-style.
Supply Voltage:	20 to 250 VAC/DC	10 to 30 VDC	24 to 240 VAC/DC	24 to 240 VAC/DC
Load Current, min:	8 mA	NA	NA	NA
Load Current, max:	300 mA	200 mA	4 AMPS @ 120 VAC 3 AMPS @ 24 VDC	4 AMPS @ 120 VAC 3 AMPS @ 24 VDC
Leakage Current:	1.7 mA, max.	10 micro amps max.	-	-
Voltage Drop:	7 V, max.	2 VDC max.	NA	NA
Operating Temperature:	-14° to +158° F	-14° to +158° F	-40°F to +221° F	-40° F to +400° F
Sensor Type:	Inductive proximity	Inductive proximity	Non-contacting magnetically actuated	Non-contacting magnetically actuated
Part Number:	148897****	148896****	148275****	149109****
Part Number Suffix ** :**	**** 4-digit suffix indicates probe length: 0125=1.25", 0206=2.06", 0288=2.875", 0456=4.562"			
Connection:	3 pin mini	5 pin mini	3 pin mini	144" PTFE Coated Flying Leads with 1/2" conduit hub
Enclosure Rating:	IEC IP67	IEC IP67	NEMA 1, 2, 3, 4, 4x, 5, 6, 6P, 11, 12, 12K, 13	NEMA 1, 2, 3, 4, 4x, 5
LED indication:	Yes	Yes	No	No
Short Circuit Protection:	Yes	Yes	No	No
Weld Field Immunity:	Yes	Yes	Yes	Yes
Output:	2 wire, Normally Open with leakage current	Dual output: DC Sinking and DC Sourcing, user selectable via wiring	SPDT (Single Pole Double Throw), Normally Open/Normally Closed, Form C	SPDT (Single Pole Double Throw), Normally Open/Normally Closed, Form C
Approvals/Marks:	CE, UL, CSA	CE, UL, CSA	UL or CSA†	UL or CSA†
Make/Break Location:	0.125" from end of stroke, typical. Tolerance is 0/-.125"			
Wiring Instructions:	Pin 1: AC Ground (Green) Pin 2: Output (Black) Pin 3: AC Line (White)	Pin 1: +10 to 30 VDC (White) Pin 2: Sourcing Output (Red) Pin 3: Grounded (not connected or required) Pin 4: Sinking Output (Orange) Pin 5: DC Common (Black)	Pin 1: Common (Green) Pin 2: Normally Closed (Black) Pin 3: Normally Open (White)	Common: (Black) Normally Open: (Blue) Normally Closed: (Red)
Standard Cable: 6'	0853550006	0859170006	0853550006	-
Standard Cable: 12'	0853550012	0859170012	0853550012	-
Cable: 6', Right Angle	0875470006	-	0875470006	-

†CSA available upon request – consult factory

C

How to Specify EPS Switches

Schrader Bellows EPS proximity switches may be ordered on Series PA-2, PN, PL-2, PH-2, PH-3, and SHM cylinders as follows:

1) Complete the basic cylinder model number.

2) Place an "S" in the model number to denote switches and/or special features.

3) Mounting styles MT1, MT2, ME5, MF5, MF6 should be used with caution because of possible mounting interferences. See the following page.

4) Special modifications to cylinders other than switches must have a written description.

5) Specify letter prefix "H" for EPS-7, "D" for EPS-6, and "F" for CLS-1, or "B" for CLS-4, then fill in the four blanks specifying port location, switch orientation and actuation point for both head and cap. If only one switch is used, place "XXXX" in the unused blanks.

Example = H13CGG-XXXX denotes a switch on the head end only, EPS-7

Example = XXXX-B42BGG denotes a switch on the cap end only, CLS-4

Head End

H	1	3	A	GG
Specify: "H" = EPS-7 "D" = EPS-6 "F" = CLS-1[1] "B" = CLS-4[1] "N" = Prep for EPS-6 and EPS-7 switches "P" = Prep for CLS-1 and CLS-4 switches "T" = Prep for CLS-2 switch	Port Location See Figure 1.	Switch Location See Figure 1.	Switch Orientation See Figure 2 for CLS-1, CLS-4, EPS-6 and EPS-7 only.	Actuation Point GG = End of Stroke FF = Stroke to Go; See Bulletins 0840-G-E1, 2 or 3 for stroke remaining.

Cap End

H	4	2	A	GG
Specify: "H" = EPS-7 "D" = EPS-6 "F" = CLS-1 "B" = CLS-4 "N" = Prep for EPS-6 and EPS-7 switches "P" = Prep for CLS-1 and CLS-4 switches "T" = Prep for CLS-2 switch	Port Location See Figure 1.	Switch Location See Figure 1.	Switch Orientation See Figure 2 for CLS-1, CLS-4, EPS-6 and EPS-7 only.	Actuation Point GG = End of Stroke FF = Stroke to Go; See Bulletins 0840-G-E1, 2 or 3 for stroke remaining.

Note: All specified switch and port locations are as seen from rod end of cylinder.

[1] CLS-1 and CLS-4 proximity switches are not available on the head end of 1.50" bore with 1.00" rod and 2.00" bore with 1.375" rod

Figure 1

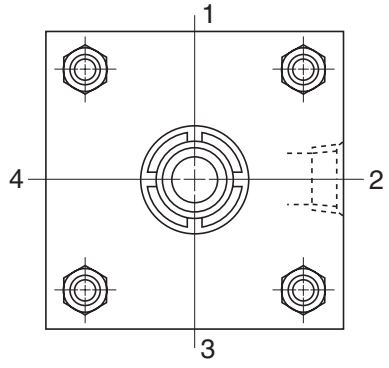
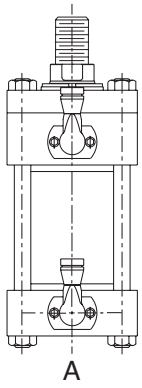


Figure 2

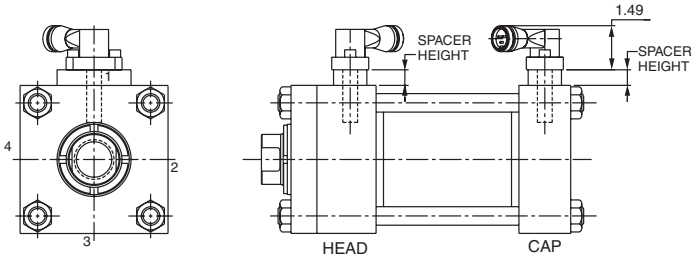


These pages contain mounting information for EPS and CLS Style Proximity Switches by bore and rod combination.

Switches, spacers and mounting bolts have each been assigned a code that can be found in Tables 2, 3 and 4.

The components of a complete switch assembly may be identified by cross referencing these codes with the part numbers in Tables 5, 6 and 7.

EPS-6 & 7 Heavy Duty
Industrial & Automotive Applications



CLS-1 & 4 Switches
Extreme Temperature Applications

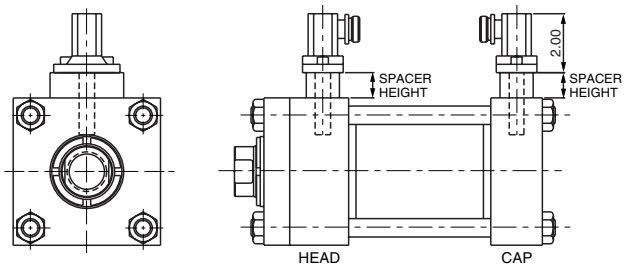


Table 1 — Available Mounting Positions for EPS-6 & 7 & CLS-1 & 4

EPS-6 & 7 & CLS-1 & 4 MOUNTING STYLES		Switch Locations for PA-2, PN, PL-2, PH-2, PH-3, SHM Series									
Bores sizes (inches):		**1.5**	**2**	**2.5**	**3.25**	**4**	**5**	**6**	**7**	**8**	**10**
MHP bores sizes (mm):		**40**	**50**	**63**	**80**	**100**	**125**	**160**	**–**	**200**	**–**
MT4, MX0, MX1, MX2, MX3, MP1	**HEAD**	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
	CAP	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
MF1, ME5, MT1 (see note 3)	**HEAD**	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
	CAP	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
MF2, ME6, MT2	**HEAD**	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
	CAP	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
MS2 (see note 2)	**HEAD**	1	1	1	1	1	1	1,2,4	1,2,4	1,2,4	1,2,4
	CAP	1	1	1	1	1	1	1,2,4	1,2,4	1,2,4	1,2,4
MS4	**HEAD**	1	1	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4
	CAP	1	1	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4	1,2,4
MF5	**HEAD**	NA	NA	NA	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
	CAP	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
MF6	**HEAD**	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
	CAP	NA	NA	NA	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4

Note: The electrical connector orientation may be restricted in some cases. Consult the dimensions in the current catalog.

Note 2: On 6" cylinders and larger, and for 160mm and 200mm bores, switches mounted in position 2 or 4 will interfere with the installation and removal of mounting bolts.

Note 3: On 1.5 through 5" Style ME5 cylinders, switches will extend beyond mounting surface of cylinder.

Note 4: Positions 1, 2, 3 and 4 are determined by viewing cylinder from piston rod end and going clockwise.

C

Table 2 CODES FOR **PA-2, PN, PL-2 SERIES** CYLINDERS WITH EPS-6, 7 & CLS-1, 4 SWITCHES

BORE	SERIES	ROD DIA	END-OF-STROKE PROBE LOCATION ("GG" ORDER CODE)	SPACER HEIGHT	SWITCH CODE	SPACER CODE	EPS-6,7 BOLT CODE (1)	CLS-1, 4 BOLT CODE (1)	OPTIONAL STROKE TO GO ("FF" ORDER CODE)
1.5	PA-2 PL-2	0.63	0.59	0.688	1	FK	299	F99	0.44
		1	0.59	0.876	1	1K	399	199	0.44
		CAP	0.63	0.468	1	BK	1D9	9D9	0.17
2	PA-2 PL-2	0.63	0.59	0.579	1	D2	2E9	0E9	0.44
		1.375	0.59	0.829	1	H2	399	199	0.44
		1	0.59	0.688	1	F2	299	F99	0.44
		CAP	0.63	1.048	2	EG2	499	299	0.17
2.5	PA-2 PL-2	0.63	0.63	0.296	1	E	29	F9	0.48
		1.75	0.63	0.796	1	EH	49	29	0.48
		1	0.63	0.421	1	G	39	19	0.48
		1.38	0.63	0.608	1	DF	39	29	0.48
		CAP	0.63	0.780	2	FG	49	29	0.17
3.25	PA-2 PL-2	1	0.88	0.858	2	FH	49	39	0.73
		2	0.56	0.608	1	DF	39	29	0.42
		1.375	0.88	0.249	1	D	2E	FE	0.73
		1.75	0.88	0.421	1	G	39	19	0.73
		CAP	0.75	0.546	2	J	39	29	0.34
4	PA-2 PL-2	1	0.88	0.499	2	H	39	19	0.73
		2.5	0.56	0.546	1	J	39	29	0.42
		1.375	0.88	0.671	2	DG	49	29	0.73
		1.75	0.88	0.858	2	FH	49	39	0.73
		2	0.56	0.249	0	D	2E	FE	0.42
		CAP	0.75	0.170	2	C	1D	0D	0.34
5	PA-2 PL-2	1	0.88	0.796	3	EH	49	39	0.72
		3.5	0.56	0.546	1	J	39	29	0.42
		1.38	0.88	0.170	2	C	2D	FD	0.72
		1.75	0.88	0.358	2	F	29	F9	0.72
		2	0.56	0.546	2	J	39	29	0.42
		2.5	0.56	0.858	2	FH	49	39	0.42
		3	0.56	0.296	1	E	29	F9	0.42
		CAP	0.75	0.499	3	H	39	19	0.34
6	PA-2 PL-2	1.38	1.13	0.499	3	H	39	29	0.98
		4	0.81	0.296	1	E	29	F9	0.66
		1.75	1.13	0.671	3	DG	49	29	0.98
		2	0.81	0.858	3	FH	49	39	0.66
		2.5	0.81	0.358	2	F	29	F9	0.66
		3	0.81	0.608	2	DF	39	29	0.66
		3.5	0.81	0.858	2	FH	49	39	0.66
		CAP	0.75	0.109	3	A	1D	GD	0.34
7	PA-2	1.38	1.13	0	3	NONE	1	G	0.98
		1.75	1.13	0.170	3	C	2D	FD	0.98
		2	0.81	0.358	3	F	29	F9	0.66
		CAP	0.94	1.296	4	EHH	6B	5B	0.53
8	PA-2 PL-2	1.38	1.13	1.171	4	DGH	6B	4B	0.98
		5.5	0.69	0.921	2	GH	5B	3B	0.54
		1.75	1.13	1.358	4	FHH	6B	5B	0.98
		2	0.81	1.546	4	HHJ	7C	6C	0.66
		2.5	0.81	0.170	3	C	2D	FD	0.66
		3	0.81	0.421	3	G	39	19	0.66
		3.5	0.81	0.671	3	DG	49	29	0.66
		4	0.81	0.110	2	A	1D	GD	0.66
		5	0.81	0.671	2	DG	49	29	0.66
		CAP	0.94	0.796	4	EH	49	39	0.63
10	PA-2	1.75	1.38	0.296	4	E	29	F9	1.22
		2	1.06	0.499	4	H	39	19	0.91
		2.5	1.06	0.499	4	EH	49	39	0.91
		3	1.06	1.046	4	DEH	5B	4B	0.91
		3.5	1.06	1.296	4	EHH	6B	5B	0.91
		4	1.06	0	3	NONE	1	G	0.91
		5	0.94	0.421	3	G	39	19	0.79
		5.5	0.94	0.671	3	DG	49	29	0.79
		CAP	0.94	0	4	NONE	1	G	0.53

(1) The first digit of the Bolt Code refers to screws that mount the switch to the cylinder. The second and third digits refer to screws that mount the spacers to the cylinder.

Table 3 CODES FOR **PH-2 and PH-3 SERIES** CYLINDERS WITH EPS-6, 7 & CLS-1, 4 SWITCHES

BORE	SERIES	ROD DIA	END-OF-STROKE PROBE LOCATION ("GG" ORDER CODE)	SPACER HEIGHT	SWITCH CODE	SPACER CODE	EPS-6, 7 BOLT CODE (1)	CLS-1, 4 BOLT CODE (1)	OPTIONAL STROKE TO GO ("FF" ORDER CODE)
1.5	PH-2	0.63	0.880	0.439	1	A2	1D9	GD9	.422
		1	0.880	0.626	1	E2	299	F99	.422
		CAP	0.937	1.048	2	EG2	499	299	.381
2	PH-2	1	0.880	0.439	1	A2	1D9	GD9	.442
		1.375	0.880	0.579	1	D2	2E9	0E9	.442
		CAP	0.875	0.938	2	DF2	399	299	.319
2.5	PH-2	1	0.880	0.170	1	C	2D	FD	.475
		1.75	0.880	0.546	1	J	39	29	.475
		1.375	0.880	0.358	1	F	39	F9	.475
		CAP	0.875	0.671	2	DG	49	29	.319
3.25	PH-2	1.375	1.125	0.671	2	DG	49	29	.725
		2	0.812	0.249	1	D	2	FE	.417
		1.75	1.125	0.858	2	FH	49	39	.725
		CAP	1.062	0.296	2	E	29	F9	.506
4	PH-2	1.75	1.125	0.608	2	DF	39	29	.725
		2.5	0.812	0.296	1	E	29	F9	.417
		2	0.812	0	1	NONE	1	G	.417
		CAP	1.000	0.170	2	C	2D	FD	.444
5	PH-2	2	0.812	0.858	3	FH	49	39	.417
		3.5	0.812	0.858	2	FH	49	39	.417
		2.5	0.812	0.358	2	F	29	F9	.417
		3	0.812	0.608	2	DF	39	29	.417
		CAP	0.875	0.358	3	F	29	F9	.319
6	PH-2	2.5	1.062	0.671	3	DG	49	29	.663
		4	1.062	0.608	2	DF	39	29	.663
		3	1.062	0.109	2	A	1	GD	.663
		3.5	0.812	0.358	2	F	29	F9	.417
		CAP	1.250	1.749	4	DHHH	8D	6C	.683
7	PH-3	3	1.562	0.421	3	G	39	19	1.162
		5	1.437	0.671	2	DG	49	29	1.037
		3.5	1.562	0.671	3	DG	49	29	1.162
		4	1.062	0.109	2	A	1D	GD	.663
		CAP	1.687	1.421	4	GHH	7B	51	1.117
8	PH-3	3.5	1.812	0.170	3	C	2D	FD	1.412
		5.5	1.687	0.421	2	G	39	19	1.287
		4	1.062	0.421	3	G	39	19	.663
		5	1.437	0.170	2	C	2D	FD	1.037
		CAP	1.687	0.921	4	GH	5B	3B	1.183

(1) The first digit of the Bolt Code refers to screws that mount the switch to the cylinder. The second and third digits refer to screws that mount the spacers to the cylinder.

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Table 4 CODES FOR **SHM SERIES** CYLINDERS WITH EPS-6, 7 & CLS-1, 4 SWITCHES

BORE	SERIES	ROD DIA	END-OF-STROKE PROBE LOCATION ("GG" ORDER CODE)	SPACER HEIGHT	SWITCH CODE	SPACER CODE	EPS-6, 7 BOLT CODE (1)	CLS-1, 4 BOLT CODE (1)	OPTIONAL STROKE TO GO ("FF" ORDER CODE)
40	SHM	18	0.875	0.688	1	E3	HPP	LPP	.532
		28	0.875	0.688	1	F3	HPP	LPP	.532
		CAP	0.875	1.048	2	EG3	KPP	UPP	.656
50	SHM	22	0.875	1.188	2	FH3	KPP	UPP	.532
		36	0.875	0.626	1	E3	HPP	LPP	.532
		28	0.875	0.500	1	C3	HNP	WPP	.532
		CAP	0.875	0.829	2	H3	JPP	HPP	.656
63	SHM	28	0.875	0.249	1	D	HN	LN	.500
		45	0.875	0.546	1	J	JP	UP	.500
		36	0.875	0.358	1	F	HP	HP	.500
		CAP	0.875	0.671	2	DG	KP	UP	.656
80	SHM	36	1.125	0.671	2	DG	KP	UP	.500
		56	0.812	0.296	1	E	HN	LN	.500
		45	1.125	0.858	2	FH	KP	UP	.500
		CAP	1.000	0.296	2	E	HP	LP	.656
100	SHM	45	1.125	0.608	2	DF	JP	UP	.500
		70	0.812	0.358	1	F	HP	LP	.500
		56	0.812	0.858	2	FH	KP	JP	.500
		CAP	1.000	0.170	2	C	HN	LN	.656
125	SHM	56	0.812	0.170	2	C	HN	LN	.500
		90	0.812	0.109	1	A	LN	WN	.500
		70	0.812	0.499	2	H	JP	HP	.500
		CAP	1.000	0.421	3	G	JP	HP	.656
160	SHM	70	1.062	0.499	3	H	JP	HP	.500
		110	1.062	0.499	2	H	JP	HP	.500
		90	1.062	0.109	2	A	LN	WN	.500
		CAP	1.312	0.546	4	J	MQ	YQ	.670
200	SHM	90	1.562	0.170	3	C	HN	LN	.670
		140	1.687	0.421	2	G	JP	HP	.670
		110	1.687	0.546	3	J	JP	UP	.670
		CAP	1.937	0.671	4	DG	KP	UP	.670

(1) The first digit of the Bolt Code refers to screws that mount the switch to the cylinder. The second and third digits refer to screws that mount the spacers to the cylinder.

Table 5 EPS & CLS Switches

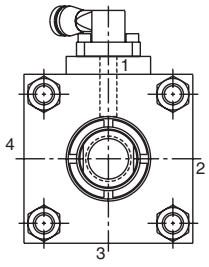
Code	Probe Length (inches)	Schrader Bellows Part Number			
		EPS-6 DC	EPS-7 AC	CLS-1 AC	CLS-4 AC
1	1.250	1488960125	1488970125	1482750125	1491090125
2	2.062	1488960206	1488970206	1482750206	1491090206
3	2.875	1488960287	1488970287	1482750287	1491090287
4	4.562	1488960456	1488970456	1482750456	1491090456
Brand		Pepperl & Fuchs	Pepperl & Fuchs	Topworx	Topworx
Connection		5 Pin Mini	3 Pin Mini	3 Pin Mini	144" PTFE Coated Flying Leads with 1/2" conduit hub
Voltage		10-30 VDC	50-220 VAC/DC	24-240 VAC/DC	24 to 240 VAC/DC
Output		PNP & NPN	Normally Open	SPDT, Form C	SPDT, Form C
Leakage Current		NA	<1.7mA	–	–
Voltage Drop		<.8 VDC	<10 Volts	NA	NA

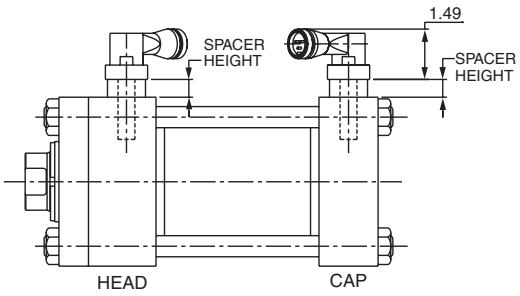
Table 6 — Spacer Blocks					
Letter Code	Part #	Spacer Height (inches)	Letter Code	Part #	Spacer Height (inches)
A	0854690110	.109	EH	0854690797	.796
B	0854670000	.138	FH	0854690859	.858
C	0854690171	.170	GH	0854690922	.921
D	0854690250	.249	BGG	0854690983	.982
E	0854690297	.296	DEH	0854691047	1.046
F	0854680359	.358	DGH	0854691172	1.171
G	0854690422	.421	EHH	0854691297	1.296
H	0854690500	.499	FHH	0854691359	1.358
J	0854690547	.546	GHH	0854691422	1.421
K	0854660000	.330	HHJ	0854691547	1.546
DF	0854690609	.608	DHHH	0854691750	1.749
DG	0854690672	.671	1	0854680547	.546
EG	0854690719	.718	2	0854820000	.330
FG	0854690781	.780	3*	0875830000	.330

One O-Ring per spacer, Size# 2 - 15, Part Number 0100240003 (Fluorocarbon)

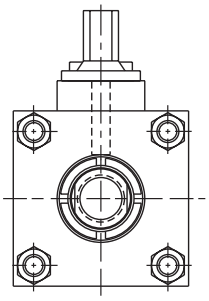
* Used on SHM only

EPS-6 & 7 Heavy Duty Industrial & Automotive Applications





CLS-1 & 4 Extreme Temperature Applications



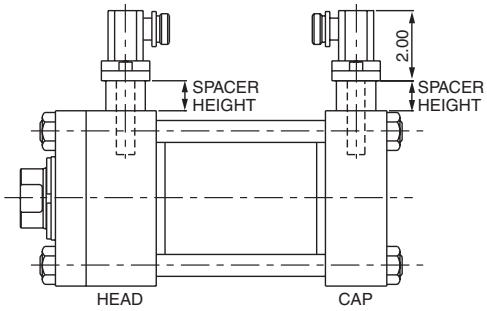


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Table 7 — Mounting Bolts

Two mounting bolts are required per switch.

Mounting Bolts for PA-2, PN, PL-2, PH-2, PH-3

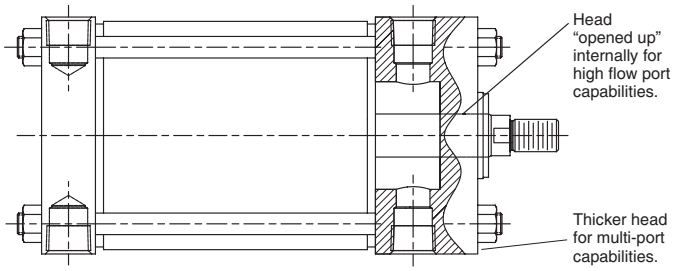
Code #	Bolt Part Number	Bolt Length Inches	Bolt Thread & Type
0	0106340048	0.75	1/4-20 SHCS
1	0106340100	1.00	1/4-20 SHCS
2	0106340116	1.25	1/4-20 SHCS
3	0106340132	1.50	1/4-20 SHCS
4	0106340148	1.75	1/4-20 SHCS
5	0106340200	2.00	1/4-20 SHCS
6	0106340216	2.25	1/4-20 SHCS
7	0106340232	2.50	1/4-20 SHCS
8	0106340248	2.75	1/4-20 SHCS
9	0106280024	0.38	#8-32 SHCS
A	0106280032	0.50	#8-32 SHCS
B	0106280100	1.00	#8-32 SHCS
C	0106280132	1.50	#8-32 SHCS
D	0104530024	0.38	#8-32 PHS
E	0104530032	0.50	#8-32 PHS
F	0106340056	0.88	1/4-20 SHCS
G	0106340040	0.62	1/4-20 SHCS

Mounting Bolts for SHM

Code #	Bolt Part Number	Bolt Length mm	Bolt Thread & Type
H	1474210030	30	M6X1.0 SHCS
J	1474210040	40	M6X1.0 SHCS
K	1474210045	45	M6X1.0 SHCS
L	1474210025	25	M6X1.0 SHCS
M	1474210065	65	M6X1.0 SHCS
N	1487220210	10	M6X1.0 SHCS
P	1487640010	10	M6X1.0 SHCS (LOW HEAD)
Q	1474190035	35	M4X0.7 SHCS
R	1487220212	12	M4X0.7 FHSS
S	1487220216	16	M4X0.7 FHSS
T	1487220220	20	M4X0.7 FHSS
U	1474210035	35	M6X1.0 SHCS
V	1487220208	8	M4X0.7 FHSS
W	1474210020	20	M6X1.0 SHCS
X	1474210055	55	M6X1.0 SHCS
Y	1474210060	60	M6X1.0 SHCS
Z	0108800016	1/4" HI COLLAR LOCK WASHER, 4 REQ'D	

FHSS=Flat Head Socket Screw PHS=Phillip Head Screw

PA-2 Series Counter Balance Cylinder



The innovative PA-2 Series Counter Balance Cylinder is designed with special dimensioned heads and caps opened up internally to allow for the high flow port option. The heads and caps are also thicker to accommodate multi-porting capabilities.

Standard Specifications

- Square head – tie rod design.
- Bore sizes – 1½" through 14" standard.
- Nominal pressure – to 250 psi air.
- Strokes available in any practical length.
- Porting properly sized for optimum air flow.
- Heads and caps properly sized to accommodate porting.
- Case hardened, chrome plated piston rod is standard.

An efficient counter balance system consists of cylinders working in conjunction with receiver tanks to balance a vertical load, with minimized restrictions to air flow situations. Simplified examples of a cylinder and an air tank are shown below in Figures A and B.

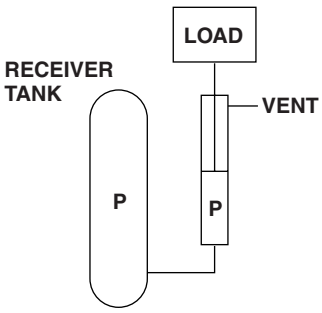


FIGURE A
CAP END PRESSURIZED

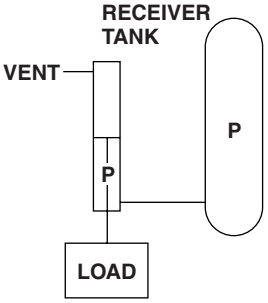


FIGURE B
ROD END PRESSURIZED

Pipe Schedule Chart

A_F for Proper Pipe			
Pipe	**A_F (in.²)**	**Pipe**	**A_F (in.²)**
½	.304	1½	2.036
¾	.533	2	3.356
1	.864	2½	4.788
1¼	1.496	3	7.392

In many vertical driven load applications, use of the Counter Balance Cylinder is very effective for load control. The machine designer must assure that the cylinder itself does not become an excessive restricting factor. Restricting factor occurs when rapidly moving air tries to pass through a cylinder port or other orifice.

Excessive restricting factor will usually show up as higher than anticipated motor current draw at the vertical drive. The higher amperage causes increased electricity costs. Also the additional mechanical load due to air flow restricting factor could cause premature failure of motor, drive or other machine components.

The PA-2 Series Special Counter Balance Cylinders are specifically designed for applications where it is desirable to reduce the restricting factor of air flow through a cylinder orifice. An excellent guideline to follow regarding restricting factor is to have standard condition air velocity through the cylinder port at or below 5,000 feet per minute.

By applying the following information, you can properly size ports for a flow rate within the 5,000 feet/minute guideline.

- Cylinder Bore (D)..... in.
- Cylinder Rod Size (d) ..... in.
- Stroke Length (l)..... in.
- Stroke Time (t).....Sec.
- Receiver Tank Pressure (P) .....psi

Using the above information in the following formulas, with the provided Pipe Schedule Chart, you can properly size the Counter Balance Cylinder ports at both pressurized and vented ends.

AE: Cylinder Piston Areas

AE for cylinders connected to receiver tank as shown in Fig. A, cap end pressurized

$$\mathbf{AE} = \frac{\pi \times D^2}{4} = \_\_\_\_ \text{in.}^2$$

AE for cylinders connected to receiver tank as shown in Fig. B, rod end pressurized.

$$\mathbf{AE} = \frac{\pi \times (D^2 - d^2)}{4} = \_\_\_\_ \text{in.}^2$$

CR: Compression Ratio. At vented end, CR = 1.

$$\mathbf{CR} = \frac{P + 14.7}{14.7} = \_\_\_\_\_$$

A_F: Minimum Orifice Area for 5,000 ft./min. velocity.

$$\mathbf{A_F}^* = \frac{AE \times l \times CR}{1000t} = \_\_\_\_ \text{in.}^2$$

*A_F can be achieved by the use of one or two ports. Once A_F is found, compare to pipe chart shown at left for required flow areas in in². Select proper pipe schedule based upon operating pressure.

- The counterbalance version of the heavy duty PA-2 cylinder is a special and cannot be ordered directly from a standard PA-2 catalog.
- When dealing with extreme air velocities, it is critical that the PA-2 cylinder load, stroke, and speed requirements are satisfied before attempting to use the provided formulas.
- Once the flow rate guideline of 5,000 feet/minute is satisfied, provide the proper port size to accommodate the pipe size shown on the chart to the left. Apply minimum orifice area formula A_F (in.²) to match proper port size.

C

NOTES

Schrader Bellows®

PC, PD and PS Series

Intensifiers

C

- **Maximum Input Pressures:**
  Air – 250 psi (17 BAR)
  Oil – 1000 psi (69 BAR)
- **Maximum Output Pressures:**
  5/8" to 3" RAM – 5000 psi (345 BAR);
  3 1/2" to 5" RAM – 3000 psi (206 BAR)
- **Maximum Operating Temperatures:**
  –10°F to +165°F (–23°C) to (+74°C)

Schrader Bellows Intensifiers

Designed to Save Energy, Time, Space and Money in a Wide Variety of Applications.

A Schrader Bellows Intensifier is an efficient way of generating high pressure hydraulic fluid. Its operation is quite simple. Pressurized fluid – either air or oil – enters the intensifier and acts on a confined piston. This in turn drives a smaller diameter ram or piston to deliver a given volume of fluid. As a result, the output pressure is intensified and is considerably higher than the input pressure.

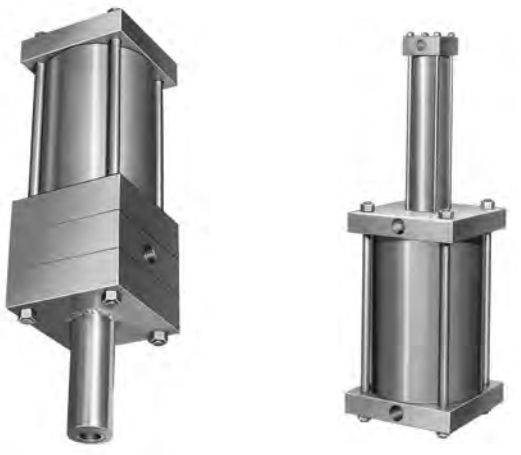
By using a Schrader Bellows Intensifier you can save in many ways. First, since it requires only low pressure input and less costly control valving, you eliminate the extra expense of high pressure pumps, valving and a large electrical power source. The simpler mountings and controls also save you valuable installation time.

In addition, since Schrader Bellows Intensifiers produce high hydraulic pressure, you can save space by using a smaller bore hydraulic cylinder in place of a larger bore air cylinder that is heavier and more costly.

Finally, because of the rugged dependability of Schrader Bellows Intensifiers and the simpler circuitry required, you eliminate the constant motion, heat generation and power consumption found in pump systems. This means that you use less energy with less downtime and maintenance.

These abilities and benefits of Schrader Bellows Intensifiers make them the ideal component in many applications. You can use them for such operations as marking, forming, molding, punching, riveting, shearing, straightening, laminating, embossing, welding and testing.

What's more, the Schrader Bellows Intensifier can be mounted on or off the equipment and can even be integrally combined with the work cylinder. This flexibility makes them particularly useful hydraulic pressure sources on portable equipment.



Schrader Bellows Intensifiers are available in various sizes and configurations. There are cylinder-to-ram units with capability for either single pressure or dual pressure service (left above), as well as several cylinder-to-cylinder models (above right).

Here are the features you'll find in every Schrader Bellows Intensifier:

1. Compact, high-strength steel heads, cap and tie rods meet the most demanding applications.

2. Seal by pressure O-rings serve as cylinder body-to-head seals prevent leaks. The cylinder body is also piloted on the O.D. to insure metal-to-metal contact to support the seals.

3. The rugged one-piece iron piston is threaded and Loctited to the ram. Schrader Bellows Lipseal™ piston seals are used with air; piston rings with hydraulic fluid.

4. The driving cylinder body is steel tubing with chrome-plated bore for corrosion-resistance in bore sizes 3¼" through 14" sizes.

5. The smooth, wear-resistant surface of the chrome-plated and induction-hardened ram greatly lengthens seal life.

6. Static O-ring seals prevent leaks past the O.D. of the glands. Back-up washers prevent extrusion.

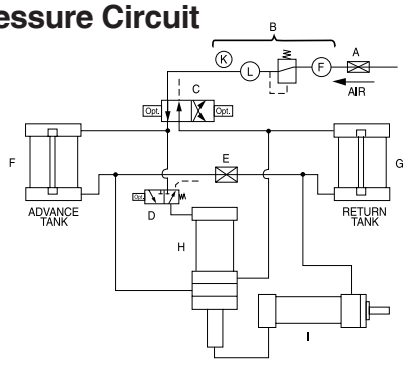
7. Intensifier operation is speeded up by the free flow of fluid in and out of the unobstructed ports. All high-pressure hydraulic ports are SAE straight thread o-ring type for leak-proof service.

8. Rod Lipseals are self-compensating and self-adjusting to provide leakproof ram seal for both high and low pressure operation.

9. For servicing the high pressure ram seals, the pressure chamber is independently secured with studs so it can be easily removed without disassembling the complete intensifier.

10. For optimum strength and safety, the pressure chamber wall is made of extra thick steel tubing that is piloted in a counterbore and pressure-welded to the head.

Dual Pressure Circuit



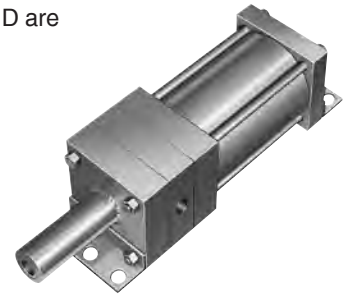
A Cutoff Valve
B Air Preparation Unit (Filter Regulator Lubricator-Gauge)
C 4-Way Valve (Normally 2 Position)
D 3-Way Valve
E Cutoff Valve (For Balancing Tank Fluid Levels)
F Advancing Tank (Air-Oil)
G Retracting Tank (Air-Oil)
H Intensifier
I Work Cylinder

Dual Pressure Circuit *(continued)*

This basic circuit is for a dual pressure system supplying pressure to a double-acting work system. The circuit may be readily changed for other operating conditions such as single acting cylinder and single pressure delivery.

The input pressure is introduced to the system through shop air lines to the 4-way directional control valve C. When valve C is shifted to position as shown, air is directed into air-oil tank F and to valve D. Oil, acted upon by air pressure, is forced from tank through pressure chamber of retracted intensifier and into work cylinder. The cylinder advances in stroke, being driven by this incoming oil. At a predetermined point in the stroke length of the work cylinder, valve D is synchronized to shift and direct air pressure to the intensifier to drive it in its power stroke, isolating tank F and supplying high pressure to work cylinder for its high thrust stroke. The work cylinder and intensifier are retracted by the shifting of valves C and D simultaneously to exhaust the intensifier and tank F. At the same time, air pressure is directed to tank G and to rod end side of intensifier piston. Oil from tank G retracts cylinder at low pressure.

The operators for valves C and D are optional – mechanical, manual, pilot or solenoid. The method of synchronizing valve D to stroke length position of work cylinder is also optional. This may be done by pilot control, limit switch, pressure switch, mechanically such as cams, or manually.



How to Select Schrader Bellows Intensifiers

Step 1: Determine the intensifier ratio for your application. This is the ratio of the available input fluid pressure and the output operating pressure required for the application. For cylinder-to-ram or cylinder-to-cylinder units, use the following formula:

$$\text{Intensifier ratio} = \frac{\text{Output pressure}}{\text{Input pressure}}$$

Step 2: Locate the intensifier ratio in column 5 of the appropriate chart on the following page. If the exact ratio is not shown, use the next larger ratio listed. When more than one choice is possible, usually the smallest driving cylinder bore size for a given intensifier ratio is the most economical answer.

Step 3: On same horizontal line as ratio determined in Step 2, select the driving cylinder bore size from column 1 and the ram diameter or driven cylinder bore size from column 3.

Note: For cylinder-to-ram applications, proceed with Steps 4 and 5. If a cylinder-to-cylinder unit is required, go to Step 6.

Step 4: Determine the type of cylinder-to-ram intensifier needed. Generally, a single pressure intensifier is used when the hydraulic work cylinder requires a high pressure for the entire stroke or in test vessel applications. A dual pressure intensifier is recommended if the high pressure is to be used only during the last portion of the work cylinder stroke.

Step 5: Calculate the intensifier stroke.

For single pressure intensifiers, use the formula:

$$\text{Intensifier stroke} = \frac{V + Vc}{Ar}$$

For dual pressure intensifier, use this formula:

$$\text{Intensifier stroke} = \frac{Vh + Vc + 2"^{*}}{Ar}$$

Where: V = work cylinder volume or test vessel fluid requirement in cubic inches.

Vh = oil volume in cubic inches required to move the work cylinder piston through its high pressure stroke.

Vc = compressibility allowance of 1% per 1000 psi of total volume in cubic inches of oil in the high pressure circuit, determined from:

Vc = total volume x .01 x high pressure/1000.

Ar = area of intensifier ram in square inches.

*This 2" is the intensifier stroke advance necessary to close the high pressure seal on dual pressure intensifiers only.

Note: If the calculated intensifier stroke results in a fraction, correct to the next larger **even** inch. The recommended maximum stroke is 20". If stroke calculation results in longer than 20" stroke, select a larger driving cylinder and ram having a similar intensifier ratio and recalculate stroke.

Step 6: For cylinder-to-cylinder intensifiers: Select the proper output cylinder. Since the output pressure is limited by the cylinder construction, the cylinder should be selected using the maximum pressure to be developed under nonshock conditions.

For Schrader Bellows PL-2 and PH-2 Series hydraulic cylinders, the maximum pressures under nonshock conditions are:

PL-2 Series: 1½" – 2500 psi; 2" – 2000 psi; 2½" – 1800 psi;
3¼" – 2000 psi; 4" – 1350 psi; 5" – 1500 psi;
6" – 1100 psi; 8" – 900 psi

PH-2 Series: All bore sizes – 3000 psi.

General Guidelines

1. Intensifiers are generally faster operating when:
   a. There is adequate input pressure.
   b. The ports and piping are large enough. Consider the use of oversize ports and connecting lines, to minimize pressure drop.
   c. The intensifier is pre-exhausted prior to the power stroke.
   d. Size hydraulic lines so that fluid flow velocity does not exceed 7 feet per second.
2. Bypass the intensifier with a pre-fill low pressure line by direct connection through a check valve to the pressure vessel.
3. Regulate the driving pressure to the intensifier to achieve the required high pressure output.
4. Keep all piping lengths to a minimum by having the tanks, intensifier and pressure vessel as close together as possible.
5. A single pressure intensifier usually provides faster cylinder action because it does not need to change from low to high pressure but instead immediately supplies the high pressure.
6. Intensifiers are generally used in circuits where limited quantities of high pressure fluid is required.

C

(Series PS and PD) Cylinder to Ram Intensifiers

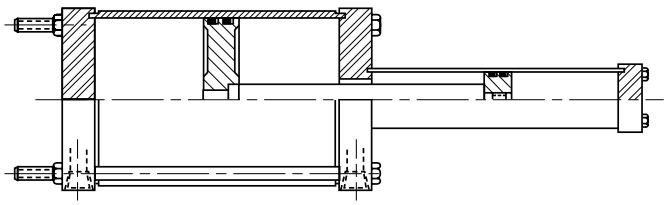
Driving Cylinder		Hydraulic Ram		Intensifier	Theoretical Intensified Hydraulic Pressure (psi) Using An Input Pressure Of					
Bore	Area	Dia.	Area of Volume Displ Per in Stroke	Ratio	50	80	100	200	500	1000
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
3 1/4	8.296	5/8	.307	27.02	1351	2161	2702			
		1	.785	10.57	529	846	1057	2114		
		1 3/8	1.485	5.59	280	447	559	1118	2795	
		1 3/4	2.405	3.45	173	276	345	690	1725	3450
		2	3.142	2.64	132	211	264	528	1320	2640
4	12.566	5/8	.307	40.93	2046	3274	4093			
		1	.785	16.00	800	1280	1600	3200		
		1 3/8	1.485	8.46	423	677	846	1692	4230	
		1 3/4	2.405	5.23	262	418	523	1046	2615	
		2	3.142	4.00	200	320	400	800	2000	4000
		2 1/2	4.909	2.56	128	205	256	512	1280	2560
5	19.635	5/8	.307	63.95	3197	5116				
		1	.785	25.01	1250	2000	2501	5002		
		1 3/8	1.485	13.22	661	1058	1322	2644		
		1 3/4	2.405	8.16	408	653	816	1632	4080	
		2	3.142	6.25	313	500	625	1250	3125	
		2 1/2	4.909	4.00	200	320	400	800	2000	4000
		3	7.069	2.78	139	222	278	556	1390	2780
		3 1/2	9.621	2.04	102	163	204	408	1020	2040
6	28.274	1	.785	36.01	1800	2880	3601			
		1 3/8	1.485	19.05	953	1524	1905	3810		
		1 3/4	2.405	11.76	588	941	1176	2352		
		2	3.142	9.00	450	720	900	1800	4500	
		2 1/2	4.909	5.76	288	461	576	1152	2880	
		3	7.069	4.00	200	320	400	800	2000	4000
		3 1/2	9.621	2.94	147	235	294	588	1470	2940
8	50.265	1	.785	64.03	3201	5122				
		1 3/8	1.485	33.85	1693	2708	3385			
		1 3/4	2.405	20.90	1045	1672	2090	4180		
		2	3.142	16.00	800	1280	1600	3200		
		2 1/2	4.909	10.24	512	819	1024	1048		
		3	7.069	7.11	356	569	711	1422	3555	
		3 1/2	9.621	5.23	262	418	523	1046	1615	
10	78.540	1 3/8	1.485	52.89	2644	4231				
		1 3/4	2.405	32.66	1633	2613	3266			
		2	3.142	25.00	1250	2000	2500	5000		
		2 1/2	4.909	16.00	800	1280	1600	3200		
		3	7.069	11.11	556	889	1111	2222		
		3 1/2	9.621	8.16	408	653	816	1632	4080	
12	113.10	1 3/8	1.485	76.16	3808					
		1 3/4	2.405	47.02	2351	3761	4702			
		2	3.142	36.00	1800	2880	3600			
		2 1/2	4.909	23.04	1152	1843	2304	4608		
		3	7.069	16.00	800	1280	1600	3200		
		3 1/2	9.621	11.75	588	940	1175	2350		
14	153.94	1 3/4	2.405	64.00	3200	5120				
		2	3.142	48.99	2449	3919	4899			
		2 1/2	4.909	31.36	1568	2509	3136			
		3	7.069	21.78	1089	1742	2178	4356		
		3 1/2	9.621	16.00	800	1280	1600	3200		

(Series PC) Cylinder to Cylinder Intensifiers

Driving Cylinder		Driving Cylinder		Intensifier	Theoretical Intensified Hydraulic Pressure (psi) Using An Input Pressure Of					
Bore	Area	Bore	Area	Ratio	50	80	100	200	500	1000
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
3 1/4	8.296	1 1/2	1.767	4.69	235	375	469	938	2345	
		2	3.142	2.64	132	211	264	528	1320	2640*
4	12.566	1 1/2	1.767	7.11	356	569	711	1422	3555*	
		2	3.142	4.00	200	320	400	800	2000	4000*
		2 1/2	4.909	2.56	128	205	256	512	1280	2560*
5	19.635	1 1/2	1.767	11.11	556	889	1111	2222		
		2	3.142	6.25	313	500	625	1250	3125*	
		2 1/2	4.909	4.00	200	320	400	800	2000*	4000*
		3 1/4	8.296	2.37	119	190	237	474	1185	2370*
6	28.274	2	3.142	9.00	450	720	900	1800	4500*	
		2 1/2	4.909	5.76	288	461	576	1152	2880*	
		3 1/4	8.296	3.41	171	273	341	682	1705	3410*
		4	12.566	2.25	113	180	225	450	1125	2250*
		5	19.635	1.44	72	115	144	188	720	1440
8	50.265	2	3.142	16.00	800	1280	1600	3200*		
		2 1/2	4.909	10.24	512	819	1024	2048		
		3 1/4	8.296	6.06	303	485	606	1212	3030*	
		4	12.566	4.00	200	320	400	800	2000*	4000*
		5	19.635	2.56	128	205	256	512	1280	2560*
		6	28.274	1.78	89	143	178	356	890	1780*
10	78.540	2 1/2	4.909	16.00	800	1280	1600	3200*		
		3 1/4	8.296	9.47	474	758	947	1894	4735*	
		4	12.566	6.25	313	500	625	1250	3125*	
		5	19.635	4.00	200	320	400	800	2000*	4000*
		6	28.274	2.78	139	223	278	556	1390*	2780*
12	113.10	3 1/4	8.296	13.64	682	1091	1364	2728*		
		4	12.566	9.00	450	720	900	1800*	4500*	
		5	19.635	5.76	288	460	576	1152	2880*	
		6	28.274	4.00	200	320	400	800	2000*	4000*
		7	38.485	2.94	147*	235*	294*	588*	1470*	2940*
		8	50.265	2.25	113	180	225	450	1125*	2250*
14	153.94	4	12.566	12.25	613	980	1225	2450*		
		5	19.635	7.84	392	227	784	1568*	3920*	
		6	28.274	5.45	273	436	545	1090	1725*	
		7	38.485	4.00	200*	320*	400*	800*	2000*	4000*
		8	50.265	3.06	153	245	306	612	1530*	3060*

*Not recommended for PL-2 Series driven cylinder, use PH-2 Series.

Cylinder to Cylinder Intensifier – Series PC

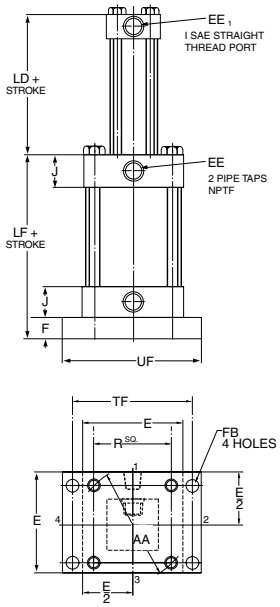


Schrader Bellows Cylinder to Cylinder Intensifiers (Series PC)

Series PC Intensifiers consist of two cylinders joined into an integral unit with one piston driving a second piston of smaller diameter. These intensifiers are not self-bleeding or self-filling, therefore, for the most effective operation, it is recommended that these tasks be done manually.

Special Note: It is recommended that Series PC cylinder-to-cylinder intensifiers be mounted vertically with the smaller cylinder up.

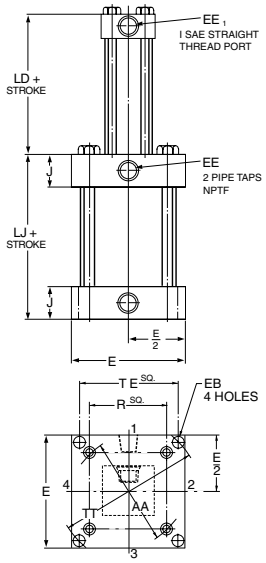
Bore	1 1/2	2	2 1/2	3 1/4	4	5	6	8	10	12	14
	PA-2 & PL-2 Series								PA-2 Series Only		
E	2	2 1/2	3	3 3/4	4 1/2	5 1/2	6 1/2	8 1/2	10 5/8	12 3/4	14 3/4
F	3/8	3/8	3/8	5/8	5/8	5/8	3/4	–	–	–	–
J	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2 1/4
K	7/32	17/64	17/64	21/64	21/64	7/16	7/16	35/64	41/64	41/64	3/4
R	1.43	1.84	2.19	2.76	3.32	4.10	4.88	6.44	7.92	9.40	10.90
AA	2.02	2.6	3.1	3.9	4.7	5.8	6.9	9.1	11.2	13.3	15.4
BB	1	1 1/8	1 1/8	1 3/8	1 3/8	1 13/16	1 13/16	2 5/16	2 11/16	2 11/16	3 3/16
DD	1/4-28	5/16-24	5/16-24	3/8-24	3/8-24	1/2-20	1/2-20	5/8-18	3/4-16	3/4-16	7/8-14
EE	3/8	3/8	3/8	1/2	1/2	1/2	3/4	3/4	1	1	1 1/4
EE_1	#6	#6	#6	#10	#10	#10	#12	#12	–	–	–
EB	–	–	–	–	–	–	–	11/16	13/16	13/16	15/16
FB	5/16	3/8	3/8	7/16	7/16	9/16	9/16	–	–	–	–
LD	2 5/8	2 5/8	2 3/4	3	3	3 1/4	3 1/2	3 5/8	4 5/8	5 1/8	5 7/8
LF	3 1/2	3 1/2	3 5/8	4 3/8	4 3/8	4 5/8	5 1/4	–	–	–	–
LJ	3 1/8	3 1/8	3 1/4	3 3/4	3 3/4	4	4 1/2	4 5/8	6 1/8	6 5/8	7 5/8
TE	–	–	–	–	–	–	–	7.57	9.40	11.10	12.87
TF	2 3/4	3 3/8	3 7/8	4 11/16	5 7/16	6 5/8	7 5/8	–	–	–	–
TT	–	–	–	–	–	–	–	10.7	13.3	15.7	18.2
UF	3 3/8	4 1/8	4 5/8	5 1/2	6 1/4	7 5/8	8 5/8	–	–	–	–



Mounting Style H
Cap Rectangular Flange

This mounting available in driving cylinder bore sizes 3 1/4-inches through 6-inches.

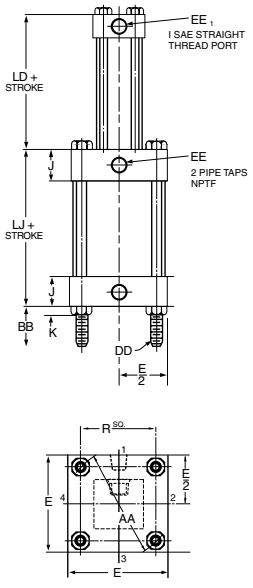
MTG Styles are:
HA – Air Input
HL – Hyd. Input



Mounting Style HB
Cap Square Flange

This mounting available in driving cylinder bore sizes 8-inches through 14-inches.

MTG Styles are:
HBA – Air Input
HBL – Hyd. Input



Bore	1 1/2	2	2 1/2	3 1/4	4	5	6	7	8
	PH-2 & PH-3 Series								
E	2 1/2	3	3 1/2	4 1/2	5	6 1/2	7 1/2	8 1/2	9 1/2
F	3/8	5/8	5/8	3/4	7/8	7/8	1	1	1
J	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	2	2 1/4	2 1/2
K	21/64	7/16	7/16	35/64	35/64	3/4	55/64	31/32	1 1/16
R	1.63	2.05	2.55	3.25	3.82	4.95	5.73	6.58	7.50
AA	2.3	2.9	3.6	4.6	5.4	7.0	8.1	9.3	10.6
BB	1 3/8	1 13/16	1 13/16	2 5/16	2 5/16	3 3/16	3 5/8	4 1/8	4 1/2
DD	3/8-24	1/2-20	1/2-20	5/8-18	5/8-18	7/8-14	1-14	1 1/8-12	1 1/4-12
EE	1/2	1/2	1/2	3/4	3/4	3/4	1	1 1/4	1 1/2
EE_1	#10	#10	#10	#16	#16	#16	#16	#20	#24
FB	7/16	9/16	9/16	11//16	11/16	15/16	1 1/16	1 3/16	1 5/16
LD	3 3/8	3 3/8	3 1/2	4	4 1/4	4 3/4	5 5/8	6 1/4	7
LF	4 3/4	5	5 1/8	6	6 3/8	6 7/8	8 1/8	9	10
LJ	4 3/8	4 3/8	4 1/2	5 1/4	5 1/2	6	7 1/8	8	9
TF	3 7/16	4 1/8	4 5/8	5 7/8	6 3/8	8 3/16	9 7/16	10 5/8	11 13/16
UF	4 1/8	5 1/8	5 5/8	7 1/8	7 5/8	9 3/4	11 1/4	12 5/8	14

Maximum non-shock pressure rating for PL-2 and PH-2 Series can be found on page 56.

Mounting Style TC
Cap Tie Rods Extended

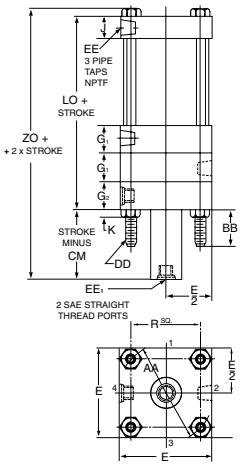
This mounting available in driving cylinder bore sizes 3 1/4-inches through 14-inches.

MTG Styles are:
TCA Cap End – Air Input
TCL Cap End Hyd. Input

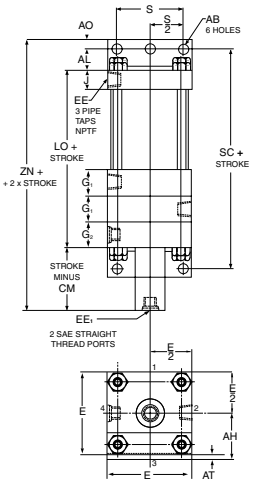
C

Schrader Bellows Cylinder to Ram Dual Pressure Intensifiers (Series PD)

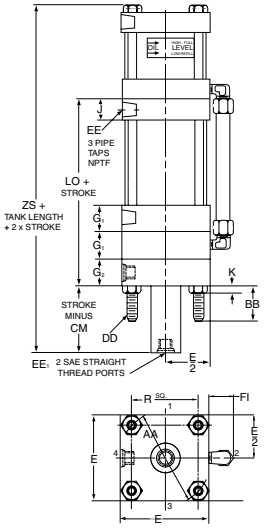
Series PD Intensifiers are similar to the Series PS units except a center head has been added to retain another gland and a third ram seal. When the ram is fully retracted, it withdraws from this third seal, allowing the low pressure hydraulic fluid to flow through the port in the center head. The fluid then goes past the ram and out the pressure chamber port to prefill and advance the work cylinder. Actually, this third seal and the ram act as a check valve. As the circuit sequences, the ram advances into the seal to close this "valve" and build up high pressure. With this arrangement and the proper mounting, Series PD intensifiers are self-bleeding and self-filling. And these intensifiers may be used in either single or dual pressure circuits.



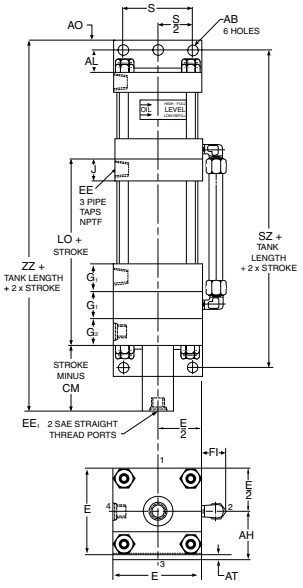
Mounting Style TB – Head Tie Rods Extended
(Styles TC – Cap Tie Rods Extended and TD – Both Ends Tie Rods Extended are also available. Dimensions "BB" remains the same in all cases.)



Mounting Style CB – End Angles



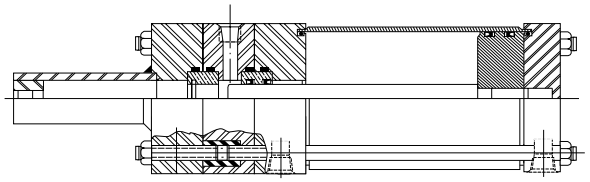
Mounting Style TB – Head Tie Rods Extended with Integral Air-Oil Tank



Mounting Style CB – End Angles with Integral Air-Oil Tanks

Special Notes:

1. **When equipped with integral air-oil tanks, Series PD intensifiers have a maximum input pressure of 150 psi.**
2. **It is recommended that Series PD dual pressure intensifiers be mounted vertically with the pressure chamber down.**



Dimensions Independent of Ram Size

Bore	3 1/4	4	5	6	8	10	12	14
	PA-2 & PL-2 Series					PA-2 Series		
E	3 3/4	4 1/2	5 1/2	6 1/2	8 1/2	10 5/8	12 3/4	14 3/4
G_1	1 3/4	1 3/4	1 3/4	2	2	2 1/4	2 1/4	2 3/4
J	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2 1/4
K	3/8	3/8	7/16	7/16	9/16	11/16	11/16	3/4
R	2.76	3.32	4.10	4.88	6.44	7.92	9.40	10.90
S	2 3/4	3 1/2	4 1/4	5 1/4	7 1/8	8 7/8	11	12 5/8
AA	3.9	4.7	5.8	6.9	9.1	11.2	13.3	15.4
AB	9/16	9/16	11/16	13/16	13/16	1 1/16	1 1/16	1 5/16
AH	1 15/16	2 1/4	2 3/4	3 1/4	4 1/4	5 5/16	6 3/8	7 3/8
AL	1 1/4	1 1/4	1 3/8	1 3/8	1 13/16	2 1/8	2 1/8	2 7/16
AO	1/2	1/2	5/8	5/8	11/16	7/8	7/8	1 1/16
AT	1/8	1/8	3/16	3/16	1/4	1/4	3/8	3/8
BB	1 3/8	1 3/8	1 13/16	1 13/16	2 5/16	2 11/16	2 11/16	3 3/16
DD	3/8-24	3/8-24	1/2-20	1/2-20	5/8-18	3/4-16	3/4-16	7/8-14
EE	1/2	1/2	1/2	3/4	3/4	1	1	1 1/4
EE_1	#8	#8	#8	#8	#8	#12	#12	#16
FI	1 3/8	1 3/8	1 3/8	1 21/32	1 21/32	1 15/16	1 15/16	2 13/32
ST	5	5	5 1/4	5 3/4	6 5/8	8 1/4	8 1/4	9 3/8
ZI	413/64	413/64	4 3/4	5 1/4	5 55/64	7 21/64	7 21/64	8 7/16
ZK	6	6	6 1/2	7	8	10	10	11 1/2
ZN	8 3/8	8 3/8	8 7/8	9 1/2	10 1/8	12	12 1/2	14 1/2
ZO	6 61/64	6 61/64	7 5 /16	7 15/16	8 11/64	9 41/64	10 9/64	11 3/4
ZS	9 29/64	9 29/64	10 5/16	10 15/16	11 11/64	13 41/64	14 9/64	16 1/4
ZZ	10 1/8	10 7/8	11 7/8	12 1/2	13 1/8	16	16 1/2	19

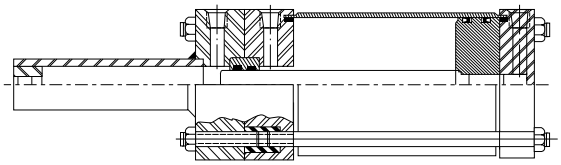
Dimensions Dependent on Ram Size

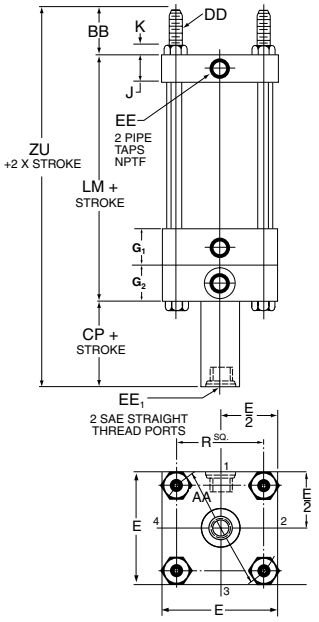
Bore	3 1/4	4	5	6	8	10	12	14
	PA-2 & PL-2 Series					PA-2 Series		
						Ram Sizes		
					1 3/8		2, 2 1/2	2 1/2, 3
					1 3/4, 2	1 3/4, 2	3, 3 1/2, 4	3 1/2, 4
G_2	–	–	–	–	2	2	2 1/4	2 1/4
CM	–	–	–	–	1 1/2	1 5/8	1 7/8	2 1/8
LO	–	–	–	–	9 1/8	10 5/8	11 3/8	13 1/8
SC	–	–	–	–	10 3/4	12 7/8	13 3/8	15 3/4
SZ					13 3/4	16 7/8	17 3/8	20 1/4
						Ram Sizes		
					3 1/2, 5 5 1/2	3 1/2		
G_2	1 3/4	1 3/4	1 3/4	2	2	2 1/4	2 1/4	2 3/4
CM	1 1/8	1 1/8	1 1/8	1 1/2	1 1/2	1 7/8	1 7/8	2 5/8
LO	7 3/4	7 3/4	8	9	9 1/8	10 7/8	11 3/8	13 5/8
SC	10 1/4	10 1/4	10 3/4	11 3/4	12 3/4	15 1/8	15 5/8	18 1/2
SZ	12 3/4	12 3/4	13 3/4	14 3/4	15 3/4	19 1/8	19 5/8	23

Schrader Bellows Cylinder to Ram Single Pressure Intensifiers (Series PS)

Series PS Intensifier delivers a single pressure through a double acting piston driving a ram. One seal on the ram gland works on the driving piston side; the other on the pressure chamber side. Since this intensifier is neither self-bleeding nor self-filling, for best performance it is recommended that these tasks be performed manually.

Special Note: It is recommended that Series PS single pressure intensifiers be mounted vertically with the pressure chamber up.





Dimensions Independent of Ram Size

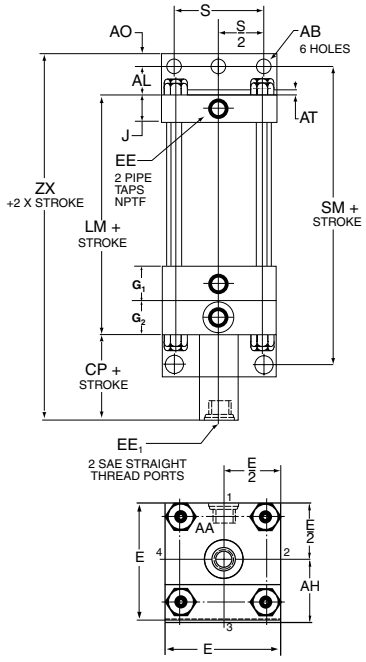
Bore	3 1/4	4	5	6	8	10	12	14
	PA-2 & PL-2 Series					PA-2 Series		
E	3 3/4	4 1/2	5 1/2	6 1/2	8 1/2	10 5/8	12 3/4	14 3/4
G_1	1 3/4	1 3/4	1 3/4	2	2	2 1/4	2 1/4	2 3/4
J	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2 1/4
K	3/8	3/8	7/16	7/16	9/16	11/16	11/16	3/4
R	2.76	3.32	4.10	4.88	6.44	7.92	9.40	10.90
S	2 3/4	3 1/2	4 1/4	5 1/4	7 1/8	8 7/8	11	12 5/8
AA	3.9	4.7	5.8	6.9	9.1	11.2	13.3	15.4
AB	9/16	9/16	11/16	13/16	13/16	1 1/16	1 1/16	1 5/16
AH	1 15/16	2 1/4	2 3/4	3 1/4	4 1/4	5 5/16	6 3/8	7 3/8
AL	1 1/4	1 1/4	1 3/8	1 3/8	1 13/16	2 1/8	2 1/8	2 7/16
AO	1/2	1/2	5/8	5/8	11/16	7/8	7/8	1 1/16
AT	1/8	1/8	3/16	3/16	1/4	1/4	3/8	3/8
BB	1 3/8	1 3/8	1 13/16	1 13/16	2 5/16	2 11/16	2 11/16	3 3/16
DD	3/8-24	3/8-24	1/2-20	1/2-20	5/8-18	3/4-16	3/4-16	7/8-14
EE	1/2	1/2	1/2	3/4	3/4	1	1	1 1/4
EE_1	#8	#8	#8	#8	#8	#12	#12	#16
ZU	8 3/8	8 3/8	9 1/6	9 9/16	10 3/16	11 13/16	12 5/16	14 1/16
ZX	8 3/4	8 3/4	9 1/4	9 3/4	10 3/8	12 1/8	12 5/8	14 3/8

Dimensions Dependent on Ram Size

Bore	3 1/4	4	5	6	8	10	12	14
	PA-2 & PL-2 Series					PA-2 Series Only		
					Ram Sizes			
					1 3/8 1 3/4, 2	1 3/4, 2	2, 2 1/2 3, 3 1/2, 4	2 1/2, 3 3 1/2, 4
G_2	–	–	–	–	2	2	2 1/4	2 1/4
CP	–	–	–	–	3/4	3/4	1/2	1/2
LM	–	–	–	–	7 1/8	8 3/8	9 1/8	10 3/8
SM	–	–	–	–	8 3/4	10 5/8	11 1/8	13
					Ram Sizes			
					2 1/2, 3 3 1/2, 5 5 1/2	2 1/2, 3 3 1/2,		
G_2	1 3/4	1 3/4	1 3/4	2	2	2 1/4	2 1/4	2 3/4
CP	1	1	1	3/4	3/4	1/2	1/2	0
LM	6	6	6 1/4	7	7 1/8	8 5/8	9 1/8	10 7/8
SM	8 1/2	8 1/2	9	9 3/4	10 3/4	12 7/8	13 3/8	15 3/4

Mounting Style TC –
Cap Tie Rods Extended

(Style TB – Head Rods Extended, and TD – Both Ends Tie Rods Extended, are also available. Dimension "BB" remains the same in all cases.)



Mounting Style CB – End Angles

C

How to Order Schrader Bellows Intensifiers

How To Order

When ordering Schrader Bellows Intensifiers, please specify:

a. Quantity

b. Driving Cylinder bore size

c. Mounting style – specify by using style letters given beneath dimension drawings.

d. Driving cylinder operating fluid medium

e. Intensifier series (PS, PD or PC)

f. Intensifier ram diameter (for cylinder-to-ram intensifiers) or Output cylinder bore (for cylinder-to-cylinder units)

g. Driving cylinder stroke

h. Input pressure, output pressure and volume

Note: Standard intensifiers are designed for use with petroleum base hydraulic oil. If other fluids will be used, please consult the factory.

Model Numbers

Each Schrader Bellows Intensifier has a model number. This, along with the driving cylinder bore size and stroke, is an accurate and coded description of the unit. The chart here shows the elements of these model numbers. It is provided so that you can check our order acknowledgement against your order.

When Ordering Intensifiers By Model Number

Driving Cylinder Bore	Driving Cylinder Mounting Style	Driving Cylinder Operating Fluid		Intensifier Series	Driven Cylinder Series PC Only	Special Features	Intensifier Ram (or Driven Cylinder) Diameter		Driving Cylinder Stroke
3 1/4, 4, 5, 6, 8, 10, 12 or 14	CB, TB, TC, TD, H or HB	PA-2 (Air) or PL-2* (HYD.) Specify One Series Only	–	PD, PS, PC	PH-2 / PH-3 (3000 psi Maximum) or PL-2 (900 to 2500 psi Maximum Depending on Bore Size	S Use Only if Intensifier Varies From Catalog	Specify From Dimension Tables	X	Specify For PD Style See Note Below

NOTE: PD style intensifiers require 2" additional stroke to seal the high pressure end. See page 19.
*PL-2 supplied with cast iron piston rings unless otherwise specified.

Specifications

Maximum Input Pressures:
Air – 250 psi (17 BAR); Oil – 1000 psi (69 BAR).

Maximum Output Pressures:
5/8" to 3" RAM – 5000 psi (345 BAR);
3 1/2" to 5 1/2" RAM – 3000 psi (206 BAR).

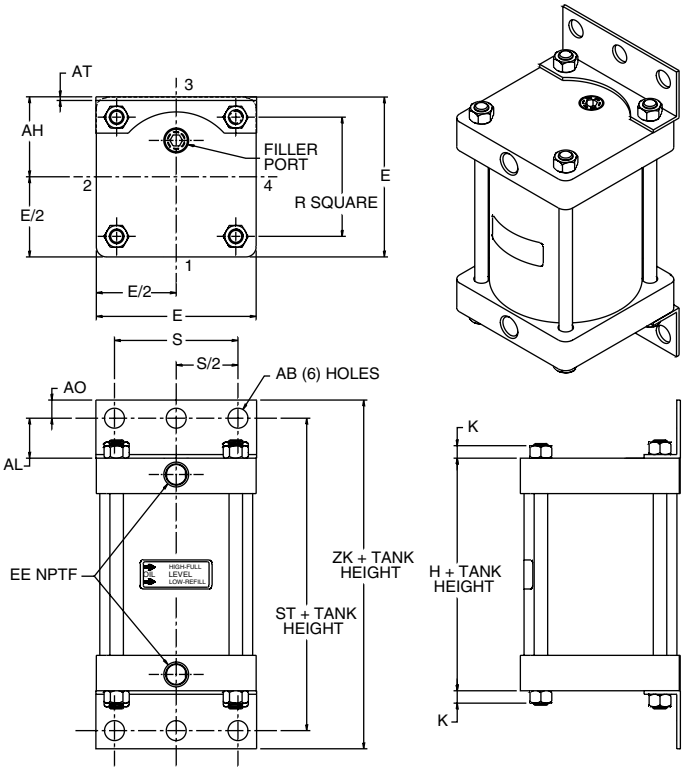
Maximum Operating Temperatures:
-10°F to +165°F (-23°C) to (+74°C).

Schrader Bellows®

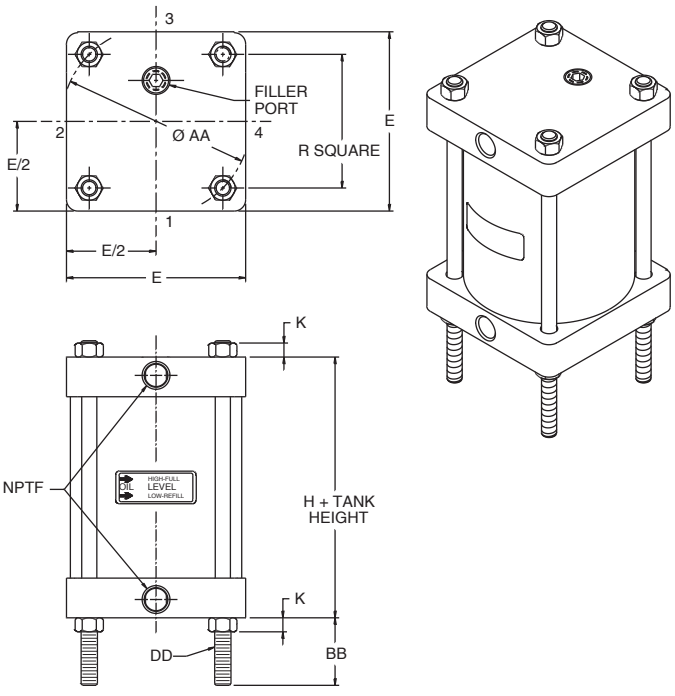
Air-Oil Tanks
F02 Series

C

- 6 Standard Bore Sizes 2½" - 8" Bores
- Operating Pressure: Up to 250 psi
- Operating Temperature: 165°F Max.
- Lightweight Aluminum/Fiberglass Design
- Premium Quality and Economy
- Larger Bore Sizes Available



Mounting Style 01
Side end angles



Mounting Style 57
Tie rods extended – oil end
Mounting Style 61
Tie rods extended – air end

Air-Oil Tanks Dimensions

Bore Size	E	H	K	R	S	AB	AH	AL	AO	AT	BB	DD	EE	ST	ZK
2 1/2	3	2	5/32	2.19	2 1/4	7/16	1 5/8	1	3/8	1/8	1 1/8	5/16-24	3/8	4	4 3/4
3 1/4	3 3/4	2 1/2	3/16	2.76	2 3/4	9/16	1 15/16	1 1/4	1/2	1/8	1 3/8	3/8-24	1/2	5	6
4	4 1/2	2 1/2	3/16	3.32	3 1/2	9/16	2 1/4	1 1/4	1/2	1/8	1 3/8	3/8-24	1/2	5	6
5	5 1/2	3	7/16	4.10	4 1/4	11/16	2 3/4	1 3/8	5/8	3/16	1 13/16	1/2-20	1/2	5 3/4	7
6	6 1/2	3	7/16	4.88	5 1/4	13/16	3 1/4	1 3/8	5/8	3/16	1 13/16	1/2-20	3/4	5 3/4	7
8	8 1/2	3	9/16	6.44	7 1/8	13/16	4 1/4	1 13/16	11/16	1/4	2 5/16	5/8-18	3/4	6 5/8	8

In a basic air-oil circuit the advance tank is connected to the cap end port of a hydraulic cylinder and the return tank to the head end port. Shop air is applied alternately to the two tanks through a 4-way air control valve. The oil in the advance tank is forced into the cap end of the cylinder to cause the piston rod to extend. At the same time, oil from the head end port is forced into the return tank, the air side of which is open to exhaust. To return cylinder to retract position, air pressure is applied to the oil in return tank.

To limit the fluid velocity, speed controls should be applied to the air side of the tank to restrict the exhaust.

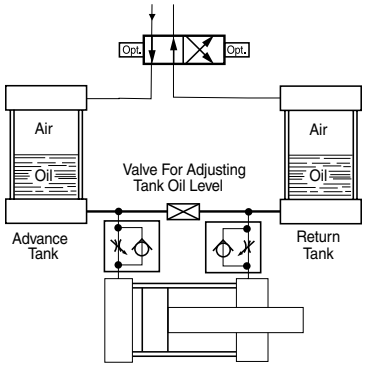


Table A Rated Capacities – Cubic Inches

USABLE TANK VOLUME (CUBIC INCHES)												
INTERNAL LENGTH OF TANK												
BORE	**BORE CODE**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**14**	**16**	**18**	**20**
2 1/2	C	12	16.6	21.6	25.5	30	34	43	52	61	70	78
3 1/4	D	19	26	34	41	49	56	74	86	101	116	131
4	E	28	40	51	62	74	85	107	129	153	175	195
5	F	39	57	75	92	110	128	163	199	234	269	305
6	G	62	86	111	137	161	186	232	284	333	386	432
8	J	109	146	195	239	280	324	414	504	592	684	774

How to Select

Step 1: Determine the volume (cu. in.) of fluid required to fill the work cylinder at full stroke by taking the bore area times the stroke length.

Step 2: Select the proper tank bore height from the chart. Since there are usually several combinations with similar capacities, select the one having a rated capacity closest to but slightly greater than your volume requirements. Generally, the most economical choice is a higher tank with a smaller bore.

Air-Oil Tanks – For Smoother Hydraulic Flow

Schrader Bellows Air-Oil tanks provide a means to convert shop air pressure into hydraulic pressure. Compressed air is applied directly to the oil in the air-oil tank to convert it into hydraulic pressure. The hydraulic pressure is at a 1-to-1 ratio, i.e. 80 psi air produces 80 psi hydraulic pressure.

All Schrader Bellows Air-Oil tanks have a fiberglass tube which shows the proper oil level. They also contain two fluid flow baffles. The top baffle disperses the incoming air over the surface of the oil in such a way to avoid agitation and aeration. The bottom baffle insures a smooth flow pattern that minimizes oil turbulence and eliminates swirling, funneling or splashing which in turn could cause oil aeration or the oil to be blown from the tank into the exhaust air.

Air-Oil tanks are used to smooth out the cylinder piston rod travel and to prevent chatter. They are mainly used in slow speed circuits. Fluid velocity in or out of the tank through standard ports should be less than 6 feet per second to prevent aeration of the oil. Since each tank is designed for a specific port size, increasing the port size in a tank to lower the fluid velocity is not recommended. A tank with a larger port size should be selected.

C

How To Order

When ordering Schrader Bellows Air-Oil Tanks, please specify:

a. Type **F02**
b. Bore Code (see above)
c. Rod Code **NN** (none)
d. Mount **01** (side end angles), **57** (tie rod extended - oil end), **61** (tie rods extended - air end)
e. Rod Style **N** (none)
f. Seals **1** (Buna N)
g. Tank Length

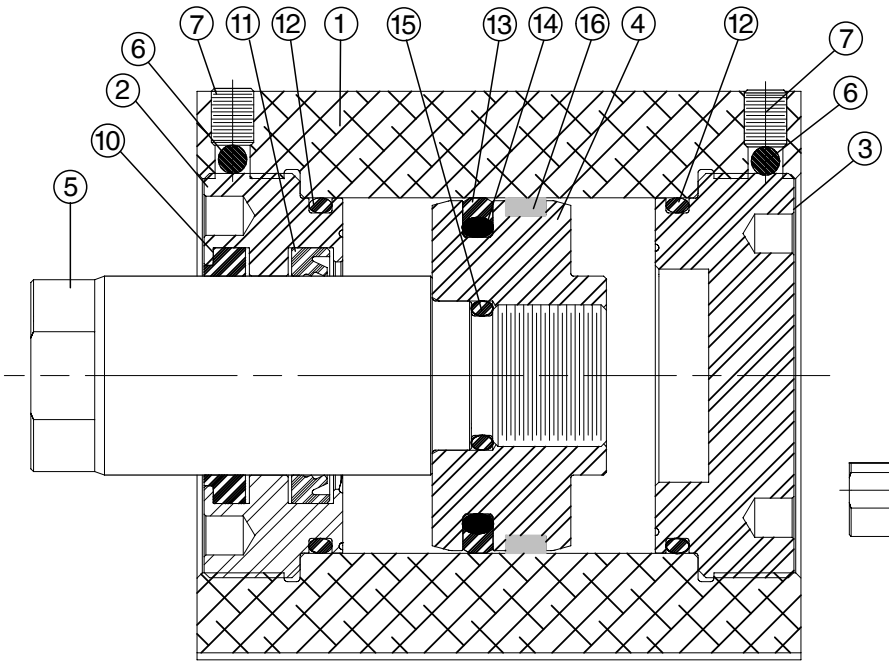
Example: F02 E NN 01 N 1 x 6.00

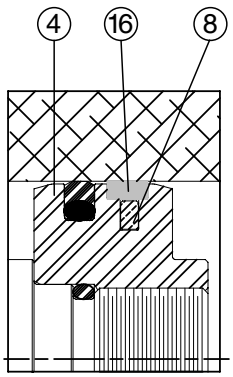
Notes: Standard air-oil tanks are designed for use with petroleum base hydraulic oil. If other fluids will be used, please consult the factory. For larger than 8" Bore Sizes consult factory.

NOTES

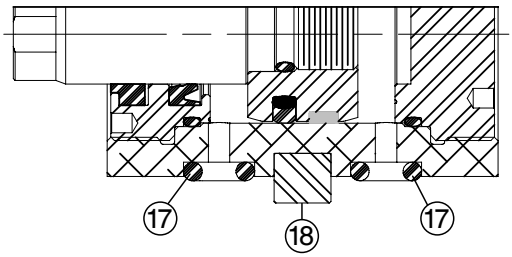
Cylinder Parts Identification and Seal Kit Data

Parts Identification Drawing – Standard Piston





Series CHE
Magnetic Piston Option



Series CHD - C & CN Mount
Manifold Port Option

Item No.	Description	Material
1	Cylinder Body - CHE	Aluminum Alloy (Hard Anodized)
	Cylinder Body - CHD	Steel
2	Gland	Nodular Iron or Bronze
3	Cap	Nodular Iron or Bronze
4	Piston – Standard	Nodular Iron
	Piston – with Magnet	Aluminum Alloy
5	Piston Rod	Carbon Steel (Hard Chrome Plated)
6	Ball	Nylon
7	Set Screw	Alloy Steel
8	Magnet	Sintered NdFeB[1]

[1] Neodymium Iron Boron

Item No.	Description	Material	
		Standard	Fluorocarbon
10	Rod Wiper	PUR	Fluorocarbon
11	Rod Seal	PUR	Fluorocarbon
Not Shown	Rod Seal Back-up Washer	Not Required	Virgin PTFE
12	End Seal	PUR	Fluorocarbon
13	Piston Seal	PUR	Filled PTFE
14	PS Energizer	NBR	Fluorocarbon
15	Piston-to-Rod o-ring	PUR	Fluorocarbon
16	Piston Wear Band	Glass-reinforced nylon	Glass-reinforced nylon
17	Manifold Port Seal	PUR	Fluorocarbon
18	C & CN Mount Key	Steel	

Seal Kits

See Standard Specifications Page for fluid and temperature compatibility. Cylinder gland and cap are threaded into the cylinder body. To service rod seal, rod wiper, piston seal, or end seals the gland or cap must be removed. Spanner holes in the gland and cap are available for the purpose of removing and installing these components. Be sure to torque the gland or cap to the specifications below and replace the nylon ball and set screw to further lock them in place.

Rod Gland and Rod Seal Kits

Rod Ø	Rod Gland (w/o pilot[1]) Kits		Rod Seal Kits	
	Class 1	Class 5[2]	Class 1	Class 5[2]
	Consists of 1 ea. of items #2, 6, 10, 11, & 12		Consists of 1 ea. of items #6, 10, 11, & 12	
12	A63430A12	A63430B12	A63430C12	A63430D12
14	A63430A14	A63430B14	A63430C14	A63430D14
18	A63430A18	A63430B18	A63430C18	A63430D18
22	A63430A22	A63430B22	A63430C22	A63430D22
28	A63430A28	A63430B28	A63430C28	A63430D28
36	A63430A36	A63430B36	A63430C36	A63430D36
45	A63430A45	A63430B45	A63430C45	A63430D45
56	A63430A56	A63430B56	A63430C56	A63430D56

Complete Seal Kits

Bore Ø	Class 1	Class 5[2]	Gland & Cap Torque Specifications			
	Consists of 1 ea. of items #10, 11, 13, 14, 16 & 2 ea. of items #6 & 12		Series CHE		Series CHD	
20	A63440A20	A63440B20	17 - 18 N-m	155 - 162 lb-in	27 - 28 N-m	20 - 21 lb-ft
25	A63440A25	A63440B25	31 - 32 N-m	23 - 24 lb-ft	47 - 49 N-m	35 - 36 lb-ft
32	A63440A32	A63440B32	68 - 71 N-m	50 - 52 lb-ft	98 - 102 N-m	72 - 75 lb-ft
40	A63440A40	A63440B40	129 - 135 N-m	95 - 99 lb-ft	169 - 177 N-m	125 - 131 lb-ft
50	A63440A50	A63440B50	203 - 213 N-m	150 - 157 lb-ft	285 - 299 N-m	210 - 220 lb-ft
63	A63440A63	A63440B63	305 - 320 N-m	225 - 236 lb-ft	488 - 512 N-m	360 - 378 lb-ft
80	A63440A80	A63440B80	576 - 604 N-m	425 - 446 lb-ft	881 - 925 N-m	650 - 682 lb-ft
100	A63440A00	A63440B00	881 - 925 N-m	650 - 682 lb-ft	–	–

[1] Pilot gland is required for AN, CA, CN, J, MN and TN mounting styles. For Gland Kit with pilot change the '0' to a 'P' before the 'A' or 'B'. For example:A6343PA12.

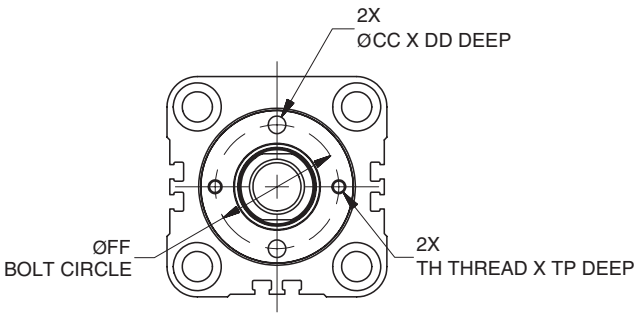
[2] Class 5 kits for 18-56mm rods in 32-100mm bores include a PTFE Back-up Washer for the Rod Seal.

C

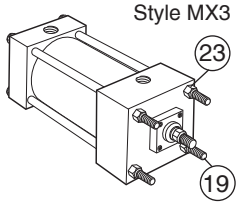
Spanner Hole Dimensions

Gland & Cap Spanners

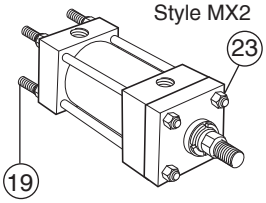
Bore Ø	CC	DD	FF Ø	TH	TP
20	2.75	2.75	22	–	–
25	3.25	3.25	25	–	–
32	4.25	4.25	30	M3x0.5 - 6H	6
40	5.25	5.25	35	M4x0.7 - 6H	7
50	6.38	6.25	45	M5x0.8 - 6H	7
63	8.38	8.25	55	M6x1 - 6H	8
80	10.50	10.50	70	M8x1.25 - 6H	9
100	10.50	10.50	85	M8x1.25 - 6H	9



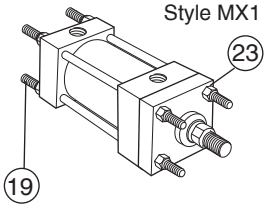
NFPA Style MX3



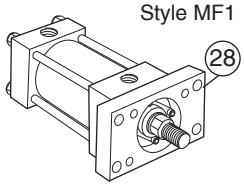
NFPA Style MX2



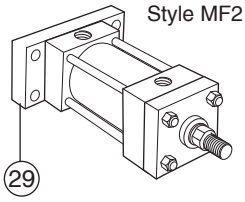
NFPA Style MX1



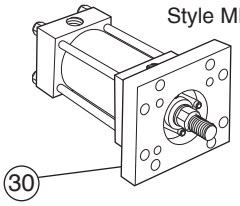
NFPA Style MF1



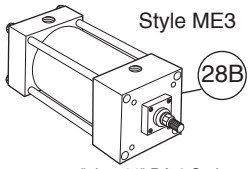
NFPA Style MF2



NFPA Style MF5

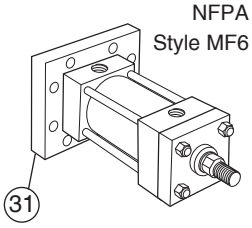


NFPA Style ME3

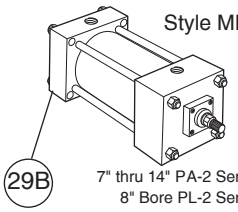


7" thru 14" PA-2 Series
8" Bore PL-2 Series

NFPA Style MF6

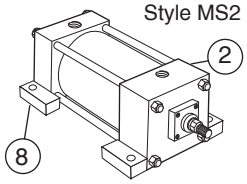


NFPA Style ME4



7" thru 14" PA-2 Series
8" Bore PL-2 Series

NFPA Style MS2



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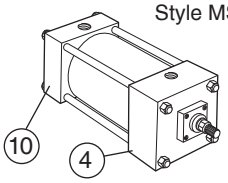
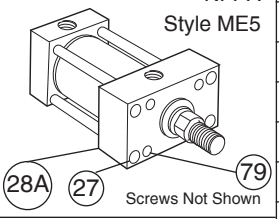
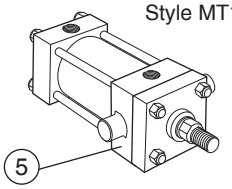


NFPA Style ME5

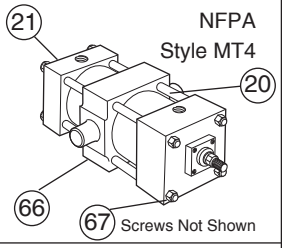


Screws Not Shown

NFPA Style MT1

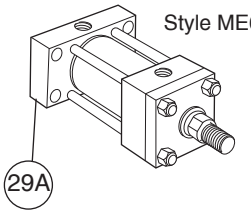


NFPA Style MT4

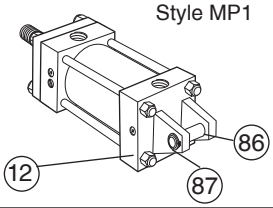


Screws Not Shown

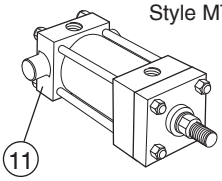
NFPA Style ME6



NFPA Style MP1



NFPA Style MT2



Replacement Mountings and Hardware

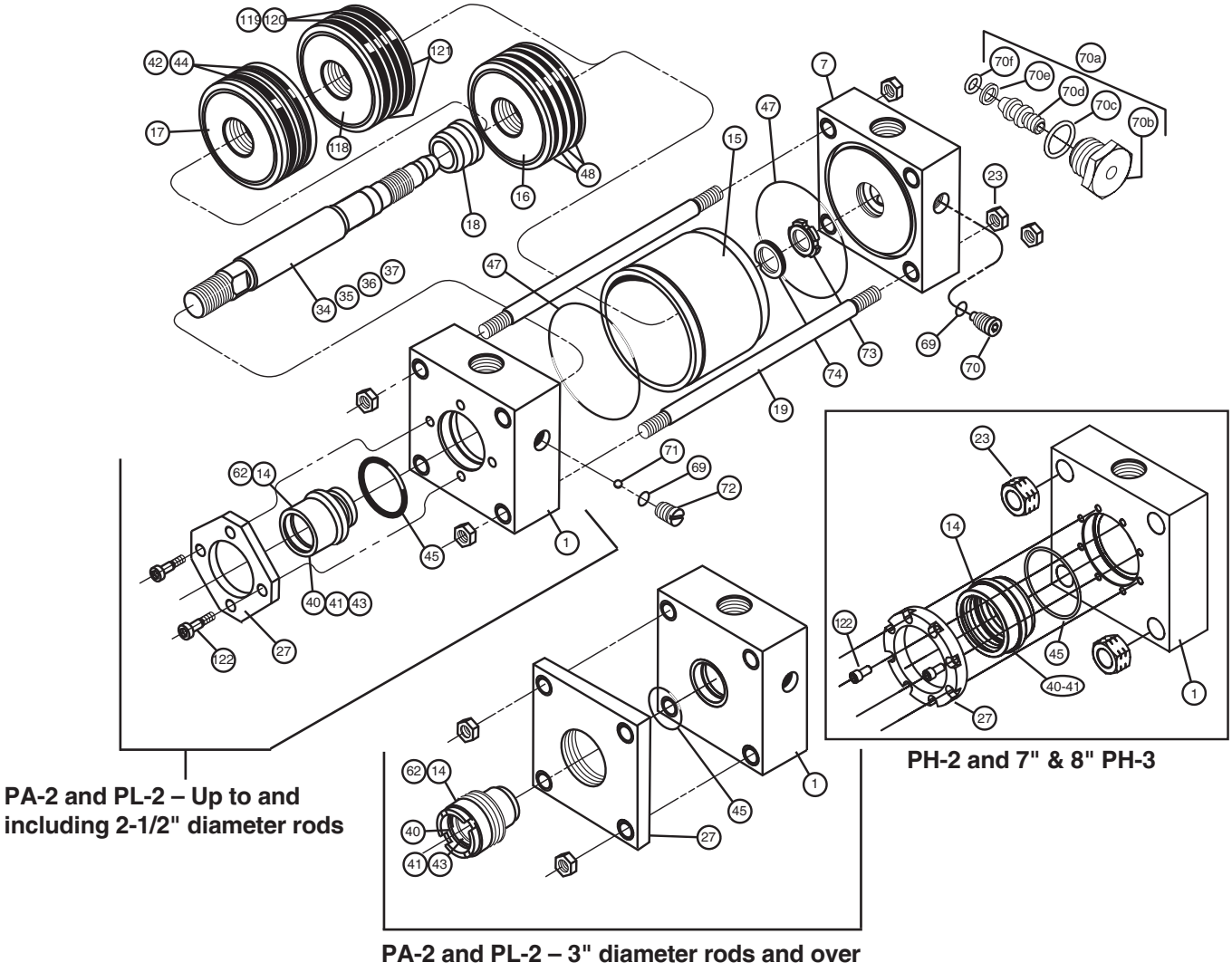
Note: For items not shown see pages 33 and 34.

Symbol	Description
2	Head, side lug mounting
4	Head, side tap mounting
5	Head, trunnion mounting
8	Cap, side lug mounting
10	Cap, side tap mounting
11	Cap, trunnion mounting
12	Cap, fixed clevis mounting
19	Tie rod
20	Tie rod, head end mounting
21	Tie rod, cap end mounting
23	Tie rod nut
27	Retainer
28	Flange, rectangular mounting
28A	Head, rectangular mounting
28B	Head, square mounting
29	Flange, rectangular mounting
29A	Cap, rectangular mounting
29B	Cap, square mounting
30	Flange, square mounting
31	Flange, square mounting
66	Intermediate trunnion
67	Screws, intermediate trunnion mtg.
79	Socket head cap screws
86	Clevis pin mounting
87	Retaining ring mounting

How to Order

Give cylinder model number, bore, stroke, serial number and symbol number shown above to insure proper replacement.

Note: All mounting styles may not be available.



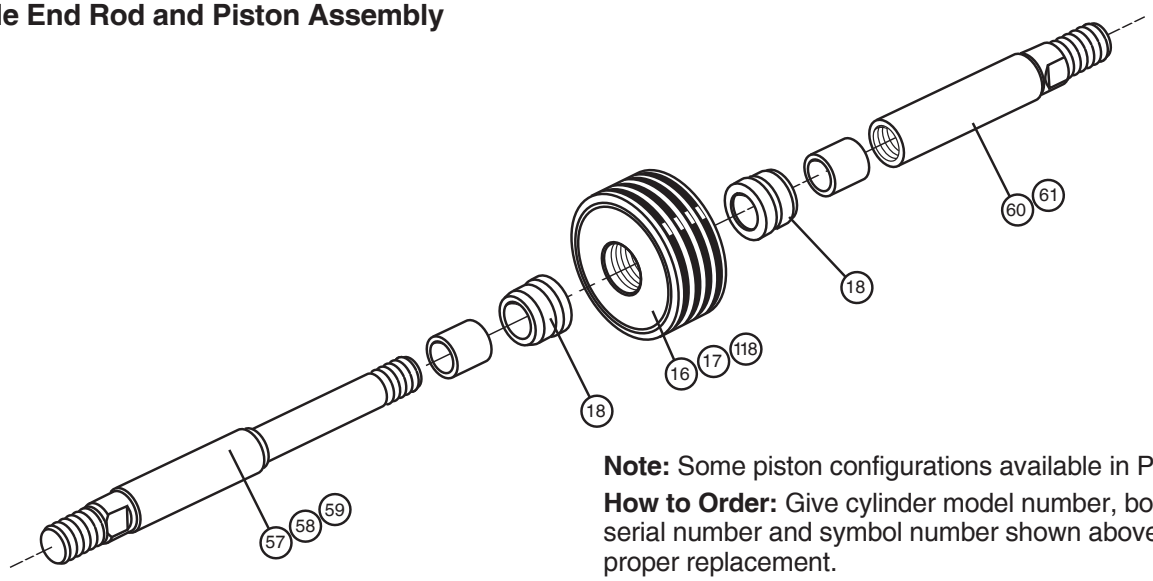
PA-2 and PL-2 – Up to and including 2-1/2" diameter rods

PH-2 and 7" & 8" PH-3

PA-2 and PL-2 – 3" diameter rods and over

C

Double End Rod and Piston Assembly



Note: Some piston configurations available in PH-2 only.

How to Order: Give cylinder model number, bore, stroke, serial number and symbol number shown above to insure proper replacement.

Note: For specific mounting styles see page 32.

Parts		Assemblies (Includes Symbol Numbers Shown)				
Symbol	**Description**	**Symbol**	**Description**	**Ring Type Piston**	**Lipseal Type Piston**	**Hi-Load Type Piston**
1	Head, ported, non-cushioned	C1SA	Head, ported, cushioned		1, 69, 70, 71 & 72	
7	Cap, ported, non-cushioned	C7SA	Cap, ported, cushioned		7, 69, 70, 73 & 74	
14	Gland	62	Gland cartridge kit		14, 40, 41, 43 & 45	
15	Cylinder body	—	—	—		
16	Piston body, ring type					
17	Piston body, lipseal type					
18	Cushion sleeve, cushioned cylinder only					
19	Tie rod					
23	Tie rod nut					
27	Retainer					
34	Piston rod, single rod type, non-cushioned	34SA	Piston & rod assembly, single rod type — non-cushioned	16, 34 & 48	17, 34, 42 & 44*	34, 118, 119, 120 & 121*
35	Piston rod, single rod type, cushioned head end	35SA	Piston & rod assembly, single rod type — cush. head end	16, 18, 35 & 48	17, 18, 35, 42 & 44*	35, 118, 119, 120 & 121
36	Piston rod, single rod type, cushioned cap end	36SA	Piston & rod assembly, single rod type — cush. cap end	16, 36 & 48	17, 36, 42 & 44*	37, 118, 119, 120 & 121
37	Piston rod, single rod type, cushioned both ends	37SA	Piston & rod assembly, single rod type — cush. both ends	16, 18, 37 & 48	17, 18, 37, 42 & 44	37, 118, 119, 120 & 121
40	Wiperseal, gland	—	Seal Kits	—		
41	Lipseal, gland					
42	Lipseal, piston					
43	Back-up washer, gland					
44	Back-up washer, piston					
45	O-ring, gland to head seal					
47	O-ring, cylinder body and seal					
48	Piston ring					
57	Piston rod, double rod type, non-cushioned	57SA	Piston & rod assembly, double rod type — non-cushioned	16, 48, 57 & 60	17, 42, 44*, 57 & 60	57, 60, 118, 119, 120 & 121
58	Piston rod, double rod type, cushioned one end	58SA	Piston & rod assembly, double rod type — cushioned one end	16, 18, 48, 58 & 60	17, 18, 42, 44*, 58 & 60	18, 58, 60, 118, 119, 120 & 121
59	Piston rod, double rod type, cushioned both ends	59SA	Piston & rod assembly, double rod type — cushioned both ends	16, 18, 48, 58 & 61	17, 18, 42, 44*, 58 & 61	18, 58, 61, 118, 119, 120 & 121
60	Piston rod extension, double rod type, non-cushioned	—	—	—		
61	Piston rod extension, double rod type, cushioned					
69	O-ring, cushion adjustment & check valve screw	—	Cushion Kits See table below.	—		
70	Needle valve, cushion adjustment					
70a**	Needle valve, cushion adjustment - cartridge type					
70b	Cartridge screw					
70c	O-ring, cartridge screw					
70d	Needle screw					
70e	Back-up washer - needle screw					
70f	O-ring - needle screw					
71	Ball, check valve					
72	Plug screw, check valve					
73	Cushion bushing, cap end floating check valve					
74	Retaining ring, floating cushion bushing					
75	Seal, cushion sleeve	—	—	—		
118	Piston, hi-load type					
119	Outer ring	—	Seal Kits	—		
120	Inner ring					
121	Wear ring					
122	Socket cap screws	—				

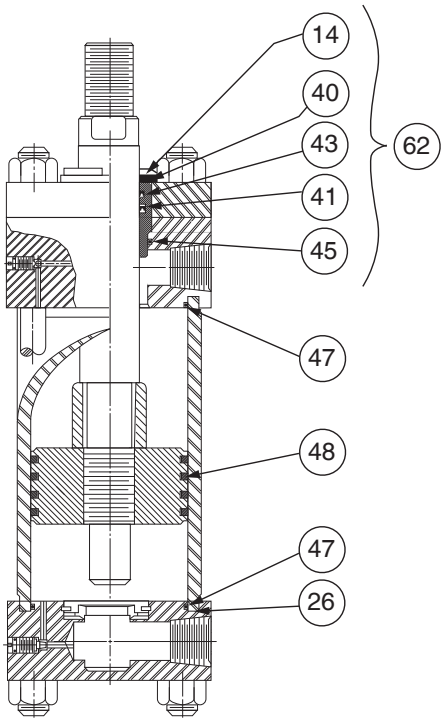
**In some cases the adjusting screw is installed in a cartridge. *Piston back-up washer (Symbol 44) not supplied on PA-2 Series air cylinders.

Cushion Hardware Kits

Bore Size	Rod Dia.	PA-2 Series				PL-2 Series			
		For Head Assemblies (Kits Include symbols 69, 70, 71, & 72)		For Cap Assemblies (Kits Include symbols 69, 70, 73, & 74)		For Head Assemblies (Kits Include symbols 69, 70, 71, & 72)		For Cap Assemblies (Kits Include symbols 69, 70, 73, & 74)	
		Standard	**Fluorocarbon**	**Standard**	**Fluorocarbon**	**Standard**	**Fluorocarbon**	**Standard**	**Fluorocarbon**
1	All	None	None	None	None	A63221102	A63211005	A63221102	A63211005
1 1/2	5/8	A63211503	A63211005	A63211504	A63221502	A63221503	A63221503	A6321504	A63221502
	1	A63211002	A63211005			A63211002	A63211005		
2	5/8, 1	A63211503	A63221503	A63211504	A63221502	A63221503	A63221503	A6321504	A63221502
	1 3/8	A63211002	A63211005			A63211002	A63221503		
2 1/2	5/8 - 1 3/8	A63211503	A63221503	A63211504	A63221502	A63221503	A63221503	A6321504	A63221502
	1 3/4	A63211002	A63211005			A63211002	A63211005		
3 1/4	All	A63213203	A63223203	A63213204	A63223202	A63213203	A63223203	A63213202	A63223202
4	All	A63213203	A63223203	A63213204	A63223202	A63213203	A63223203	A63213202	A63223202
5	All	A63213203	A63223203	A63213204	A63223202	A63213203	A63223203	A63213202	A63223202
6	All	A63216003	A63226003	A63216004	A63226004	A63216003	A63226003	A63216004	A63226002
7	All	A63216003	A63226003	A63216004	A63226004	–	–	–	–
8	All	A63216003	A63226003	A63216004	A63229004	A63216003	A63226003	A63216004	A63226002
10	All	A63216003	A63226003	A63219004	A63229004	–	–	–	–
12	All	A63216003	A63226003	A63219204	A63229204	–	–	–	–
14	All	A63216003	A63226003	A63219404	A63229404	–	–	–	–

Symbol	Description
14	Gland cartridge
40	Gland wiperseal
41	Gland lipseal
42	Piston lipseal
43*	Gland back-up washer
44	Piston back-up washer
45	Gland to head o-ring
47	End seal o-ring
48	Piston ring
62	Gland cartridge kit

*Not used in PL-2 cylinders.

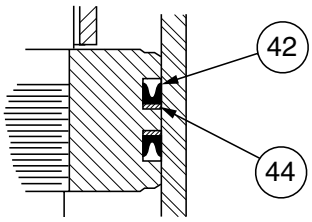


Piston Seal Options

Ring Type Piston

(as shown above)
Supplied as standard on PL-2 series hydraulic cylinders.

Lipseal Type Piston



Supplied as standard on PA-2 series air cylinders. Optional for PL-2 series hydraulic cylinders.

Seal Kits for Class 1 & 2 Service

Material: Buna-N (Nitrile) except item 41, in PL-2 series which is polyurethane.

For operating temperature and fluid compatibility, see Section C, pages 54 & 55.

Gland and spanner wrenches are available to ease (rod) seal or gland cartridge removal without disassembly of the cylinder. **(For rod diameters over 2 1/2".)**

For detailed seal replacement instructions see service bulletin SB0995-M1, M2 and M3.

Rod Dia.	PA-2 Cylinders Only		PL-2 Cylinders Only			
	Gland (Symbol 62) Cartridge Kits	Rod Seal Kits	Gland (Sym. 62) Cartridge Kits	Rod Seal Kits	Gland Wrench	Spanner Wrench
	Contains Symbols 14, 40, 41, 43 & 45	Contains Symbols 40, 41, 43 & 45	Contains Symbols 14, 40, 41 & 45	Contains Symbols 40, 41 & 45		
1/2	A63210105	A63210305	A63210505	A63210705	Not Required	Not Required
5/8	A63210108	A63210308	A63210508	A63210708		
1	A63210110	A63210310	A63210510	A63210710		
1 3/8	A63210113	A63210313	A63210513	A63210713		
1 3/4	A63210114	A63210314	A63210514	A63210714		
2	A63210120	A63210320	A63210520	A63210720		
2 1/2	A63210125	A63210325	A63210525	A63210725		
3	A63210130	A63210330	A63210530	A63210730	069596 0000	011677 0000
3 1/2	A63210135	A63210335	A63210535	A63210735	069597 0000	011677 0000
4	A63210140	A63210340	A63210540	A63210740	069598 0000	011678 0000
4 1/2	A63210145	A63210345	A63210545	A63210745	083877 0000	011678 0000
5	A63210150	A63210350	A63210550	A63210750	069599 0000	011678 0000
5 1/2	A63210155	A63210355	A63210555	A63210755	069600 0000	011678 0000

Bore Size	Piston Seal Kits PA-2 Series Contains 2 Each Symbols: 42, 44 & 47	Piston Seal Kits PL-2 Series Contains 2 Each Symbols: 42, 44 & 47	Piston Ring Kits PL-2 Series Contains 2 Each Symbols 47 & 4 Each Symbol 48
1	A63211006	A63211007	A63211008
1 1/2	A63211506	A63211507	A63211508
2	A63212006	A63212007	A63212008
2 1/2	A63212506	A63212507	A63212508
3 1/4	A63213206	A63213207	A63213208
4	A63214006	A63214007	A63214008
5	A63215006	A63215007	A63215008
6	A63216006	A63216007	A63216008
7	A63217006	–	–
8	A63218006	A63218007	A63218008
10	A63219006	–	–
12	A63219206	–	–
14	A63219406	–	–

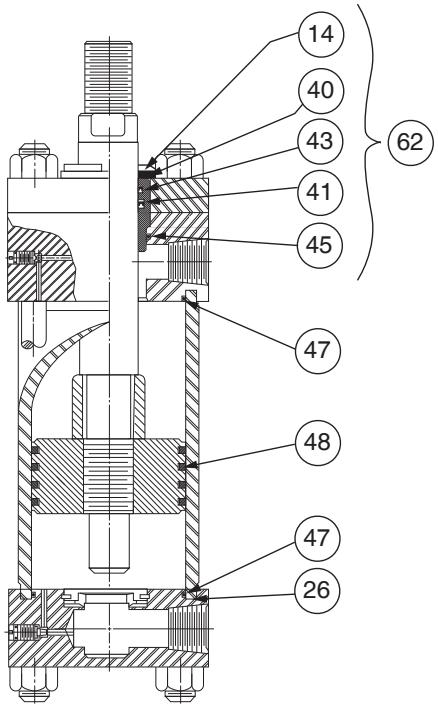
Bore Size	Cylinder Body Seal Kits PA-2 Series Contains 2 Each Symbol 47	Cylinder Body Seal Kits PL-2 Series Contains 2 Each Symbol 47	Tie Rod Torque Specifications (lb-ft) PA-2 Series Steel Cylinder Body	Tie Rod Torque Specifications (lb-ft) PA-2 Series Brass Cylinder Body	Tie Rod Torque Specifications (lb-ft) PL-2 Series
1	A63211010	A63211010	2	1	2
1 1/2	A63215010	A63215010	5	3	5
2	A63220010	A63220010	11	6	11
2 1/2	A63225010	A63225010	11	6	11
3 1/4	A63232010	A63232011	25	18	25
4	A63240010	A63240011	25	18	25
5	A63250010	A63250011	60	45	60
6	A63260010	A63260011	60	45	60
7	A63270010	–	90	–	–
8	A63280010	A63280011	110	80	110
10	A63290010	–	150	115	–
12	A63292010	–	172	150	–
14	A63294010	–	275	230	–

How to Order

Individual seals contained in the kits are available separately; however, we recommend purchasing complete kits because of convenience and lower replacement cost. When ordering seal kits, give part number listed above. To be sure of exact replacement, give serial number of cylinder when ordering replacement kits or seals.

C

Symbol	Description
14	Gland cartridge
40	Gland wiperseal
41	Gland lipseal
42	Piston lipseal
43	Gland back-up washer
44	Piston back-up washer
45	Gland to head o-ring
47	End seal o-ring
48	Piston ring
62	Gland cartridge kit



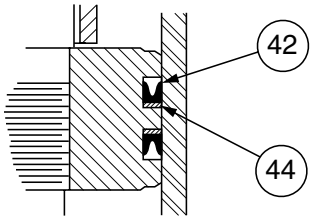
Piston Seal Options

Ring Type Piston

(as shown above)

Supplied as standard on PL-2 series hydraulic cylinders.

Lipseal Type Piston



Supplied as standard on PA-2 series air cylinders. Optional for PL-2 series hydraulic cylinders.

Seal Kits for Fluorocarbon Seals

Material: Fluorocarbon

For operating temperature and fluid compatability, see Section C, pages 54 & 55.

Gland and spanner wrenches are available to ease (rod) seal or gland cartridge removal without disassembly of the cylinder. **(For rod diameters over 2 1/2".)**

For detailed seal replacement instructions see service bulletin SB0995-M1, M3 and M5.

Rod Dia.	PA-2 Cylinders Only: Gland (Symbol 62) Cartridge Kits — Contains Symbols 14, 40, 41, 43 & 45	PA-2 Cylinders Only: Rod Seal Kits — Contains Symbols 40, 41, 43 & 45	PL-2 Cylinders Only: Gland (Sym. 62) Cartridge Kits — Contains Symbols 14, 40, 41, 43 & 45	PL-2 Cylinders Only: Rod Seal Kits — Contains Symbols 40, 41, 43 & 45	Gland Wrench	Spanner Wrench
1/2	A63220205	A63220405	A63220605	A63220805	Not Required	Not Required
5/8	A63220208	A63220408	A63220408	A63220808		
1	A63220210	A63220410	A63220610	A63220810		
1 3/8	A63220213	A63220413	A63220613	A63220813		
1 3/4	A63220214	A63220414	A63220614	A63220814		
2	A63220220	A63220420	A63220620	A63220820		
2 1/2	A63220225	A63220425	A63220625	A63220825		
3	A63220230	A63220430	A63220630	A63220830	0695960000	0116770000
3 1/2	A63220235	A63220435	A63220635	A63220835	0695970000	0116770000
4	A63220240	A63220440	A63220640	A63220840	0695980000	0116780000
4 1/2	A63220245	A63220445	A63220645	A63220845	0838770000	0116780000
5	A63220250	A63220450	A63220650	A63220850	0695990000	0116780000
5 1/2	A63220255	A63220455	A63220655	A63220855	0696000000	0116780000

Bore Size	Piston Seal Kits PA-2 Series — Contains 2 Each Symbols: 42, 44 & 47	Piston Seal Kits PL-2 Series — Contains 2 Each Symbols: 42, 44 & 47	Piston Ring Kits PL-2 Series — Contains 2 Each Symbols 47 & 4 Each Symbol 48
1	A63221006	A63221007	A63221008
1 1/2	A63221506	A63221507	A63221508
2	A63222006	A63222007	A63222008
2 1/2	A63222506	A63222507	A63222508
3 1/4	A63223206	A63223207	A63223208
4	A63224006	A63224007	A63224008
5	A63225006	A63225007	A63225008
6	A63226006	A63226007	A63226008
7	A63227006	–	–
8	A63228006	A63228007	A63228008
10	A63229006	–	–
12	A63229206	–	–
14	A63229406	–	–

Bore Size	Cylinder Body Seal Kits: PA-2 Series — Contains 2 Each Symbol 47	Cylinder Body Seal Kits: PL-2 Series — Contains 2 Each Symbol 47	Tie Rod Torque Specifications (lb-ft): PA-2 Series — Steel Cylinder Body	Tie Rod Torque Specifications (lb-ft): PA-2 Series — Brass Cylinder Body	Tie Rod Torque Specifications (lb-ft): PL-2 Series
1	A63221020	A63221020	2	1	2
1 1/2	A63221520	A63221520	5	3	5
2	A63222020	A63222020	11	6	11
2 1/2	A63222520	A63222520	11	6	11
3 1/4	A63223230	A63223230	25	18	25
4	A63224030	A63224030	25	18	25
5	A63225030	A63225030	60	45	60
6	A63226030	A63226030	60	45	60
7	A63227030	–	90	–	–
8	A63228030	A63228030	110	80	110
10	A63229030	–	150	115	–
12	A63229230	–	172	150	–
14	A63229430	–	275	230	–

How to Order

Individual seals contained in the kits are available separately; however, we recommend purchasing complete kits because of convenience and lower replacement cost. When ordering seal kits, give part number listed above. To be sure of exact replacement, give serial number of cylinder when ordering replacement kits or seals.

In the PN Series you get all the cost saving benefits and features of the popular heavy duty PA-2 Series air cylinder including...

- Bolt On Rod Gland Assembly for positive no leak sealing.
- Piston rod, hard chrome plated and case hardened steel
- High strength rolled thread Piston Rod Stud
- Steel tube cylinder body with chrome-plated micro finish bore

PLUS the innovative "NON-LUBE" feature which further increases your benefits of lower operating and maintenance costs.

Standard Specifications

- Heavy Duty Service – ANSI/(NFPA) T3.6.7R2-1996 Mounting Dimensions Standards.
- Standard Construction – Square Head – Tie Rod Design.
- Standard Temperature – -10°F. to +165°F.
- Standard Fluid – Filtered Air.
- Strokes – Available in any Practical Stroke Length.
- Cushions – Optional at either end or both ends of stroke. "Float Check" at cap end.

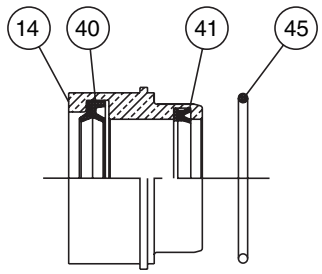
In line with our policy of continuing product improvement, specifications in this catalog are subject to change.

Seal Kits

PN Series

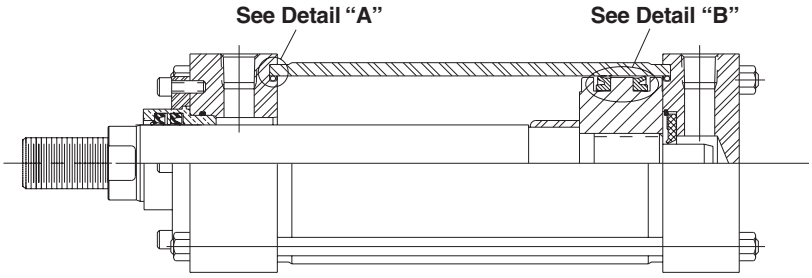
Gland Cartridge Kit

Rod Size	Consisting of Symbol 14, 40, 41, 45, 131 & 132
5/8	A63250108
1	A63250110
1 3/8	A63250113
1 3/4	A63250114
2	A63250120
2 1/2	A63250125
3	A63250130
3 1/2	A63250135
4	A63250140
4 1/2	A63250145
5	A63250150
5 1/2	A63250155



Rod Seal Kit

Rod Size	Consisting of Symbol 40, 41, 45, 131 & 132
5/8	A63250308
1	A63250310
1 3/8	A63250313
1 3/4	A63250314
2	A63250320
2 1/2	A63250325
3	A63250330
3 1/2	A63250335
4	A63250340
4 1/2	A63250345
5	A63250350
5 1/2	A63250355



Bore Size	Piston Seal Kit Consisting of 2 Ea. Symbol 42, 129*, 130* & 47	Cylinder Body Seal Kit Consisting of 2 Ea. Symbol 47
1 1/2	A63251520	A63215010
2	A63252020	A63220010
2 1/2	A63252520	A63225010
3 1/4	A63253220	A63232010
4	A63254020	A63240010
5	A63255020	A63250010
6	A63256020	A63260010
7	A63257020	A63270010
8	A63258020	A63280010
10	A63259020	A63290010
12	A63259220	A63292010
14	A63259420	–

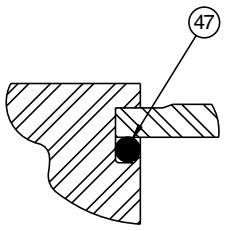
*14" bore only

Service kits of expendable parts for PN Series fluid power cylinders are stocked in principal industrial locations across the U.S.A. and other countries. For prompt delivery and complete information, contact your nearest distributor.

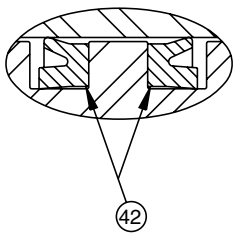
Standard Seals — Service Kits contain seals of Buna-N elastomers for standard fluid service. In addition to standard seals, each kit includes the special composite components ready for installation. These seals are suitable for use when air is the operating medium

The recommended operating temperature range for Class 1 seals is -10° F to + 165°F.

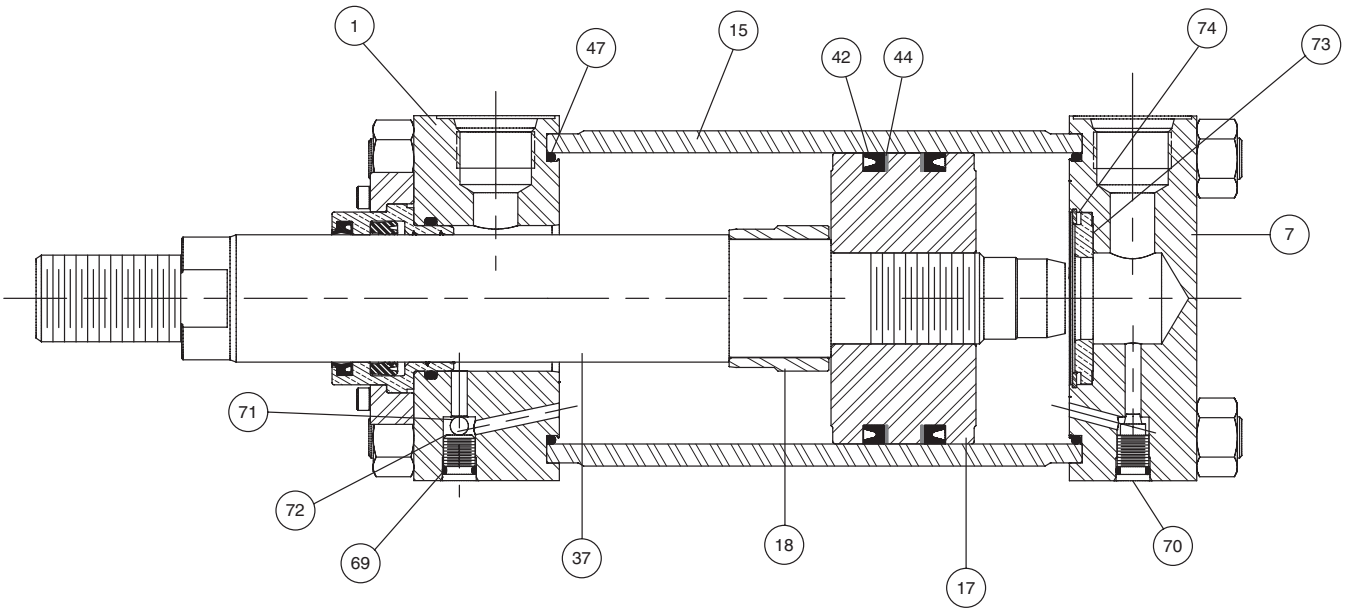
Detail "A"

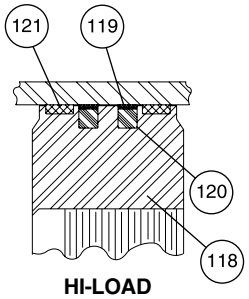


Detail "B"

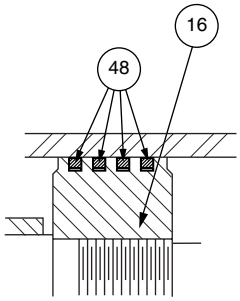


C





HI-LOAD PISTON



OPTIONAL RING TYPE PISTON

Parts List — 1 1/2" through 6" Bore Sizes

Symbol	Description
1	Head
7	Cap
15	Cylinder body
16	Piston, ring type
17	Piston, lipseal type
18	Cushion sleeve, rod head cushion
37	Piston rod, single rod type
42	Lipseal, piston
44	Back-up washer, piston
47	O-ring, cylinder tube to head and cap seal
48	Piston ring, iron
69	O-ring, cushion adjustment and check valve plug screw
70	Needle, cushion adjustment valve
71	Ball, cushion check valve
72	Plug screw, cushion check valve
73	Bushing, float check, cushion on cap end
74	Retaining ring, float check cushion bushing
118	Piston, Hi-Load type
119	Outer Ring
120	Inner Ring
121	Wear Ring

Piston and Rod Assemblies

Factory assembled piston and rod assemblies (that include seals for piston type specified) are recommended.

Seal Kits

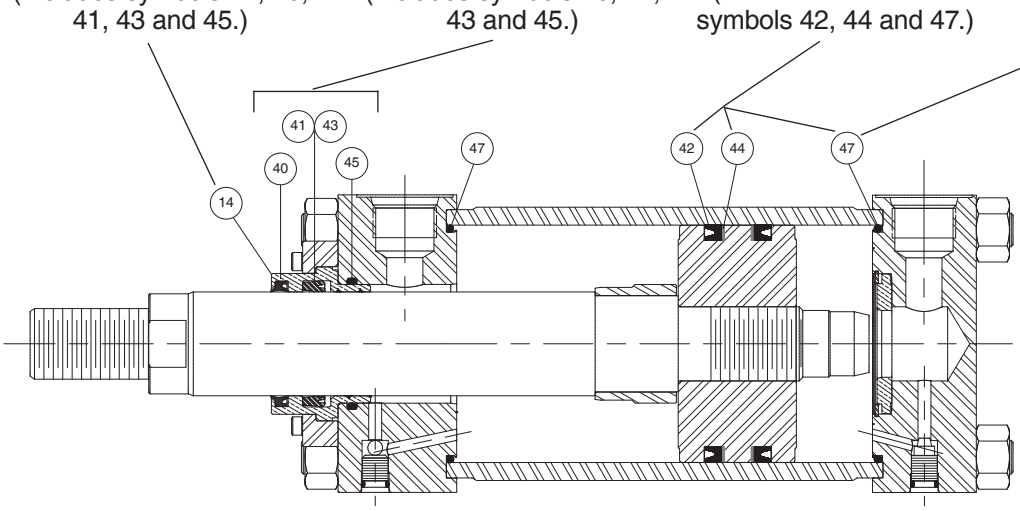
Gland Seal Kits Contain Gland and Seals for PH-2 Series (Includes symbols 14, 40, 41, 43 and 45.)

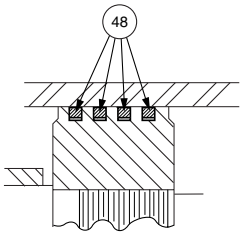
Rod Seal Kits Contain Rod Seals for PH-2 Series (Includes symbols 40, 41, 43 and 45.)

Lipseal Kits Contain Piston Lipseals™ and Body End Seals (Includes two each of symbols 42, 44 and 47.)

Body Seal Kits Contain Cylinder Body End Seals (Includes two each of symbol 47.)

Piston Ring Kits Contain Piston Rings (Includes four each symbol 48 and two each of 47.)





OPTIONAL RING TYPE PISTON

Standard Seals
Cylinders built with standard seals contain Buna-N seals except for the piston rod seal which is polyurethane. They are suitable for use with air, nitrogen or hydraulic oil. The recommended operating temperature range for standard seals is -10° F (-23° C) to +165° F (+74° C).

Fluorocarbon Seals
Fluorocarbon seals can be supplied, on request, and are especially suitable for some fire resistant fluids as shown in the table in Section C for elevated temperature service.

When using Fluorocarbon seals for high temperature service or fluid compatibility within a temperature range of -10° F (-23° C) to +250° F (+121° C) specify Fluorocarbon seals. For elevated temperature service above +250° F (+121° C) specify Fluorocarbon seals plus a non-studded piston rod end thread and a pinned piston to rod connection. This recommendation should also be followed when ordering spare piston and rod assemblies. Fluorocarbon seals can operate up to a maximum of +400° F (+204° C) with reduced service life.

WARNING!
The piston rod stud and the piston rod to piston threaded connections are secured with an anaerobic adhesive which is temperature sensitive. Cylinders ordered with Fluorocarbon seals are assembled with anaerobic adhesive having a maximum operating temperature rating of +250° F (+121° C). Cylinders ordered with all other seal compounds are assembled with anaerobic adhesive a maximum operating temperature rating of +165° F (+74° C). These temperature limitations must be strictly followed to prevent loosening of the threaded connections. When cylinders are intended to be used above +250° F (+121° C) specify a non-studded piston rod end thread and a pinned piston to rod connection.

Rod Gland and Rod Seal Kits

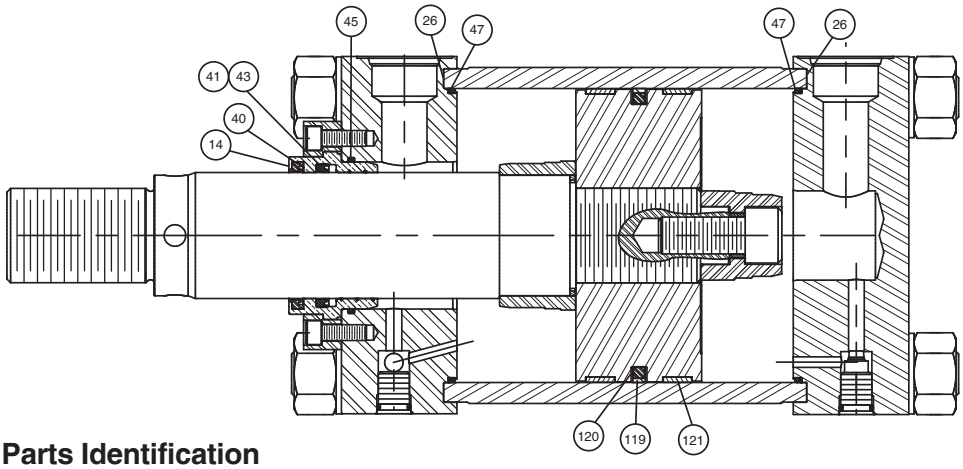
Rod Dia.	Standard Seals		Fluorocarbon Seals		Retainer Screw Torque lb-in
	Rod Gland Cartridge Kit	Rod Seal Kits	Rod Gland Cartridge Kit	Rod Seal Kits	
5/8	A63230A08	A63230C08	A63230B08	A63230D08	24
1	A63230A10	A63230C10	A63230B10	A63230D10	24
1 3/8	A63230A13	A63230C13	A63230B13	A63230D13	24
1 3/4	A63230A14	A63230C14	A63230B14	A63230D14	24
2	A63230A20	A63230C20	A63230B20	A63230D20	120
2 1/2	A63230A25	A63230C25	A63230B25	A63230D25	120
3	A63230A30	A63230C30	A63230B30	A63230D30	240
3 1/2	A63230A35	A63230C35	A63230B35	A63230D35	240
4	A63230A40	A63230C40	A63230B40	A63230D40	240

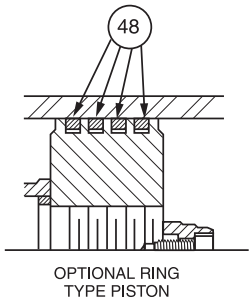
Cylinder Body and Piston Seal Kits

Bore Size	Standard Seals			Fluorocarbon Seals			Tie Rod Torque Specification lb-ft
	Cylinder Body Seal Kits	Piston Ring Kit	Piston (Lipseal) Seal Kit	Cylinder Body Seal Kits	Piston Ring Kit	Piston (Lipseal) Seal Kit	
1 1/2	A63215010	A63211508	A63211507	A63221520	A63221508	A63221507	18-19
2	A63220010	A63212008	A63212007	A63222020	A63222008	A63222007	45-49
2 1/2	A63225010	A63212508	A63212507	A63222520	A63222508	A63222507	45-49
3 1/4	A63232011	A63213208	A63213207	A63223230	A63223208	A63223207	120-124
4	A63240011	A63214008	A63214007	A63224030	A63224008	A63224007	131-135
5	A63250011	A63215008	A63215007	A63225030	A63225008	A63225007	312-316
6	A63260011	A63216008	A63216007	A63226030	A63226008	A63226007	528-544

PH-3 Series, 7" & 8" Bore Hydraulic Cylinders

Parts Identification and Maintenance Instructions





Parts Identification

Sym. No.	Description	Sym. No.	Description
14	Rod Gland	47	End Seal O-Ring
40	Rod Wiperseal	48	Piston Ring
41	Rod Lipseal	119	Outer Ring
43	Rod Seal Back-up Washer	120	Inner Ring
26	End Seal Back Up Washer	121	Wear Ring
45	Gland to Head O-Ring		

Service kits of expendable parts for fluid power cylinders are stocked in principal industrial locations across the U.S.A. and other countries. For prompt delivery and complete information, contact your nearest Schrader Bellows distributor or office.

Service kits of expendable parts for fluid power cylinders are available for either standard seals, fluorocarbon seals or HWCF seals which are intended to use with highwater content fluids.

Standard Seals – Standard Seal Service Kits contain PTFE, nitrile and polyurethane seals. These seals are suitable for use when hydraulic (mineral-type) oil is the operating medium. The recommended operating temperature range for standard seals is -10°F (-23°C) to +165°F (+74°C).

Fluorocarbon Seals – The service kits contain fluorocarbon seals and are especially suited for elevated temperature service or for some fire resistant fluids (for specific fluids not listed in current catalog consult factory). Fluorocarbon seals should be used for high temperature service within a temperature range of -10°F (-23°C) to +250°F (+121°C) the cylinder must be manufactured with a pinned piston to rod connection.

Warning – The piston rod to piston threaded connection is secured with an anaerobic adhesive which is temperature sensitive. Cylinders specified with Fluorocarbon seals are assembled with anaerobic adhesive having a maximum operating temperature range of +165°F (+74°C). These temperature limitations are necessary to prevent the possible loosening of the threaded connections. Cylinders originally manufactured with standard seals that will be exposed to ambient temperature above +165°F (+74°C) must be modified for higher temperature service. Contact the factory immediately and arrange for the piston to rod and the stud to piston rod connections to be properly reassembled to withstand the higher temperature service.

Rod Gland and Rod Seal Kits

Rod Dia.	Standard Seals		Fluorocarbon Seals		Retainer Screw Torque
	Rod Gland Cartridge Kits (Contains: 1 Each Sym. #14, 40, 41, & 45)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, & 45)	Rod Gland Cartridge Kits (Contains: 1 Each Sym. #14, 40, 41, 43, & 45)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, 43, & 45)	
3	A63230A30	A63230C30	A63230B30	A63230D30	23-24 lb-ft
3 1/2	A63230A35	A63230C35	A63230B35	A63230D35	23-24 lb-ft
4	A63230A40	A63230C40	A63230B40	A63230D40	41-43 lb-ft
5	A63230A50	A63230C50	A63230B50	A63230D50	41-43 lb-ft
5 1/2	A63230A55	A63230C55	A63230B55	A63230D55	65-68 lb-ft

Cylinder Body and Piston Seal Kits

Bore Size	Standard Seals			Fluorocarbon Seals			Tie Rod Torque Specification
	Cylinder Body Seal Kits (Contains: 2 Each Sym. #26 & 47)	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #26 & 47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #26, 47, & 121 2 Each Sym. #119 & 120)	Cylinder Body Seal Kits (Contains: 2 Each Sym. #26 & 47)	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #26 & 47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #26, 47, & 121 2 Each Sym. #119 & 120)	
7	A63307031	A63307001	A63307021	A63307035	A63307005	A63307025	800-816 lb-ft
8	A63308031	A63308001	A63308021	A63308035	A63308005	A63308025	1168-1184 lb-ft

To Service Rod Gland Seals – The rod gland cartridge is removable without disassembly of the cylinder on all PH-3 Series 7" & 8" bore hydraulic cylinders. To remove the gland, loosen the retainer screws and remove the gland retainer. It is recommended that the used gland be replaced by a complete gland cartridge kit. Later the used gland can be inspected, and if the bearing surface is still satisfactory and not out-of-round, it can be repacked with replacement seals and stored for future use.

Assemble seals for the PH-3 Series 7" & 8" bore gland by installing the rod wiperseal and rod lipseal in their proper grooves. Install head-to-gland “O” ring in its proper groove. Lubricate all seals.

THE SEALS ARE PRESSURE-ACTUATED, SO NO FURTHER ADJUSTMENTS ARE NECESSARY.

To Service The Piston Seals — Disassemble the cylinder completely; remove the old seals and clean all of the parts. The cylinder bore and the piston should then be examined for evidence of scoring. If either is damaged, it should be replaced. The piston seal is either cast iron rings, or hi-load PTFE type.

Iron piston rings seldom need replacement. If the rings show no signs of damage or abnormal wear, they may be reused. To install piston and rings, collapse the rings one at a time, while inserting the piston into the cylinder body, using a light oil to aid this process.

The hi-load piston is supplied with one continuous PTFE outer ring, Symbol 119, which is preloaded by a synthetic rubber inner ring, Symbol 120, and two split fabric-phenolic wear rings, Symbol 121. To service the hi-load piston, remove old seals and wear rings and clean all piston surfaces. Install the inner ring in groove as shown. Install the wear ring in the longer groove at each end of piston, also as shown. Heat the PTFE outer ring in boiling water and stretch it by hand until it will fit over the O.D. of the wear ring. Push outer ring over the wear ring and into the seal groove. With outer ring in its groove, compress it with ring compressor or use a starting sleeve having an I.D. same size as cylinder bore and tapered at one end.

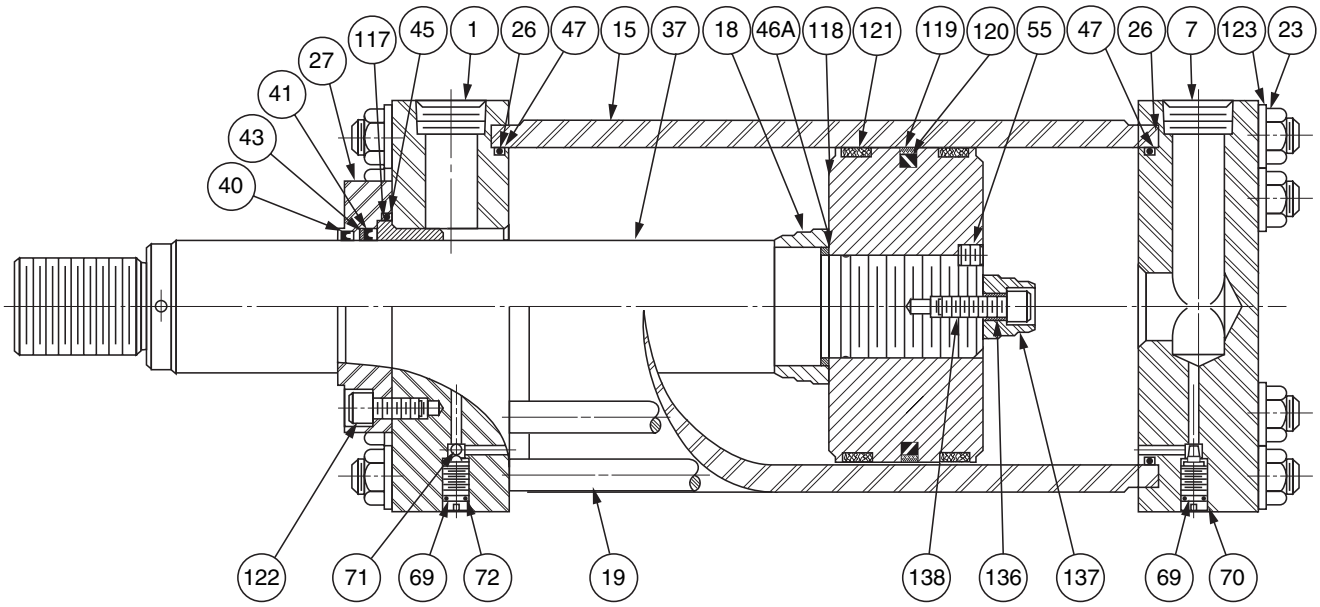
To Replace Piston — If the piston or piston rod is badly scored or otherwise damaged, they should be replaced as a complete assembly. To order a piston and rod assembly, specify serial number, bore size, stroke and model number as shown on the cylinder name plate.

Cylinder Reassembly — O-rings, Symbol 47, and back-up washers, Symbol 26, should be lightly coated with lubricant, then worked into place into the cap by hand. Cylinder body can then be assembled to the cap by rocking it down over the seal until the end of the cylinder body is metal-to-metal contact with the cap. Install O-ring, Symbol 47, and back-up washers, Symbol 26, in head. Head is then fitted over the piston rod and assembled to cylinder body. Rock gently into place until body and head are in metal-to-metal contact.

Install tie rods in holes provided in cap and thread them into the tapped holes in the head. One cap end mounting styles the tapped holes are in the cap. Install the tie rod nuts and tighten finger tight.

Inspect the surface of the piston rod for scratches, dents, raised burrs or other damage. A damaged piston rod will quickly ruin any seal through which it moves and should be replaced. Slide the gland with its seals over the piston rod until it seats against the cavity in the head. Install the gland retainer and retainer screws. Torque the tie rod nuts and gland retainer screws to the torque level shown on the previous page.

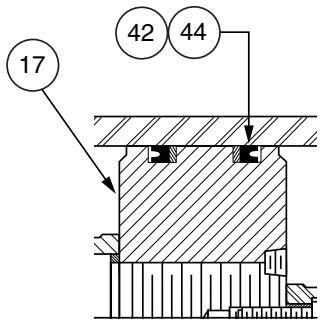
Parts Identification



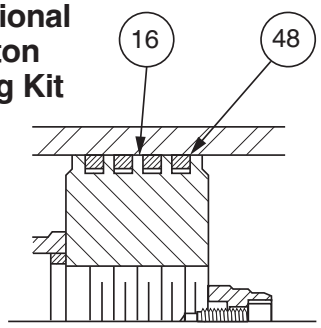
Sym. No.	
1	Head
7	Cap
15	Cylinder Body
16	Piston Body – Ring Type Piston
17	Piston Body – Lipseal
18	Cushion Sleeve
19	Tie Rod
23	Tie Rod Nut – Non-Locking
26	Back-Up Washer, Cylinder Body
27	Retainer
37	Piston Rod
40	Wiperseal
41	Rod Seal (Polypak)
42	Lipseal, Piston
43	Back-Up Washer, Polypak
44	Back-Up Washer, Lipseal
45	O-Ring, Gland to Head
46A	Cushion Sealing Ring

Sym. No.	
47	O-Ring Cylinder Body
48	Piston Ring
55	Piston Lock Pin
69	O-Ring, Cushion Adj. & Check Screws
70	Cushion Adjusting Needle Screw
71	Check Valve Ball
72	Check Valve Screw
117	Rod Bearing
118	Piston Body – Hi-Load
119	Outer Piston Ring
120	Inner Piston Ring
121	Wear Ring
122	Retainer Bolt
123	Washer, Tie Rod Nut
136	Spacer, Cushion
137	Cushion Spear, Detachable
138	Bolt, Cushion Spear

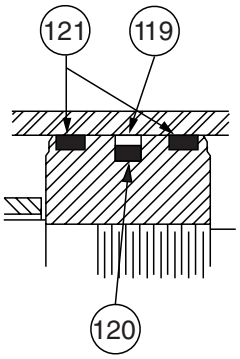
Optional Piston Lipseal Kit



Optional Piston Ring Kit



Standard Hi-Load Piston Seal Kit



Operating Fluids and Temperature Range – Fluidpower cylinders are designed for use with pressurized air, hydraulic oil and fire resistant fluids, in some cases special seals are required.

Standard Seals

Buna-N seals are supplied on all standard pneumatic and hydraulic cylinders. They are suitable for use with pressured air, nitrogen, hydraulic oil, water-in oil emulsions or water glycol fluids. The recommended operating temperature range for Buna-N seals is -10°F. (-23°C.) to +165°F (+74°C.).

Fluorocarbon Seals

Fluorocarbon seals can be supplied, on request, and are especially suitable for some fire resistant fluids as shown in the table in Section C, or for elevated temperature service.

When using Fluorocarbon seals for high temperature service or fluid compatibility within a temperature range of -10°F. (-23°C) to +250°F. (+121°C) specify Fluorocarbon seals.

For elevated temperature service above +250°F. (+121°C) specify Fluorocarbon seals plus a non-studded piston rod end thread and a pinned piston to rod connection. This recommendation should also be followed when ordering spare piston and rod assemblies. Fluorocarbon seals can operate up to a maximum of +400°F. (+204°C) with reduced service life.

The piston rod stud and the piston rod to piston threaded connections are secured with an anaerobic adhesive which is temperature sensitive. Cylinders ordered with Fluorocarbon seals are assembled with anaerobic adhesive having a maximum operating temperature rating of +250°F. (+121°C). Cylinders ordered with all other seal compounds are assembled with anaerobic adhesive having a maximum operating temperature rating of +165°F. (+74°C). These temperature limitations must be strictly followed to prevent loosening of the threaded connections. When cylinders are intended to be used above +250°F. (+121°C) specify a non-studded piston rod end thread and a pinned piston to rod connection.

Bore	Rod Dia.	Rod Seal Kits Contains Symbol 40, 41, 43, 45 Standard Kit No.	Rod Seal Kits Contains Symbol 40, 41, 43, 45 Fluorocarbon Kit No.	Rod Seal Kits Including Bearing Contains Symbol 40, 41, 43, 45 & 117 Standard Kit No.	Rod Seal Kits Including Bearing Contains Symbol 40, 41, 43, 45 & 117 Fluorocarbon Kit No.
10	4½	A63300451	A63300455	A63310451	A63310455
	7	A63300701	A63300705	A63310701	A63310705
	5	A63300501	A63300505	A63310501	A63310505
	5½	A63300551	A63300555	A63310551	A63310555
12	5½	A63300551	A63300555	A63310551	A63310555
	8	A63300801	A63300805	A63310801	A63310805
	7	A63300701	A63300705	A63310701	A63310705
14	7	A63300701	A63300705	A63310701	A63310705
	10*	A63301001	A63301005	A63311001	A63311005
	8*	A63300801	A63300805	A63310801	A63310805

*NOTE: For 16", 18" and 20" Bore PH-3 Cylinders with 8" and 10" rods use the seal kits listed above for 14" Bore PH-3 with 8" and 10" rods.

Cylinder Bore Size	Tie Rod Torque
10"	700 - 716 lb-ft
12"	1320 - 1336 lb-ft
14"	1000 - 1016 lb-ft
16"/18"/20"	2900 - 3000 lb-ft

Retainer Bolt Torque for Cylinders with Round Gland Retainer

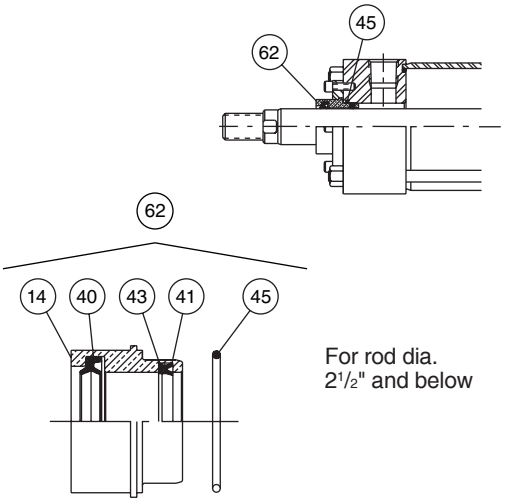
Torque values are for bolts installed with lubrication.

Screw Size	Torque
1/2"	100 - 105 lb-ft
5/8"	185 - 194 lb-ft
3/4"	330 - 346 lb-ft

Bore	Piston Ring Kit† Contains 4 Ea. Sym. 48, 2 Ea. Sym. 47 & 26 Standard Kit No.	Piston Ring Kit† Contains 4 Ea. Sym. 48, 2 Ea. Sym. 47 & 26 Fluorocarbon Kit No.	Piston Lipseal Kit† Contains 2 Ea. Sym. 42, 44, 47 & 26 Standard Kit No.	Piston Lipseal Kit† Contains 2 Ea. Sym. 42, 44, 47 & 26 Fluorocarbon Kit No.
10	A63310001	A63310005	A63310011	A63310015
12	A63312001	A63312005	A63312011	A63312015
14	A63314001	A63314005	A63314011	A63314015

Bore	Hi Load Piston Seal Kit† Contains 1 Ea. Sym. 119, 120, 2 Ea. Sym. 121, 47 & 26 Standard Kit No.	Hi Load Piston Seal Kit† Contains 1 Ea. Sym. 119, 120, 2 Ea. Sym. 121, 47 & 26 Fluorocarbon Kit No.	Cylinder Body Seal Kit† Contains 2 Ea. Sym. 47 & 26 Standard Kit No.	Cylinder Body Seal Kit† Contains 2 Ea. Sym. 47 & 26 Fluorocarbon Kit No.
10	A63310021	A63310025	A63310031	A63310035
12	A63312021	A63312025	A63312031	A63312035
14	A63314021	A63314025	A63314031	A63314035

†For 16", 18" and 20" bore piston kits – consult factory.



For rod dia. 2½" and below

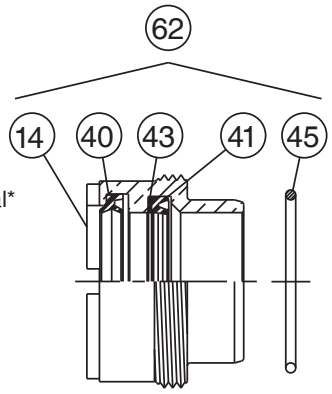
GLAND CARTRIDGE KIT

RG (symbol 62) contains 1 each of the following:
- symbol 14, gland
- symbol 40, rod Wiperseal
- symbol 41, rod Lipseal
- symbol 43, back-up washer for rod gland lipseal*
- symbol 45, O-ring gland to head seal.

ROD SEAL KIT

Contains 1 each of the following:
- symbol 40, rod Wiperseal
- symbol 41, rod Lipseal**
- symbol 41, rod Polypack Seal**
- symbol 43, backup washer for rod Lipseal*
- symbol 45, O-ring, gland to head seal.

*Required only for ½" dia. rod and for Class 5 service, 3" dia. rod and larger.



For rod dia. 3" and over

Service kits of expendable parts for air and hydraulic cylinders are stocked in principal industrial locations across the U.S.A. and other countries. For prompt delivery and complete information, contact your nearest Schrader Bellows distributor.

Service kits of expendable parts for fluid power cylinders are available for either Class 1 or Class 5 fluid service.

Standard Seals — Class 1 Service Kits are standard, and contain polyurethane seals. Class 1 Service Kits are suitable for use when air and hydraulic (mineral type) oil are the operating media.

The recommended operating temperature range for Class 1 seals is -10°F (-23°C) to +165°F (+74°C).

Fluorocarbon Seals — Class 5 Service Kits contain Fluorocarbon seals and are especially suited for elevated temperature service or for some fire resistant fluids (for specific fluids not listed in the latest Schrader Bellows Actuator Catalog, consult factory). Fluorocarbon seals (Class 5) should be used for high temperature service within a temperature range of -10°F (-23°C) to +250°F (+121°C). Fluorocarbon seals may be operated to +400°F (+204°C) with limited service life. For temperatures above +250°F (+121°C) the cylinder must be manufactured with a non-studded piston rod end thread and a pinned piston to rod connection.

Warning — The piston rod stud and the piston rod to piston threaded connections are secured with an anaerobic adhesive which is temperature sensitive. Cylinders specified with fluorocarbon seals are assembled with anaerobic adhesive having a maximum operating temperature rating of +250°F (+121°C). Cylinders specified with all other seal compounds are assembled with anaerobic adhesive having a maximum operating temperature rating of +165°F (+74°C). These temperature limitations are necessary to prevent the possible loosening of the threaded connections. Cylinders originally manufactured with Class 1 seals (Buna-N) that will be exposed to ambient temperatures above +165°F (+74°C) must be modified for higher temperature service. Contact the factory immediately and arrange for the piston to rod and the stud to piston rod connections to be properly reassembled to withstand the higher temperature service.

** This seal kit contains both a poly pack and a serrated lipseal as the primary piston rod seal symbol (41). Cylinders manufactured before the spring of 1999 contained the poly pack seal while cylinders built after this date contained the serrated seal with a larger cross-section. If servicing a gland which contained a poly pack rod seal, replace it with the poly pack provided. If the gland contained a serrated seal, replace it with the serrated seal provided. If it is desired to use the serrated seal regardless of the original construction order kit no. A63210510.

	PL-2 Cylinders — Class 1			Fluorocarbon PL-2 Series Cylinders — Class 5	
	Gland (Symbol 62) Cartridge Kits	Rod Seal Kits		Gland (Symbol 62) Cartridge Kits	Rod Seal Kits
Rod Dia.	Contains Symbols 14, 40, 41, 43† & 45	Contains Symbols 40, 41, 43† & 45	Rod Dia.	Contains Symbols 14, 40, 41, 43† & 45	Contains Symbols 40, 41, 43† & 45
½	A63210505	A63210705	½	A63220605	A63220805
⅝	A63210508	A63210708	⅝	A63220608	A63220808
1	A63210510	A63210710	1	A63220610	A63220810
1⅜	A63210513	A63210713	1⅜	A63220613	A63220813
1¾	A63210514	A63210714	1¾	A63220614	A63220814
2	A63210520	A63210720	2	A63220620	A63220820
2½	A63210525	A63210725	2½	A63220625	A63220825
3	A63210530	A63210730	3	A63220630	A63220830
3½	A63210535	A63210735	3½	A63220635	A63220835
4	A63210540	A63210740	4	A63220640	A63220840
4½	A63210545	A63210745	4½	A63220645	A63220845
5	A63210550	A63210750	5	A63220650	A63220850
5½	A63210555	A63210755	5½	A63220655	A63220855

†Required only for ½" diameter rod and Class 5 service 3" diameter rod and larger.

Service Assemblies and Seal Kits

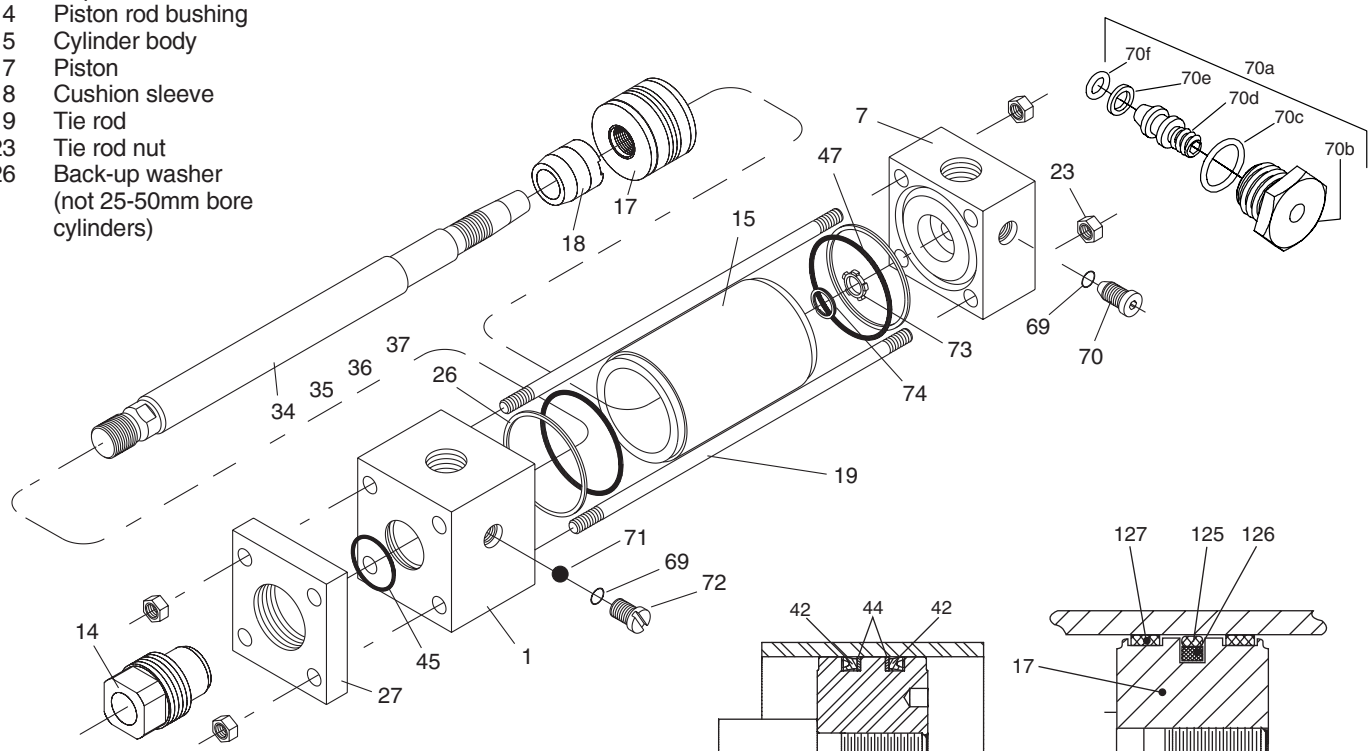
Service Assembly Kits and Seal Kits for SHM cylinders simplify the ordering and maintenance processes. They contain sub-assemblies which are ready for installation, and are supplied with full instructions. When ordering Service Assemblies and Seal Kits, please refer to the identification plate on the cylinder body, and supply the following information:

Serial Number - Bore - Stroke - Model Number - Fluid Type

Key to Part Numbers

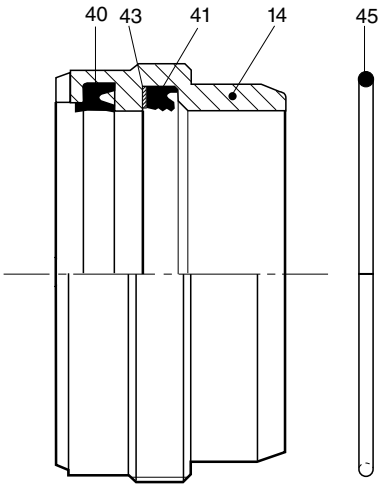
1 Head
7 Cap
14 Piston rod bushing
15 Cylinder body
17 Piston
18 Cushion sleeve
19 Tie rod
23 Tie rod nut
26 Back-up washer (not 25-50mm bore cylinders)
27 Retainer
34 Piston rod – single rod, no cushion
35 Piston rod – single rod, cushion at head end
36 Piston rod – single rod, cushion at cap end
37 Piston rod – single rod, cushion at both ends
40 Wiperseal – for 14 and 122
41 Lipseal – for 14
42 Lipseal, Piston 25-40mm bores only
43 Back-up washer, bushing lipseal 41 (not Group 1 seals)
44 Back-up washer, piston lipseal
45 O-ring – bushing/head
47 O-ring – cylinder body
57[1] Piston rod – double rod, no cushion
58[1] Piston rod – double rod, cushion one end
60[1] Piston rod – double rod, no cushion
61[1] Piston rod – double rod, cushion one end
69 O-ring – needle valve and check valve screws
70[2] Needle valve, cushion adjustment
70a[2] Needle valve, cushion adjustment – cartridge type
70b Cartridge screw
70c O-ring – cartridge screw
70d Needle screw
70e Back-up washer – needle screw
70f O-ring – needle screw
71 Ball – cushion check valve
72 Cushion check valve screw
73 Floating cushion bushing
74 Retaining ring for cushion bushing
125 Standard piston seal
126 Energizing ring for standard seal 125
127 Wear ring for standard piston

[1]Not illustrated
[2]In some cases, the adjusting screw is installed in a cartridge.



Piston 25mm, 32mm and 40mm bore

Piston 50mm bore and larger



Piston Rod Bushing and Seals

C

Contents and Part Numbers of Seal Kits for Pistons and Rod Bushings

(see key to part numbers opposite)

Gland Kit – Rod Bushing and Seals Contain items 14, 40, 41, 43, 45. Where the original bushing incorporates a bushing drain, please consult the factory.

Rod Seal Kit – Bushing Seals Contain items 40, 41, 43, 45

Rod ø	Bushing Assembly		Rod Seal Kit	
	Standard	Fluorocarbon	Standard	Fluorocarbon
12	B732-944	B732-1100	B732-966	B732-1112
14	B732-945	B732-1101	B732-967	B732-1113
18	B732-946	B732-1102	B732-968	B732-1114
22	B732-947	B732-1103	B732-969	B732-1115
28	B732-948	B732-1104	B732-970	B732-1116
36	B732-949	B732-1105	B732-971	B732-1117
45	B732-950	B732-1106	B732-972	B732-1118
56	B732-951	B732-1107	B732-973	B732-1119
70	B732-952	B732-1108	B732-974	B732-1120
90	B732-953	B732-1109	B732-975	B732-1121
110	B732-954	B732-1110	B732-976	B732-1122
140	B732-955	B732-1111	B732-977	B732-1123

Body Kit – Cylinder Body End Seals Contain two each of items 47, 26 (no backup washer in 25-50mm bore).

Piston Kit

B-Style Piston Kit - (includes Cylinder Body End Seals) Contains two each of items 47, 26 (no backup washer in 25mm-50mm bores), two of item 127, and one each of items 125 & 126

Lipseal Piston Kit - (includes Cylinder Body End Seals) Contains two each of items 42, 44 & 47.

Bore ø	Body Seal Kit	
	Standard	Fluorocarbon
25	B732-956	B732-1124
32	B732-957	B732-1125
40	B732-958	B732-1126
50	B732-959	B732-1127
63	B732-960	B732-1128
80	B732-961	B732-1129
100	B732-962	B732-1130
125	B732-963	B732-1131
160	B732-964	B732-1132
200	B732-965	B732-1133

Bore ø	Piston Seal Kits†		
	B-Style Piston Seals		Piston Lipseals
	Standard	Fluorocarbon	Fluorocarbon*
25	B732-1169	B732-1179	B732-1189
32	B732-1170	B732-1180	B732-1190
40	B732-1171	B732-1181	B732-1191
50	B732-1172	B732-1182	N/A
63	B732-1173	B732-1183	
80	B732-1174	B732-1184	
100	B732-1175	B732-1185	
125	B732-1176	B732-1186	
160	B732-1177	B732-1187	
200	B732-1178	B732-1188	

† Piston Lipseals were made standard in 25mm - 40mm bores beginning in June 2006. Carefully check the model number for a 'B' - B-Style or 'L' - Lipseal Style piston before specifying a piston seal kit.

* Piston Lipseal Kits contain group 5 seals that are also suitable for group 1 service.

Tie Rod Torques

Bore ø	Tie Rod Torque Nm
25	4.5-5.0
32	7.6-9.0
40	19.0-20.5
50	68-71
63	68-71
80	160-165
100	160-165
125	450-455
160	815-830
200	1140-1155

The tie rod torque values listed in this table are intended for SHM series cylinders having a pressure envelope pressure rating of 210 bars or 3000 psi Consult factory for tie rod torque of SHM series cylinders having a higher pressure rating.

Repairs

Although SHM cylinders are designed to make on-site maintenance or repairs as easy as possible, some operations can only be carried out in our factory. It is standard policy to fit a cylinder returned to the factory for repair with those replacement parts which are necessary to return it to 'as good as new' condition. Should the condition of the returned cylinder be such that repair would be uneconomical, you will be notified.

Piston Seal Kits for PA-2, PL-2 and PH-2 Series with Magnetic Piston Option

See Position Indicating Switch catalog HY08-SB1132 for product details.

PA-2 Series

Bore Ø	Piston Seal Kit[1] for Magnetic Piston	
	Class 1 & 2 Service	Class 5 Service
1.00	A632110M6	A632210M6
1.50	A632115M6	A632215M6
2.00	A632120M6	A632220M6
2.50	A632125M6	A632225M6
3.25	A632132M6	A632232M6
4.00	A632140M6	A632240M6

[1] Kit includes 2 pieces each of piston lipseals, cylinder tube to head and cap o-ring seal and 1 piston wear band.

PL-2 Series

Bore Ø	Piston Seal Kit[2] for Magnetic Piston	
	Class 1 & 2 Service	Class 5 Service
1.00	A632110M7	A632210M7
1.50	A632115M7	A632215M7
2.00	A632120M7	A632220M7
2.50	A632125M7	A632225M7
3.25	A632132M7	A632232M7
4.00	A632140M7	A632240M7

[2] Kit includes 1 piece each of bi-directional piston seal, piston seal energizer o-ring, piston wear band and 2 pieces of cylinder tube to head and cap o-ring seal.

PH-2 Series

Bore Ø	Piston Seal Kit[3] for Magnetic Piston	
	Class 1 & 2 Service	Class 5 Service
1.50	A6321156M	A6322156M
2.00	A6321206M	A6322206M
2.50	A6321256M	A6322256M
3.25	A6321326M	A6322326M
4.00	A6321406M	A6322406M
5.00	A6321506M	A6322506M
6.00	A6321606M	A6322606M

[3] Kit includes 1 piece each of bi-directional piston seal, piston seal energizer o-ring, piston wear band and 2 pieces of cylinder tube to head and cap o-ring seal.

NOTES

Hydraulic and Pneumatic Cylinder Application Engineering Data

C

Cylinder Operation

Cylinders are used in the majority of applications to convert fluid energy into straight line motion. For this reason, they are often called linear actuators.

Cylinders are manufactured in a variety of diameters, stroke lengths, and mounting styles. They may be classified, according to construction, into four types: tie-rod, threaded, welded, and flanged. Cylinders are also made using retaining rings.

$$\text{Area} = \frac{\pi D^2}{4} \text{ or Area} = .7854 \times D^2$$

When calculating force developed on the return stroke, pressure does not act on the rod area of the piston, therefore the rod area must be subtracted from the total piston area.

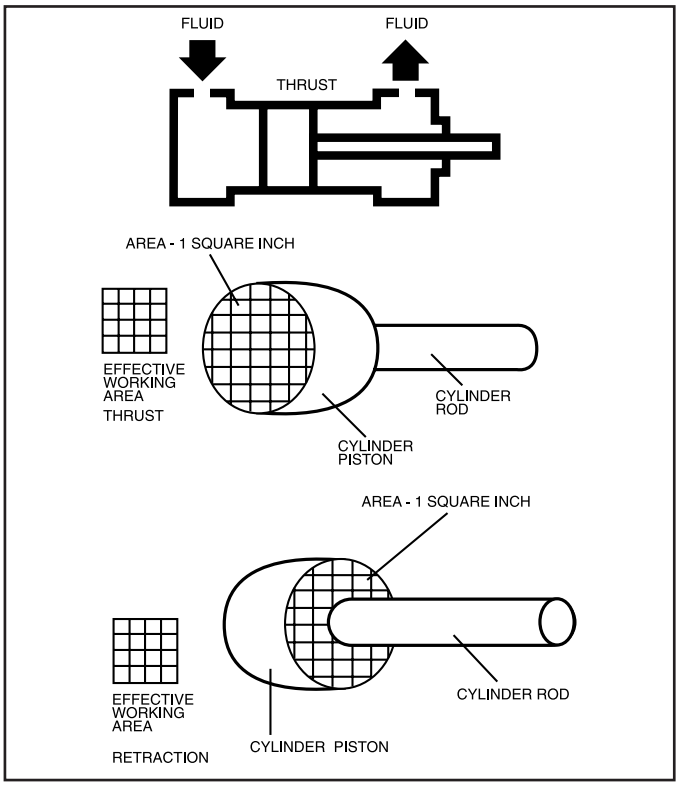
Basic Construction

The major components of a cylinder are the head, cap, tube tie rods, piston, piston rod, rod bearing and seals.

Cylinder Heads and Caps are usually made from rolled steel or cast iron. Some are also from aluminum or bronze.

Cylinder Tubes are usually brass, steel or aluminum. The inside, and sometimes the outside, is plated or anodized to improve wear characteristics and reduce corrosion.

Illustration B-28



Pistons vary in design and materials used. Most are made of cast iron, steel or aluminum. Several methods of attaching the piston to the rod are used. Cushions, are an available option on most cylinders and most often, can be added with no change in envelope dimensions.

Piston Rods are generally high strength steel, case-hardened, ground, polished and hard chrome plated for wear and corrosion resistance. Corrosive atmosphere conditions usually require rods of stainless steel, which may be chrome plated for wear resistance.

Rod Glands or Bearings are used on the head end of most industrial cylinders to support the piston rod as it travels back and forth. The gland also acts as a retainer for the rod packing and seals. Most are made of ductile iron or bronze and usually are removable without disassembling the entire cylinder.

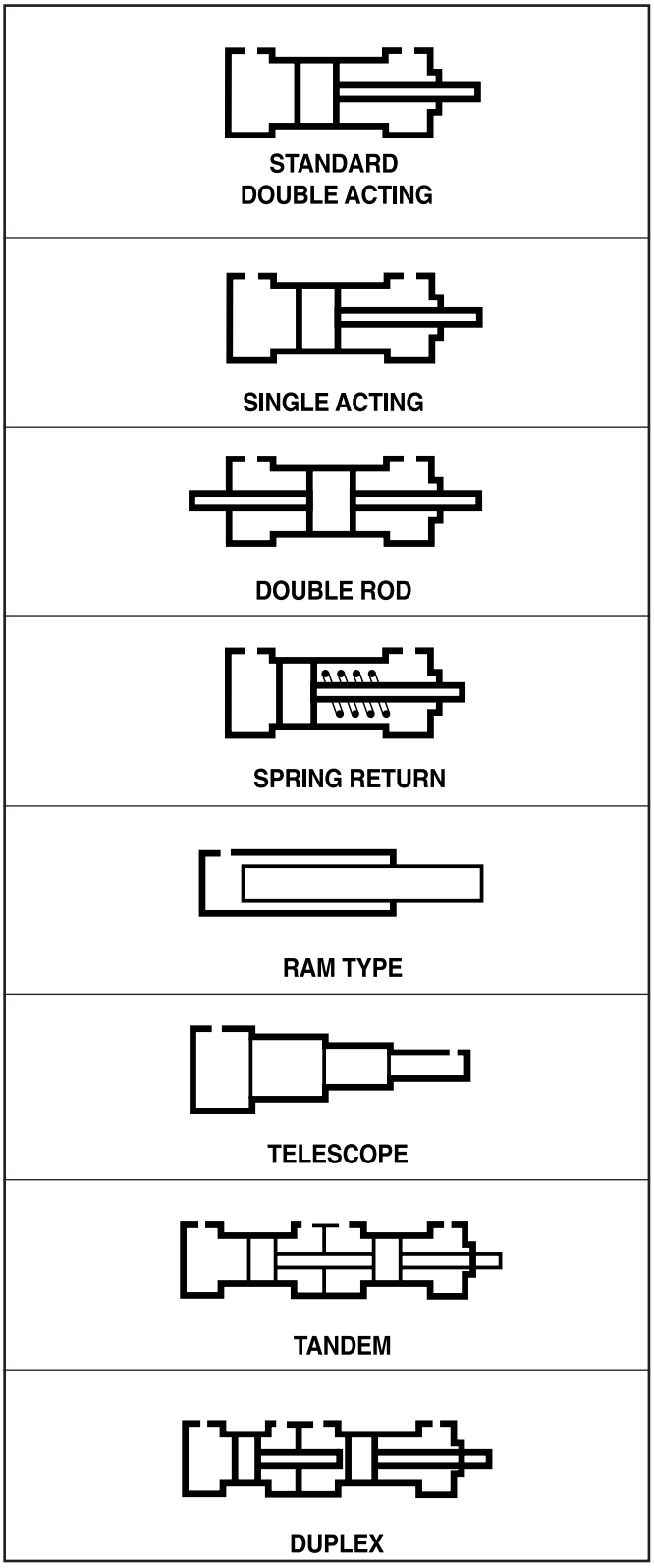
The gland usually contains a piston rod wiper or scraper on the outboard side to remove dirt and contamination from the rod, and prevent foreign material from being drawn into the packings. A primary seal is used to seal the cylinder pressure.

Seals are generally made from Nitrile or fluorocarbon elastomers, polyurethane, leather or PTFE The Lipseal™ shape is commonly used for both piston and piston rod seals. Generally, O-Rings are used for static applications such as head to tube, piston to rod, and head to gland. Cup or V-packings are used for sealing piston and piston rod. Piston rings are usually cast iron.

Tie-Rods are usually high tensile steel with either cut or rolled threads, prestressed during assembly. Prestressing with proper torque prevents separation of parts when subjected to pressure and reduces the need for locknuts, although locknuts are sometimes used.

Fundamental Cylinders

Illustration B29



Standard Double-Acting Cylinders

Power stroke is in both directions and is used in the majority of applications.

Single-Acting Cylinders

When thrust is needed in only one direction, a single-acting cylinder may be used. The inactive end is vented to atmosphere through a breather/filter for pneumatic applications, or vented to reservoir below the oil level in hydraulic application.

Double-Rod Cylinders

Used when equal displacement is needed on both sides of the piston, or when it is mechanically advantageous to couple a load to each end. The extra end can be used to mount cams for operating limit switches, etc.

Spring Return, Single-Acting Cylinders

Usually limited to very small, short stroke cylinders used for holding and clamping. The length needed to contain the return spring makes them undesirable when a long stroke is needed.

Ram Type, Single-Acting Cylinders

Containing only one fluid chamber, this type of cylinder is usually mounted vertically. The weight of the load retracts the cylinder. They are sometimes know as “displacement cylinders”, and are practical for long strokes.

Telescoping Cylinders

Available with up to 4 or 5 sleeves; collapsed length is shorter than standard cylinders. Available either single or double-acting, they are relatively expensive compared to standard cylinders.

Tandem Cylinders

A tandem cylinder is made up of two cylinders mounted in line with pistons connected by a common piston rod and rod seals installed between the cylinders to permit double acting operation of each. Tandem cylinders allow increased output force when mounting width or height are restricted.

Duplex Cylinders

A duplex cylinder is made up of two cylinders mounted in line with pistons not connected and with rod seals installed between the cylinders to permit double acting operation of each. Cylinders may be mounted with piston rod to piston (as shown) or back to back and are generally used to provide three position operation.

C

Theoretical Push and Pull Forces for Pneumatic and Hydraulic Cylinders

Push Force and Displacement

Cyl. Bore Size (Inches)	Piston Area (Sq. In.)	Cylinder Push Stroke Force In Pounds At Various Pressures										Cu. Ft. Free Air At 80 psi Pressure, Required To Move Max. Load 1 Inch	Displacement Per Inch Of Stroke (Gallons)
		25	50	65	80	100	250	500	1000	2000	3000		
1	.785	20	39	51	65	79	196	392	785	1570	2355	0.00293	0.00340
1 1/2	1.767	44	88	115	142	177	443	885	1770	3540	5310	0.00659	0.00765
2	3.14	79	157	204	251	314	785	1570	3140	6280	9420	0.01171	0.0136
2 1/2	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	0.01830	0.0213
3 1/4	8.30	208	415	540	664	830	2075	4150	8300	16600	24900	0.03093	0.0359
4	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	0.04685	0.0544
5	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	0.07320	0.0850
6	28.27	707	1414	1838	2262	2827	7068	14135	28270	56540	84810	0.10541	0.1224
7	38.49	962	1924	2502	3079	3849	9623	19245	38490	76980	115470	0.14347	0.1666
8	50.27	1257	2513	3268	4022	5027	12568	25135	50270	100540	150810	0.18740	0.2176
10	78.54	1964	3927	5105	6283	7854	19635	39270	78540	157080	235620	0.29280	0.3400
12	113.10	2828	5655	7352	9048	11310	28275	56550	113100	226200	339300	0.42164	0.4896
14	153.94	3849	7697	10006	12315	15394	38485	76970	153940	307880	461820	0.57389	0.6664
16	201.06	5027	10053	13069	16085	20106	50265	100530	201060	402120	603180	0.74923	0.8704
18	254.47	6362	12724	16541	20358	25447	63618	127235	254470	508940	763410	0.94893	1.1016
20	314.16	7854	15708	20420	25133	31416	78540	157080	314160	628320	942480	1.17119	1.3600

Deductions for Pull Force and Displacement

Piston Rod Dia. (Inches)	Piston Area (Sq. In.)	Piston Rod Diameter Force In Pounds At Various Pressures To determine Cylinder Pull Force or Displacement, deduct the following Force or Displacement corresponding to Rod Size, from selected Push Stroke Force or Displacement corresponding to Bore Size in table above.										Cu. Ft. Free Air At 80 psi Pressure, Required To Move Max. Load 1 Inch	Displacement Per Inch Of Stroke (Gallons)
		25	50	65	80	100	250	500	1000	2000	3000		
1/2	.196	5	10	13	16	20	49	98	196	392	588	0.00073	0.0009
5/8	.307	8	15	20	25	31	77	154	307	614	921	0.00114	0.0013
1	.785	20	39	51	65	79	196	392	785	1570	2355	0.00293	0.0034
1 3/8	1.49	37	75	97	119	149	373	745	1490	2980	4470	0.00554	0.0065
1 3/4	2.41	60	121	157	193	241	603	1205	2410	4820	7230	0.00897	0.0104
2	3.14	79	157	204	251	314	785	1570	3140	6280	9420	0.01171	0.0136
2 1/2	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	0.01830	0.0213
3	7.07	177	354	460	566	707	1767	3535	7070	14140	21210	0.02635	0.0306
3 1/2	9.62	241	481	625	770	962	2405	4810	9620	19240	28860	0.03587	0.0416
4	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	0.04685	0.0544
4 1/2	15.90	398	795	1033	1272	1590	3975	7950	15900	31800	47708	0.05929	0.0688
5	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	0.07320	0.0850
5 1/2	23.76	594	1188	1544	1901	2376	5940	11880	23760	47520	71280	0.08857	0.1028
7	38.49	962	1924	2502	3079	3849	9623	19245	38490	76980	115470	0.14347	0.1666
8	50.26	1257	2513	3267	4021	5026	12565	25130	50260	100520	150780	0.18747	0.2176
9	63.62	1591	3181	4135	5090	6362	15905	31810	63620	127240	190860	0.23722	0.2754
10	78.54	1964	3927	5105	6283	7854	19635	39270	78540	157080	235620	0.29280	0.3400

General Formula

The cylinder output forces are derived from the formula:

$$F = P \times A$$

Where F = Force in pounds.
P = Pressure at the cylinder in pounds per square inch, gauge.
A = Effective area of cylinder piston in square inches.

Free Air refers to normal atmospheric conditions of the air at sea level (14.7 psi). Use above cu. ft. free air required data to compute CFM required from a compressor at 80 psi. Cu. ft. of free air required at other pressures can be calculated using formula below.

$$V_1 = \frac{(P_2 + 14.7)\, V_2}{14.7}$$

Where V_1 = Free air consumption per inch of stroke (cubic feet).
V_2 = Cubic feet displaced per inch of stroke.
P_2 = Gauge pressure required to move maximum load.

Rod End Style 3 Minimum Stroke

Sufficient clearance must exist between machining for female rod end style 3 and the threaded piston-to-rod connection. This clearance is required to maintain pressure envelope integrity and envelope ratings shown above.

To maintain the required clearance, a minimum stroke is required for some bore and rod combinations. See the table below for minimum stroke requirements. Contact the factory when a style 3 rod end with a stroke shorter than shown in the table is required.

PH-2 & PH-3 Series

Bore Ø	Rod Ø	Minimum Stroke
1.50 - 4.00	All	None
5.00	2.000	None
	2.500	1.00
	3.000	1.38
	3.500	1.63
6.00	2.500	None
	3.000	1.38
	3.500	1.38
	4.000	2.00
7.00	3.000	1.25
	3.500	1.50
	4.000	1.50
	5.000	3.13
8.00	3.500	1.50
	4.000	1.50
	5.000	2.88
	5.500	3.63

Bore Ø	Rod Ø	Minimum Stroke
10.00	4.500	1.13
	5.000	1.38
	5.500	2.00
	7.000	3.13
12.00	5.500	1.25
	7.000	2.38
	8.000	3.13
14.00	7.000	2.00
	8.000	2.75
	10.000	4.25
16.00	8.000	1.75
	9.000	2.50
	10.000	3.25
18.00	9.000	1.50
	10.000	2.25
20.00	10.000	1.25

PL-2 Series

Bore Ø	Rod Ø	Minimum Stroke
1.00 - 4.00	All	None
5.00	2.000	None
	2.500	1.000
	3.000	1.375
	3.500	1.625
6.00	2.500	None
	3.000	1.375
	3.500	1.375
	4.000	2.000
8.00	3.500	1.500
	4.000	1.500
	5.000	2.875
	5.500	3.625

C

Operating Fluids and Temperature Range

Cylinders are designed for use with pressurized air, hydraulic oil and fire resistant fluids, in some cases special seals are required.

Standard Seals (Class 1)

Standard seals are what is normally provided in a cylinder unless otherwise specified. They are intended for use with fluids such as: air, nitrogen, mineral base hydraulic oil or MIL-H-5606 within the temperature range of -10°F (-23°C) to +165°F (+74°C). Generally they are nitrile except for piston rod seals in hydraulic cylinders. However the individual seals may be nitrile (Buna-N) enhanced polyurethane, polymyte, PTFE or filled PTFE

Water Base Fluid Seals (Class 2)

Generally these seals are intended for use with water base fluids within the temperature of -10°F (-23°C) to +165°F (+74°C) except for High Water Content Fluids (HWCF) in which case HWCF seals should be used. Typical water base fluids are: Water, Water-Glycol, Water-in Emulsion, Houghto-Safe 27, 620, 5040, Mobil Pyrogard D, Shell Irus 905, Ucon Hydrolube J-4. These seals are nitrile. Lipseal will have polymyte or PTFE back-up washer when required. O-rings will have nitrile back-up washers when required.

Ethylene Propylene (EPR) Seals (Class 3)

These seals are intended for use with some Phosphate Ester Fluids between the temperatures of -10°F (-23°C) to +130°F (+54°C). Typical fluids compatible with EPR seals are Skydrol 500 and 700. EPR are Ethylene Propylene. Lipseals will have a PTFE back-up washer when required. O-rings will have EPR back-up washers when required. Note: EPR seals are not compatible with mineral base hydraulic oil or greases. Even limited exposure to these fluids will cause severe swelling. PTFE back-up washer may not be suitable when used in a radiation environment.

Low Temperature Nitrile Seals (Class 4)

Low temperature nitrile seals are intended for low temperature service with the same type of fluids as used with standard seals within the temperature range of -50°F (-46°C) to +150°F (+66°C). Lipseals will have leather, polymyte or PTFE back-up washers when required. O-rings will have nitrile back-up washers when required.

Fluorocarbon Seals (Class 5)

Fluorocarbon seals are intended for elevated temperature service or for some Phosphate Ester Fluids such as Houghto-Safe 1010, 1055, 1120; Fyrquel 150, 220, 300, 350; Mobile Pyrogard 42, 43, 53, and 55. Note: In addition, fluorocarbon seals can be used with fluids listed below under standard service. However, they are not compatible with Phosphate Ester Fluids such as Skydrols. Fluorocarbon seals can operate with a temperature range of -10°F (-23°C) to +250°F (+121°C). Fluorocarbon seals may be operated to +400°F (+204°C) with limited service life. For temperatures above +250°F (+121°C) the cylinder must be manufactured with non-studded piston rod and thread and a pinned piston to rod connection. Fluorocarbon Lipseals will have PTFE back-up washers when required. O-rings will have fluorocarbon back-up when required.

⚠ Warning

The piston rod stud and the piston rod to piston threaded connections are secured with an anaerobic adhesive which is temperature sensitive. Cylinders specified with fluorocarbon seals are assembled with anaerobic adhesive having a maximum temperature rating of +250°F (+121°C). Cylinders specified with all other seal compounds are assembled with anaerobic adhesive having a maximum operating temperature rating +165°F (+74°C). These temperature limitations are necessary to prevent the possible loosening of the threaded connections. Cylinders originally manufactured with standard seals (Nitrile) that will be exposed to ambient temperatures above +165°F (+74°C) must be modified for higher temperature service. Contact the factory immediately and arrange for the piston to rod and the stud to piston rod connections to be properly re-assembled to withstand the higher temperature service.

HWCF Seals (Class 6)

These seals are intended for High Water Content Fluids (HWCF) such as Houghton Hydrolubric 120B and Sonsol Lubrizol within the temperature range of +40°F (+4°C) to +120°F (+49°C). HWCF seals are special nitrile compound dynamic seals. Lipseals will have PTFE and or polymyte back-up washers when required. O-rings will have nitrile back-up washers when required. Because of the viscosity of these fluids, cylinders specified with HWCF seals, will also be modified to have lip seal piston seals and straight cushions.

Energized PTFE Seals (Class 8 Seals)

Class 8 seals consist of PTFE piston lipseals, rod seal and wiper-seal. Piston seals have an internal stainless steel spring to energize both the static and dynamic sealing lips. They are intended for high temperature applications, to 400° F (204° C), where longer seal life and improved high temperature sealing performance is required. Body and gland o-ring seals will be fluorocarbon. Fluid resistance is comparable to Class 5. Cylinders incorporating Class 8 Seals will not have studded piston rods.

Hi-Load Seals

Hi-load seals consist of one or two filled PTFE dynamic piston seals with an elastomer expander underneath. Hi-load piston arrangement normally consists of a wear ring on each end of the piston with the seals in the middle. These types of seals are virtually leak free seals under static conditions and can tolerate high pressure. The wear rings on the piston can also tolerate high side loads. The dynamic portion of the seal is bronze filled PTFE and compatible with all conditions and fluids listed on this page. However, carbon filled PTFE will provide better seal life when used with HWCF fluids. A nitrile expander will be provided unless EPR or fluorocarbon seals are specified. In those cases the expander will be of EPR or fluorocarbon respectively. Note: It may be necessary to cycle the piston seals 40 or 50 times before achieving leakage free performance.

Lipseal Pistons

Under most conditions lipseals provide the best all around service for pneumatic applications. Lipseals with a back-up washer are often used for hydraulic applications when virtually zero static leakage is required. Lipseals will function properly in these applications when used in conjunction with moderate hydraulic pressures. A high load piston option is recommended when operating at high pressures and especially with large bore hydraulic cylinders.

Low Friction Hydraulic Seals

Low Friction hydraulic seals are available as an option for both piston and rod seals for PH-2, PH-3 and PL-2 Series cylinders. They are sometimes used when a cylinder is controlled by servo or proportional valve. The seal assembly itself is a two piece assembly consisting of a filled PTFE dynamic seal with an elastomer expander. A piston seal assembly consists of one seal assembly in the middle of the piston with a filled PTFE wear ring on each side of the piston. The piston rod seal assembly consists of two seal assembled and an elastomer wiper seal. The filled PTFE seals are compatible with the fluids listed on this page and provide virtually leak free sealing. The expanders and rod wiper will be nitrile unless EPR or fluorocarbon seals are specified. In those cases the expanders and wiper will be EPR and fluorocarbon respectively. When specifying low friction seals specify if piston, piston rod seals or both are required. Note: It may be necessary to cycle these seals 40 or 50 times before achieving leakage free performance.

Cast Iron Piston Rings

Cast iron rings are the standard piston seals for PH-2 and PL-2 Series cylinders. They offer the widest operating conditions by tolerating high operating pressures, wide temperature range and are compatible with most fluids. The only drawback of cast iron rings is that they allow a small amount of leakage. The leakage for a 4" bore cylinder, operating at 2000 psi, with mineral base hydraulic fluid will be less than 10in^3/min. Leakage will increase as pressure, bore size and viscosity of the operating hydraulic fluid increases. For these reasons cast iron rings are not recommended when using water or (HWCF) fluids.

Water Service

For pressures up to 250 psi PA-2 and PL-2 series cylinders can be modified to make them more suitable for use with water as the operating medium. The modifications include chrome-plated cylinder bore; cadmium-plated head, cap and piston; chrome-plated 17-4 stainless steel piston rod; chrome plated cushion sleeve or cushion spear.

Modified cylinders may also be used for higher operating pressures, up to 2000 psi, depending on bore size. See pressure rating for Hydraulic Cylinders. PL-2, PH-2 and PH-3 Series hydraulic cylinders can also be modified for water operation and supplied with chrome-plated cylinder bore; cadmium-plated head, cap and piston; chrome-plated precipitation hardened stainless steel piston rod, chrome-plated cushion sleeve or cushion spear. When high water base fluids are the operating medium, hydraulic cylinders are usually supplied with high water base rod wiper and seals. Water and high water base fluid operated cylinders are best used on short stroke applications or where high pressure is applied only to clamp the load.

Warranty

Schrader Bellows will warrant cylinders modified for water or high water content fluid service to be free of defects in materials or workmanship, but cannot accept responsibility to premature failure due to excessive wear due to lack of lubricity or where failure is caused by corrosion, electrolysis or mineral deposits within the cylinder.

Pre-Lubricated Air Cylinders

Schrader Bellows air cylinders are factory pre-lubricated with Lube-A-Cyl applied to seals, piston, cylinder bore, piston rod and gland surfaces, provides for normal cylinder operations with lubricated air.

Non-Lubricated Air Cylinders

For heavier duty operation, Series PN is recommended for non-lubricated air service. Series PN includes an innovative special composite material wick and ring reservoir assembly in each seal groove to retain the extreme pressure lubricant applied at time of assembly. This lubricant coats the cylinder bore and piston rod and mating surfaces.

Class No.	Typical Fluids	Temperature Range
1 (Standard) (Nitrile Polyurethane)	Air, Nitrogen Hydraulic Oil, Mil-H-5606 Oil	-10°F (-23°C) to +165°F (+74°C)
2 Optional Water Base Fluid Seal	Water, Water-Glycol, HWCF — See Class 6 below. Water-in-Oil Emulsion Houghto-Safe, 271, 620, 5040 Mobil Pyrogard D, Shell Irus 905 Ucon Hydrolube J-4	-10°F (-23°C) to +165°F (+74°C)
3 Special (EPR) (At extra cost) Note: (EPR) seals are not compatible with Hydraulic Oil	Some Phosphate Ester Fluids Skydrol 500, 7000	-10°F (-23°C) to +130°F (+54°C)
4 Special (Nitrile) (At extra cost)	Low Temperature Air or Hydraulic Oil	-50°F (-46°C) to +150°F (+66°C)
5 Optional (At extra cost) (Fluorocarbon Seals) Note: Fluorocarbon seals are not suitable for use with Skydrol fluid, but can be used with hydraulic oil if desired	High Temperature Houghto-Safe 1010, 1055, 1120 Fyrquel 150, 220, 300, 550 Mobil Pyrogard 42,43,53,55	See paragraph on previous page for recommended temperature range of fluorocarbon seals.
6 Optional (HWCF) (At extra cost)	Houghton, Hydrolubric 120B Sonsol Lubrizol, for other HWCF — consult factory.	+40°F (+4°C) to +120°F (+49°C)
8 Optional (At extra cost) Spring Loaded PTFE	See Class 5 Seals	-15°F (-26°C) to 400°F (204°C)

C

Application Data

The proper application of a fluid power cylinder requires consideration of the operating pressure, the fluid medium, the mounting style, the length of stroke, the type of piston rod connection to the load, thrust or tension loading on the rod, mounting attitude, the speed of stroke, and how the load in motion will be stopped. Information given here provides pressure rating data for pneumatic and hydraulic cylinders.

Pneumatic Cylinders

Standard operating fluid — filtered air which is free of moisture. PA-2 and PN Series cylinders are recommended for maximum 250 psi heavy duty service.

Pressure Ratings Fluid Medium Air

Bore Size (Inches)	Standard Piston Rod Diameters (Inches)	Series PA-2, PN
		Max. Heavy-Duty Operating Pressure (psi)
1	1/2	250
1 1/2	5/8	250
2	5/8	250
2 1/2	5/8	250
3 1/4	1	250
4	1	250
5	1	250
6	1 3/8	250
8	1 3/8	250
10	1 3/4	250
12	2	250
14	2 1/2	250

Hydraulic Cylinders (Heavy duty)

Standard operating fluid – clean, filtered hydraulic oil. Pressure ratings for heavy duty hydraulic cylinders are shown in the following table:

Pressure Ratings

PH-2 and PH-3 Series hydraulic cylinders are recommended for pressures to 3000 psi for heavy-duty service with hydraulic oil. The 4:1 design factor ratings shown are based on tensile strength of material and are for standard rod dia. only. The rating is conservative for continuous severe applications. Design factors at other pressures can be calculated from this rating. In addition, mounting styles, stroke, etc., should be considered because of the limiting effect they may have on these ratings.

Maximum Pressure Ratings

Bore Size (Inches)	Rod Ø (Inches)	4:1* Design Factor (Tensile) (psi)	Heavy-Duty Service (psi)
1 1/2	5/8	2530	3000
2	1	2950	3000
2 1/2	1	2340	3000
3 1/4	1 3/8	2250	3000
4	1 3/4	2130	3000
5	2	2170	3000
6	2 1/2	2270	3000
7	3	2030	3000
8	3 1/2	2040	3000
10	4 1/2	2720	3000
12	5 1/2	2580	3000
14	7	2320	3000
16	8	2750	3000
18	9	2900	3000
20	10	2640	3000

*Applies to all mountings except MF1.

Hydraulic Cylinders (Medium duty)

Pressure ratings for PL-2 Series hydraulic cylinders vary by bore size and rod size as shown in table below. For pressures higher than those indicated, PH-2 Series heavy duty cylinders should be used.

PL-2 Series Hydraulic Cylinders Maximum Pressure Rating

Bore Size	Rod Diameters	Pressure Rating At 4:1 Design* Factor (On Tensile)
1	1/2	1900
	5/8	1900
1 1/2	5/8	2000
	1	2300
2	5/8	1100
	1	2000
	1 3/8	2000
2 1/2	5/8	700
	1	1400
	1 3/8	1400
	1 3/4	1400
3 1/4	1	1300
	1 3/8	1300
	1 3/4	1300
	2	1300
4	1	900
	1 3/8	900
	1 3/4	900
	2	900
	2 1/2	900
5	1	600
	1 3/8	950
	1 3/4	950
	2	950
	2 1/2	950
	3	950
	3 1/2	950
6	1 3/8	700
	1 3/4	700
	2	700
	2 1/2	700
	3	700
	3 1/2	700
	4	700
8	1 3/8	400
	1 3/4	650
	2	650
	2 1/2	650
	3	650
	3 1/2	650
	4	650
	4 1/2	650
	5	650
	5 1/2	650

*Applies to all mountings except MF1.

Single rod type, fluid power cylinders are commonly available in 16 standard mounting styles ranging from head or cap end mounts to intermediate mounts. Many mounting styles are also available in double rod type cylinders. Refer to ANSI/(NFPA) T3.6.7R3-2009 Specifications and Mounting Dimension Standards or Schrader Bellows air or hydraulic cylinder catalogs for detailed description.

Standard mounting styles for fluid power cylinders fall into three basic groups. The groups can be described as follows.

Group 1 – Straight line force transfer with fixed mounts which absorb force on cylinder centerline.

Group 3 – Straight line force transfer with fixed mounts which do not absorb force on cylinder centerline.

Group 2 – Pivot force transfer with pivot mounts which absorb force on cylinder centerline and permit cylinder to change alignment in one plane.

Cylinder mounting directly affects the maximum pressure at which the fluid power cylinder can be used, and proper selection of mounting style will have a bearing on cylinder operation and service life. Whether the cylinder is used in thrust or tension, its stroke length, piston rod diameter and the method of connection to load also must be considered when selecting a mounting style.

Cylinders are offered for use with air pressure up to 250 psi; medium-duty hydraulic, depending on bore size, up to 2200 psi; and heavy-duty hydraulic service of up to 3000 psi. The industrial tie rod types, known as NFPA cylinders, with square steel heads and caps, plus steel mountings lend themselves to standardized mounts which are similar in appearance for both air and hydraulic cylinders.

Because of the all steel construction, Schrader Bellows air cylinders have a design factor of better than 4:1, and the various mounts can be used without limitations up to the cylinder manufacturer's maximum rated pressure. Medium-duty and heavy-duty hydraulic cylinders, in some mounting styles, may not be used at full rated pressure, depending on mounting style, stroke length and thrust or tension loading, as discussed in the following:

Straight Line Force Transfer (Group 1)

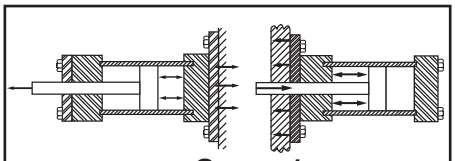
Cylinders with fixed mounts (Group 1) which absorb the force on centerline are considered the best for straight line force transfer. Tie Rods Extended, Flange or Centerline Lug mounts are symmetrical and allow the thrust or tension forces of the piston rod to be distributed uniformly about the cylinder centerline. Mounting bolts are subjected to simple tension or simple shear without compound forces, and when properly installed damaging cylinder bearing sideloading is kept to a minimum.

Tie Rods Extended are considered to be of the centerline mount type. The cylinder tie rods are designed to withstand maximum rated internal pressure and can be extended and used to mount the cylinder at cap or head end. This often overlooked mounting will securely support the cylinder when bolted to the panel or machine member to which the cylinder is mounted. The torque value for the mounting nuts should be the same as the tie rod nut torque recommended by the cylinder manufacturer. Cylinders are available with tie rod extended both ends. In such applications one end is used for mounting and the opposite end to support the cylinder or to attach other machine components.

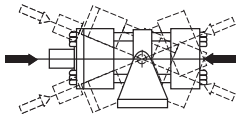
Tie rod mount cylinders may be used to provide thrust or tension forces at full rated pressures.

Tie Rods Extended Head End (Style MX3), Cap End (Style MX2) or Extended Both Ends (Style MX1) are readily available and fully dimensioned in Schrader Bellows cylinder product catalogs.

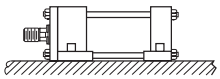
Flange Mount cylinders are also considered to be centerline mount type and thus are among the best mounts for use on straight line force transfer applications. The machine designer has a choice of three mounting styles at each end, such as Head Rectangular Flange (Style MF1), Head Square Flange (Style MF5), Head Rectangular (Style ME5), Cap Rectangular Flange (Style MF2), Cap Square Flange (Style MF6), and Cap Rectangular (Style ME6). Selection of a flange mounting style depends, in part, upon whether the major force applied to the load will result in compression (push) or tension (pull) stresses of the cylinder piston rod. Cap end mounting styles are recommended for thrust loads (push), while head end mounting styles are recommended where the major load puts the piston rod in tension (pull).



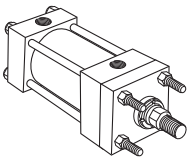
Group 1



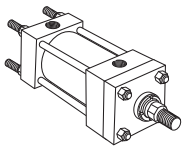
Group 2



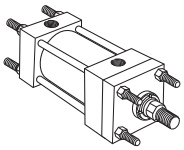
Group 3



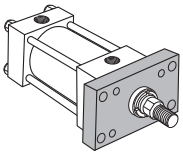
Tie Rods Extended Head End, Style MX3



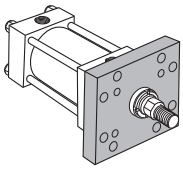
Tie Rods Extended Cap End, Style MX2



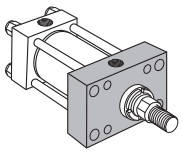
Tie Rods Extended Both Ends, Style MX1



MF1



MF5



ME5

C

Flange mounts are best used when end face is mounted against the machine support member. (Fig. 1) This is especially true where Head Rectangular Flange type (Style MF1) is used with major load in tension. In this mode, the flange is not subjected to flexure or bending stresses, nor are the mounting bolts stressed to unusually high levels. The use of Head Rectangular Flange (Style MF1) mount with major load in compression (see Fig. 2) is not recommended except on reduced pressure systems. The use of Style MF1 mount in compression subjects the flange to bending and the mounting bolts to tension stresses, which could result in early fatigue failure. For maximum allowable pressure with Style MF1 Head Rectangular Mount used for compression (push) or rear face of flange mounted, see pressure rating in product catalogs for medium- or heavy-duty hydraulic cylinders. For applications where push forces require full rated system pressure, Head Square Flange (Style MF5) or Head Rectangular (Style ME5) mounts are recommended. The best head style mounting for either push or pull applications at full rated pressure is Style ME5.

Style ME5 mount has the same mounting hole pattern and rectangular dimensions as the Style MF1 mount. To substitute the Head Rectangular Style ME5 mount for the Head Rectangular Flange, Style MF1 mount, it is necessary to use spacers to fill in the cataloged “F” dimension previously occupied by the “MF1” flange. The spacers are installed as shown in Fig. 3.

Cap flange mounts are also best used when end face is mounted against the machine support member. The use of Cap Rectangular Flange mount, Style MF2, is not recommended on applications where the major load is in tension (pull) except at reduced pressure. For maximum allowable pressure with Cap Rectangular Flange, Style MF2, used in tension application (pull) or front of flange mounted, see maximum pressure rating in product catalogs for medium- and heavy-duty hydraulic cylinders.

For applications where pull forces involved require full rated system pressure, Cap Square Flange, Style MF6, or Cap Rectangular, Style ME6, mounts are recommended. The best cap style mounting for either push or pull applications at full rated pressure is the Cap Rectangular Style ME6.

The Style ME6 mount has the same mounting hole pattern and rectangular dimensions as the Style MF2 mount. To substitute the Style ME6 for Style MF2, it is necessary to use spacers or order a cylinder with piston rod extension to make up for the cataloged “F” dimension previously occupied by the “MF2” flange.

Straight Line Force Transfer (Group 3)

Side Mount cylinders are considered to be fixed mounts which do not absorb force on their centerline. Cylinders of this group have mounting lugs connected to the ends, and one style has side tapped holes for flush mounting. The plane of their mounting surfaces is not through the centerline of the cylinder, and for this reason side mounted cylinders produce a turning moment as the cylinder applies force to the load. (Fig. 4) This turning moment tends to rotate the cylinder about its mounting bolts. If the cylinder is not well secured to the machine member on which it is mounted or the load is not well-guided, this turning moment results in side load applied to rod gland and piston bearings. To avoid this problem, side mount cylinders should be specified with a stroke length at least equal to the bore size.

Shorter stroke, large bore cylinders tend to sway on their mountings when subjected to heavy loads, especially side end lug or side and angle mounts. (Fig. 5)

Side mount cylinders are available in two mounting styles; Side Lug (Style MS2) & Side Tapped (Style MS4). Of these, the side lug mount is the most popular and reliable, since the mounting lugs are welded to head and cap to form an integral unit at each end. Side tapped mount is the choice when cylinders must be mounted side by side at minimum center-to-center distance.

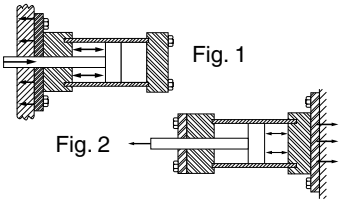


Fig. 1

Fig. 2

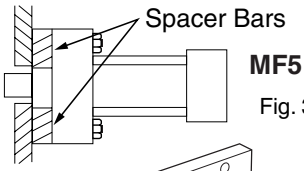
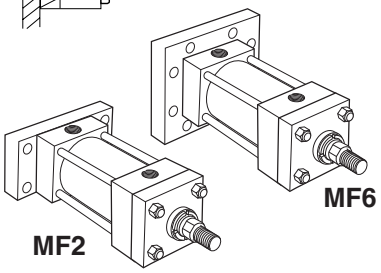
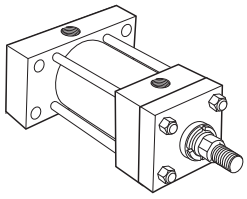
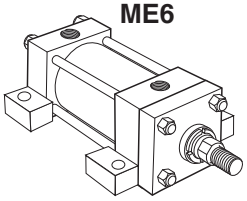


Fig. 3




ME6


MS2

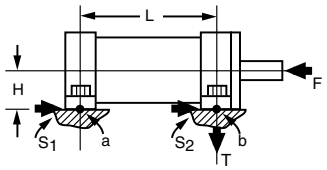


Fig. 4

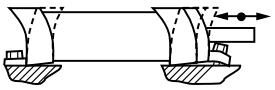
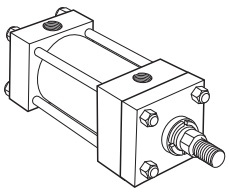


Fig. 5


MS4

Consideration should also be given to design of the machine frame used to support cylinders non-centerline mount, since stronger members are often required to resist bending moments. (See Fig. 6)

Side mount cylinders depend wholly on the friction of their mounting surfaces in contact with the machine member to absorb the force produced. Thus the torque applied to the mounting bolts is an important consideration. Since the mounting bolts are the same diameter as the tie rods for a given cylinder, it is recommended that the torque applied to the mounting bolts be the same as the tie rod torque recommended by the cylinder manufacturer for the given bore size.

For heavy loads or high shock conditions, side mounted cylinders should be held in place to prevent shifting by keying or pinning. A shear key, consisting of a plate extending from side of cylinder, can be supplied on most cylinders. (Fig. 7) This method may be used where a keyway can be milled into a machine member. It serves to take up shear loads and also provides accurate alignment of the cylinder.

Side lug mounts are designed so as to allow dowel pins to be used to pin the cylinder to the machine member. Pins, when used, are installed on both sides of the cylinder but not at both ends. (See Fig. 8)

The use of a separate shear key is fairly common. It should be placed at the proper end of the cylinder to absorb the major load. (See Fig. 9)

Side mount cylinders should not be pinned or keyed at both ends. Changes in temperature and pressure under normal operating conditions cause the cylinder to increase (or decrease) in length from its installed length and therefore must be free to expand and contract. If pinned or keyed at both ends, the advantages of cylinder elasticity in absorbing high shock loads will be lost. (Fig. 10)

If high shock loads are the major consideration, the cylinder should be mounted and pins or shear key so located as to take full advantage of the cylinder's inherent elasticity. For major shock load in tension, locate key at rear face of head or pin the head in place. For major shock load in thrust, pin cap in place or locate key at front face of cap.

Pivot Force Transfer (Group 2)

Cylinders with pivot mounts which absorb force on centerline should be used on applications where the machine member to be moved travels in a curved path. There are two basic ways to mount a cylinder so that it will pivot during the work cycle: clevis or trunnion mounts, with variations of each. Pivot mount cylinders are available in Cap Fixed Clevis (Style MP1), Cap Spherical Bearing (Style MP3), Head Trunnion (Style MT1), Cap Trunnion (Style MT2), and Intermediate Fixed Trunnion (Style MT4).

Pivot mount cylinders can be used on tension (pull) or thrust (push) applications at full rated pressure, except long stroke thrust cylinders are limited by piston rod column strength. See Piston Rod Selection Chart.

Clevis or single ear mounts are usually an integral part of the cylinder cap and provide a single pivot point for mounting the cylinder. A pivot pin of proper length and of sufficient diameter to withstand the maximum shear load developed by the cylinder at rated operating pressure is included as a part of the clevis mount style. The Fixed Clevis mount, Style MP1, is the most popular of the pivot force transfer types and is used on applications where the piston rod end travels in a curved path in one plane. It can be used vertically or horizontally or any angle in between. On long stroke push applications it may be necessary to use a larger diameter piston rod to prevent buckling or stop tube to minimize side loading due to "jackknife" action of cylinder in extended position. Fixed clevis mount cylinders will not function well if the curved path of piston rod travel is other than one plane. Such an application results in misalignment and causes the gland and piston bearing surfaces to be subjected to unnecessary side loading. For applications where the piston rod will travel in a path not more than 3° either side of the true plane motion, a cap spherical bearing mount is recommended. A spherical bearing rod eye should be used at rod end. Most spherical bearing mounts have limited pressure ratings. Consult cylinder manufacturer's product catalog.

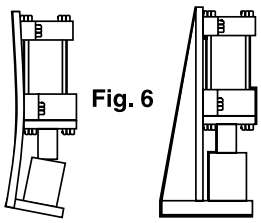


Fig. 6

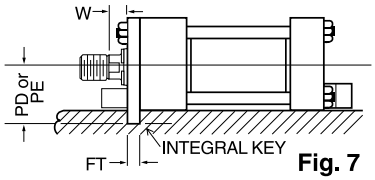


Fig. 7

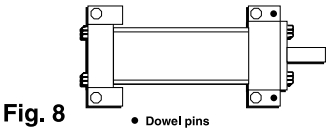


Fig. 8

• Dowel pins

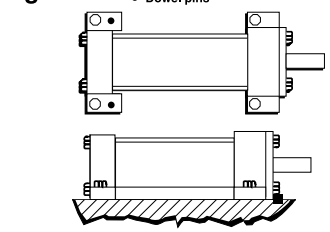


Fig. 9
Right

■ Shear key

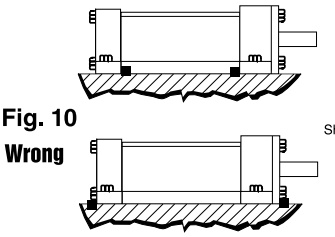
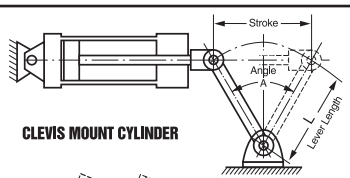
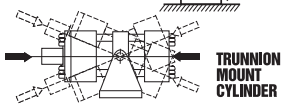
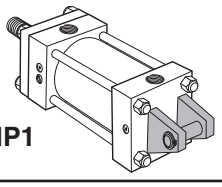


Fig. 10
Wrong

■ Shear key







MP1

C

Cap detachable clevis mounts are usually not available in heavy-duty hydraulic cylinders. They are used more for air or medium hydraulic service. Cap detachable clevis mounts are longer, centerline of pivot pin to shoulder of piston rod, than fixed clevis mount in any given bore size. They are most often specified to avoid port relocation charges. Application parameters are the same as described for fixed clevis mounting.

Trunnion mount cylinders are a second type of pivot mounts used on applications where the piston rod travels in a curved path in one plane. Three styles are available – Head Trunnion (Style MT1), Cap Trunnion (Style MT2) and Intermediate Fixed Trunnion (Style MT4). Trunnion pins are designed for shear loads only and should not be subjected to bending stresses. Pillow blocks, rigidly mounted with bearings at least as long as the trunnion pins, should be used to minimize bending stresses. The support bearings should be mounted as close to the head, cap or intermediate trunnion shoulder faces as possible.

Cap end trunnion mounts are used on cylinder applications similar to fixed clevis mounts, and the same application data applies.

Head trunnion mount cylinders can usually be specified with smaller diameter piston rods than cylinders with pivot point at cap end or at an intermediate position. This is evident in data shown in piston rod selection chart. On head end trunnion mount, long stroke, cylinder applications consideration should be given to the overhanging weight at cap end of cylinder. To keep trunnion bearing loading within limits, stroke lengths should be not more than 5 times the bore size. If cylinder stroke is greater than 5 times the bore size and piston speed exceeds 35 ft/minute, consult factory.

Intermediate fixed trunnion mount is the best of the trunnion mount types. The trunnion can be located so as to balance the weight of the cylinder, or it can be located at any point between the head or cap to suit the application. It is of fixed design, and the location of the trunnion must be specified (XI) dimension) at time of order. The location cannot be easily changed once manufactured.

Thrust exerted by a pivot transfer cylinder working at an angle is proportional to the angle of the lever arm which it operates. In Fig. 12 that vector force, T, which is at right angle to the lever axis, is effective for turning the lever. The value of T varies with the acute angle A between cylinder centerline and lever axes. To calculate effective thrust T, multiply cylinder thrust by the power factor shown in table below.

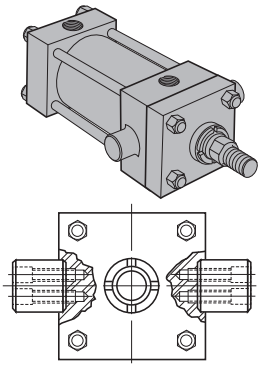
Accessories

Rod clevises or rod knuckles are available for use with either fixed or pivot mount cylinders. Such accessories are usually specified with pivot mount cylinders and are used with pivot pin centerline in same axis as pivot pin centerline on cylinder. Pivot pins for accessories must be ordered separately.

Pin size of rod clevis or rod knuckle should be at least equal in diameter to the pin diameter of the cap fixed clevis pin for the cylinder bore size specified. Larger accessories are more costly and usually result in a mis-match of pin diameters, especially when used with oversize piston rods.

Removable Trunnion Pins

Removable trunnion pins are a convenience when machine structures or confined space prohibit the use of separate pillow blocks situated close to the cylinder sides. Schrader Bellows offers a removable pin design in 1-1/2" through 8" bores sizes. (See following table for recommended maximum operating pressure.) Mounting pin diameters and lengths are identical to those in Mounting Styles MT1 and MT2 for any given bore size. These removable trunnion pins can be provided on the cap end of Series “PA-2” cylinders with any rod diameter. They can also be provided on the head end of cylinders with standard rods.



Pressure Ratings – Removable Trunnion Pin Mounting

Bore Size	1"	1 1/2"	2"	2 1/2"	3 1/4"	4"	5"	6"	8"
Std. Pressure Rating (psi)	–	250	250	250	250	250	150	200	125
Extreme Pressure Rating	–	450	400	275	375	250	150	200	125
Hydraulic Rating (psi)	–	750	700	450	625	400	250	325	200

Spherical Bearing Mount

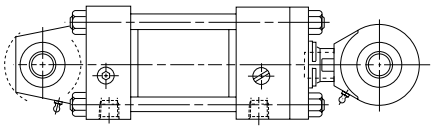
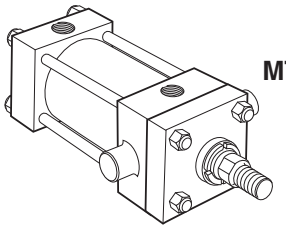
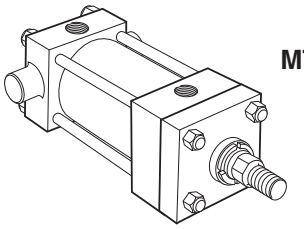


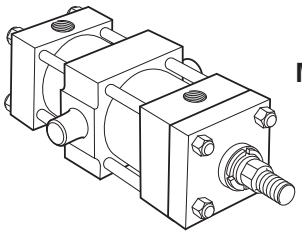
Fig. 11



MT1



MT2



MT4

Clevis Mount Cylinder

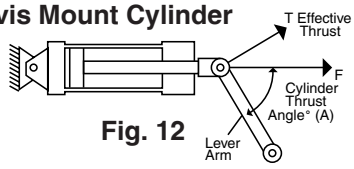


Fig. 12

Power Factor Table

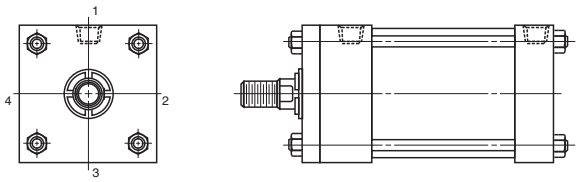
Angle A Degrees	Pwr. Factor (SIN A)	Angle A Degrees	Pwr. Factor (SIN A)
5	0.087	50	0.766
10	0.174	55	0.819
15	0.259	60	0.867
20	0.342	65	0.906
25	0.423	70	0.940
30	0.500	75	0.966
35	0.573	80	0.985
40	0.643	85	0.996
45	0.707	90	1.000

Ports

Schrader Bellows hydraulic and pneumatic cylinders can be supplied with SAE straight O-ring ports or NPTF pipe thread ports. For the type of port recommended and port size, see respective product catalogs. If specified on your order, extra ports can be provided on the sides of heads or caps that are not occupied by mountings or cushion valve on all cylinders.

Standard port location is position 1 as shown on line drawings in product catalog and Figure 1 below. Cushion adjustment needle and check valves are at positions 2 and 4 (or 3), depending on mounting style. Heads or caps which do not have an integral mounting can be rotated and assembled with ports at 90° or 180° from standard position. Mounting styles on which head or cap can be rotated at no extra charge are shown in Table A below. To order, specify by position number. In such assemblies the cushion adjustment needle and check valve rotate accordingly, since their relationship with port position does not change.

Figure 1



Head (Rod) End **Head** **Cap**

Table A

Mounting Style	Port Position Available	
	Head End	Cap End
MX0, MX1, MX2, MX3, MF2, MF5, MF6 MT4	1, 2, 3 or 4	1, 2, 3 or 4
ME6, MP1, MT2	1,2, 3 or 4	1 or 3
MF1, MT1	1 or 3	1, 2, 3 or 4
MS2, MS4	1	1

Applies to PL-2, PH-2, PH-3 Series.

Cylinder Port Options

SAE Straight Thread O-Ring Port. Recommended for most hydraulic applications.

Conventional NPTF Ports (Dry-Seal Pipe Threads). Recommended for pneumatic applications only.

BSPP Port (British Parallel Thread). ISO 228 port commonly used in Europe.

SAE Flange Ports Code 61 (3000 psi). Recommended for hydraulic applications requiring larger port sizes.

BSPT (British Tapered Thread).

Metric Straight Thread Port similar to BSPP with metric thread. Popular in some European applications.

ISO-6149-1 Metric Straight Thread Port. Recommended for all hydraulic applications designed per ISO standards.

Ports can be supplied at positions other than those shown in Table A at an extra charge. To order, specify port position as shown in Figure 1.

C

Available Ports for PH-2, PH-3 Series Cylinders

Bore	SAE Standard	NPTF Pipe Thread	BSPP Parallel Thread	SAE 4-Bolt Flange Nom. Size	BSPT Taper Thread	Metric Straight Thread	ISO-6149-1 Metric Straight Thread
1 1/2	#10	1/2	1/2	N/A	1/2	M22 x 1.5	M22 x 1.5
2	#10	1/2	1/2	N/A	1/2	M22 x 1.5	M22 x 1.5
2 1/2	#10	1/2	1/2	1/2	1/2	M22 x 1.5	M22 x 1.5
3 1/4	#12	3/4	3/4	3/4	3/4	M27 x 2	M27 x 2
4	#12	3/4	3/4	3/4	3/4	M27 x 2	M27 x 2
5	#12	3/4	3/4	3/4	3/4	M27 x 2	M27 x 2
6	#16	1	1	1	1	M33 x 2	M33 x 2
7	#20	1 1/4	1 1/4	1 1/4	1 1/4	M42 x 2	M42 x 2
8	#24	1 1/2	1 1/2	1 1/2	1 1/2	M48 x 2	M48 x 2

Available Ports for PL-2 Series Cylinders

Bore	SAE Standard	NPTF Pipe Thread	BSPP Parallel Thread	BSPT Taper Thread	Metric Straight Thread	ISO-6149-1 Metric Straight Thread
1	#6	1/4	1/4	1/4	M14 x 1.5	M14x 1.5*
1 1/2	#6	3/8	3/8	3/8	M14 x 1.5	M14 x 1.5*
2	#6	3/8	3/8	3/8	M14 x 1.5	M14 x 1.5
2 1/2	#6	3/8	3/8	3/8	M14 x 1.5	M14 x 1.5
3/4	#10	3/8	3/8	3/8	M22 x 1.5	M22 x 1.5
4	#10	1/2	1/2	1/2	M22 x 1.5	M22 x 1.5
5	#10	1/2	1/2	1/2	M22 x 1.5	M22 x 1.5
6	#12	3/4	3/4	3/4	M26 x 1.5	M27 x 2
8	#12	3/4	3/4	3/4	M26 x 1.5	M27 x 2

*Not available on maximum oversize rods

Straight Thread Ports

The SAE straight thread O-ring port is recommended for hydraulic applications. Schrader Bellows will furnish this port configuration at positions shown in Table A on previous page. This port can also be provided at positions other than those shown in Table A at an extra charge. SAE port size numbers are listed next to their NPTF pipe thread counterparts for each bore size in the respective product catalogs. Size number, tube O.D. and port thread size for SAE ports are listed in Table C.

Table C

SAE Straight Thread "O" Ring Ports

Size No.	Tube O.D. (In.)	Thread Size	Size No.	Tube O.D. (In.)	Thread Size
2	1/8"	5/16 - 24	12	3/4"	1 1/16 - 12
3	3/16"	3/8 - 24	—	—	—
4	1/4"	7/16 - 20	16	1"	1 5/16 - 12
5	5/16"	1/2 - 20	20	1 1/4"	1 5/8 - 12
6	3/8"	9/16 - 18	24	1 1/2"	1 7/8 - 12
8	1/2"	3/4 - 16	32	2"	2 1/2 - 12
10	5/8"	7/8 - 14	—	—	—

Note: For the pressure ratings of individual connectors, contact your connector supplier. Hydraulic cylinders applied with meter out or deceleration circuits are subject to intensified pressure at the cylinder piston rod end. The rod end pressure is approximately equal to:

$$\frac{\text{effective cap end piston area}}{\text{effective rod end piston area}} \times \text{Operating Pressure}$$

International Ports

Other port configurations to meet international requirements are available at extra cost. Schrader Bellows cylinders can be supplied, on request, with British standard taper port (BSPT). Such port has a taper of 1 in 16 measured on the diameter (1/16" per inch). The thread form is Whitworth System, and size and number of threads per inch are as follows:

Table D

British Standard Pipe Threads

Nominal Pipe Size	No. Threads Per Inch	Pipe O.D.
1/8	28	.383
1/4	19	.518
3/8	19	.656
1/2	14	.825
3/4	14	1.041
1	11	1.309
1 1/4	11	1.650
1 1/2	11	1.882
2	11	2.347

British standard parallel internal threads are designated as BSP and have the same thread form and number of threads per inch as the BSPT type and can be supplied, on request, at extra cost. Unless otherwise specified, the BSP or BSPT port size supplied will be the same nominal pipe size as the NPTF port for a given bore size cylinder.

Metric ports can also be supplied to order at extra cost.

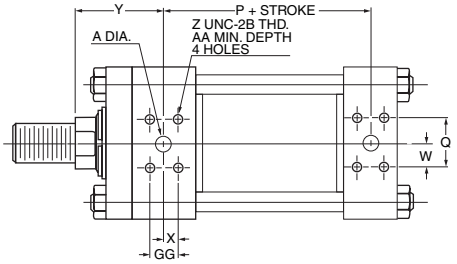
Flange Ports (Code 61, 3000 psi)

SAE 4 Bolt Flange Ports for PH-2, PH-3 (7" & 8")

Bore Size	SAE Dash No.	Rod Ø	Y	A	P	Q	W	X
2-1/2†	8	1.000	2.38	.50	3.00	1.50	.75	.34
3-1/4†	12	1.375	2.75	.75	3.50	1.87	.94	.44
		1.750	3.00					
		2.000	3.13					
4†	12	1.750	3.00	.75	3.75	1.87	.94	.44
		2.000	3.13					
		2.500	3.38					
5†	12	2.000	3.13	.75	4.25	1.87	.94	.44
		2.500	3.38					
		3.000	3.38					
		3.500	3.38					
6	16	All	3.50	1.00	5.00	2.06	1.03	.52
7	20	All	3.75	1.25	5.50	2.31	1.16	.59
8	24	All	3.88	1.50	6.25	2.75	1.37	.70

Bore Size	SAE Dash No.	Z	AA	GG
2-1/2†	8	5/16 - 18	.81	.69
3-1/4†	12	3/8 - 16	.75	.87
4†	12	3/8 - 16	.75	.87
5†	12	3/8 - 16	.75	.87
6	16	3/8 - 16	.87	1.03
7	20	7/16 - 14	1.00	1.19
8	24	1/2 - 13	1.06	1.41

†2 1/2", 3 1/4", 4" & 5" bores cap-flange port not available on MF6 mounting. MF2 mounting not available at position 2 or 4. Port flange overhangs cap on ME6 mounting. 2 1/2" bore head flange port available with 1.000" rod only.



BSPP or Metric Port for PL-2, PH-2, PH-3 Series

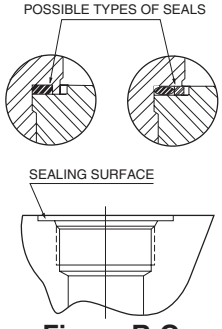


Figure R-G

ISO 6149-1 Port for PL-2, PH-2, PH-3 Series

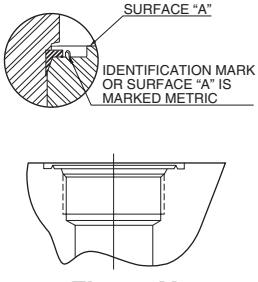
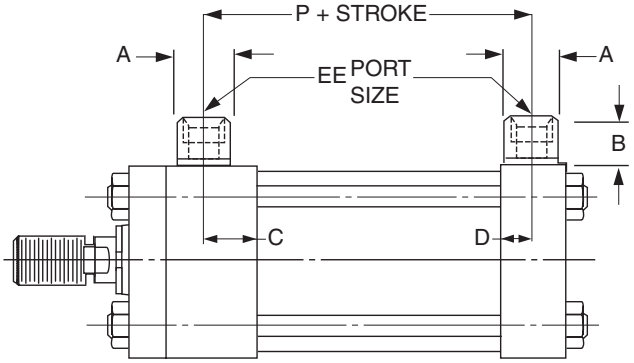


Figure Y

Oversize Ports

Oversize NPTF or SAE straight thread ports can be provided, at an extra charge, on pneumatic and hydraulic cylinders. For ports one size larger than standard, welded port bosses which protrude from the side of the head or cap are supplied. For dimensions, see drawings and tables below. PH-2 and PL-2 cylinders equipped with cushions at the cylinder cap end can sustain damage to the cushion check valve (cushion bushing) if excessive oil flow enters the cylinder from the cap end port. Cylinders which are equipped with cap end cushions and ordered with one size oversize ports having hydraulic fluid flow exceeding 25 ft./sec. in the line entering the cap end of the cylinder should be ordered with a “solid cushion” at cap end. All cylinders ordered with double oversize ports should always be ordered with a “solid cushion” at cap end.

Cylinders which are connected to a meter out flow control with flow entering the cap end of a cylinder provided by an accumulator may also experience damage to the cushion bushing due to high instantaneous fluid flows. This condition can be eliminated by using a meter in flow control or “solid cushions” at cap end.



Oversize NPTF Port Boss Dimensions
PA-2 and PL-2 Series Cylinders

Bore	EE (NPTF)	A (Dia.)	B	C	D	P
1	3/8	7/8	3/4	9/16	1/2	2 1/16
1 1/2	1/2	1 1/8	15/16	9/16	1/2	2 3/16
2	1/2	1 1/8	15/16	9/16	1/2	2 3/16
2 1/2	1/2	1 1/8	15/16	9/16	1/2	2 5/16
3 1/4	3/4	1 3/8	1	11/16	5/8	2 9/16
4	3/4	1 3/8	1	11/16	5/8	2 9/16
5	3/4	1 3/8	1	11/16	5/8	2 13/16
6	1	1 3/4	1 3/16	15/16	3/4	3 3/16
7-8	1	1 3/4	1 3/16	15/16	3/4	3 5/16
10	1 1/4	2 1/4	1 5/16	1 1/8	1	4 1/4
12	1 1/4	2 1/4	1 5/16	1 1/8	1	4 3/4
14	1 1/2	2 1/2	1 9/16	1 1/4	1 1/8	5 1/2

PH-2, PH-3 Series (7" & 8") Cylinders

Bore	EE (NPTF)	A (Dia.)	B	C	D	P
1 1/2	3/4	1 3/8	1	3/4	25/32	2 29/32
2	3/4	1 3/8	1	3/4	25/32	2 29/32
2 1/2	3/4	1 3/8	1	3/4	25/32	3 1/32
3 1/4	1	1 3/4	1 3/16	29/32	7/8	3 17/32
4	1	1 3/4	1 3/16	29/32	7/8	3 25/32
5	1	1 3/4	1 3/16	29/32	7/8	4 9/32
6	1 1/4	2 1/4	1 5/16	1 1/8	1 1/8	5 1/8
7	1 1/2	2 1/2	1 9/16	1 3/8	1 3/8	5 3/4
8	2	3	1 11/16	1 1/2	1 1/2	6 1/2

†Available at head end only. For cap end, consult factory.
**Port tapped directly into head and cap.

Oversize SAE Straight Thread Port Boss Dimensions
PL-2 Series Cylinders

Bore	EE (SAE)	A (Dia.)	B	C	D	P
1	8	1 1/8	15/16	9/16	1/2	2 1/16
1 1/2	8	1 1/8	15/16	9/16	1/2	2 3/16
2	8	1 1/8	15/16	9/16	1/2	2 3/16
2 1/2	8	1 1/8	15/16	9/16	1/2	2 5/16
3 1/4	12	1 3/8	1	11/16	5/8	2 9/16
4	12	1 3/8	1	11/16	5/8	2 9/16
5	12	1 3/8	1	11/16	5/8	2 13/16
6	16†	1 3/4	1 3/16	15/16	3/4	3 3/16
8	16†	1 3/4	1 3/16	15/16	3/4	3 5/16

PH-2, PH-3 Series (7" & 8")

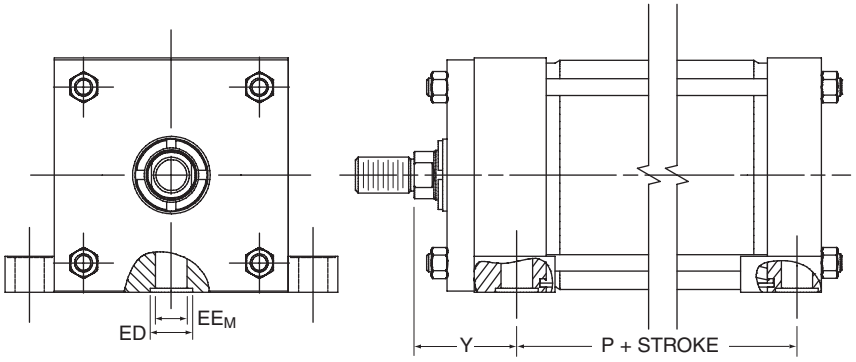
Bore	EE (SAE)	A (Dia.)	B	C	D	P
1 1/2	10[1]	–	–	–	–	2 7/8
2	10[1]	–	–	–	–	2 7/8
2 1/2	10[1]	–	–	–	–	3
3 1/4	16	1 3/4	1 3/16	29/32	29/32	3 9/16
4	16	1 3/4	1 3/16	29/32	29/32	3 13/16
5	16	1 3/4	1 3/16	29/32	29/32	4 5/16
6	20[1]	–	–	–	–	5 3/16
7	24[1]	–	–	–	–	5 5/8
8	N/A	–	–	–	–	6 3/8

[1] Port tapped directly into head and cap.

C

Manifold Ports

Side mounted cylinders, Style MS2 can be furnished with the cylinder ports arranged for mounting and sealing to a manifold surface. The ports are drilled and counterbored for O-ring seals which are provided.



Dimensions — Manifold Ports for Single and Double Rod Cylinders

PH-2, PH-3 Series (7" & 8") Cylinders

Bore	Rod Dia. (MM)	Y±1/32	P±1/32	PK±1/32	EEM	ED
1 1/2	5/8	2	2 7/8	2 7/8	3/4	1 1/8
	1	2 3/8				
2	1	2 3/8	2 7/8	2 7/8	3/4	1 1/8
	1 3/8	2 5/8				
2 1/2	1	2 3/8	3	3	3/4	1 1/8
	1 3/4	2 7/8				
	1 3/8	2 5/8				
3 1/4	1 3/8	2 3/4	3 1/2	3 1/2	1	1 3/8
	2	3 1/8				
	1 3/4	3				
4	1 3/4	2 27/32	4	4 1/16	1	1 3/8
	2 1/2	3 7/32				
	2	2 31/32				
5	2	3 1/8	4 1/4	4 1/4	1	1 3/8
	3 1/2	3 3/8				
	2 1/2					
	3					
6	2 1/2	3 1/2	5 1/8	4 7/8	1 1/4	1 5/8
	4					
	3					
	3 1/2					
7	3	3 13/16	5 7/8	5 3/8	1 1/2	1 7/8
	5					
	3 1/2					
	4					
	4 1/2					
8	3 1/2	3 15/16	6 5/8	6 1/8	1 1/2	1 7/8
	5 1/2					
	4					
	4 1/2					
	5					

PA-2, PL-2 Series Cylinders

Bore	Rod Dia. (MM)	Y±1/32	P±1/32	EEM	ED
1	All	1 15/16	2 1/8	3/8	11/16
1 1/2	5/8	2	2 1/8	1/2	13/16
	1	2 3/8			
2	5/8	2	2 1/8	1/2	13/16
	1 3/8	2 5/8			
	1	2 3/8			
2 1/2	5/8	2	2 1/4	1/2	13/16
	1 3/4	2 7/8			
	1	2 3/8			
	1 3/8	2 5/8			
3 1/4	1	2 7/16	2 5/8	5/8	15/16
	2	3 1/16			
	1 3/8	2 11/16			
	1 3/4	2 15/16			
4	1	2 7/16	2 5/8	5/8	15/16
	2 1/2	3 5/16			
	1 3/8	2 11/16			
	1 3/4	2 15/16			
	2	3 1/16			
5	1	2 7/16	2 7/8	5/8	15/16
	3 1/2, 2 1/2 & 3	3 5/16			
	1 3/8	2 11/16			
	1 3/4	2 15/16			
	2	3 1/16			
6	1 3/8	2 13/16	3 1/8	7/8	1 3/16
	4, 2 1/2, 3 & 3 1/2	3 7/16			
	1 3/4	3 1/16			
	2	3 3/16			
7 - 8	1 3/8	2 13/16	3 1/4	7/8	1 3/16
	5 1/2, 2 1/2, 3, 3 1/2, 4, 4 1/2 & 5	3 7/16			
	1 3/4	3 1/16			
	2	3 3/16			
10	1 3/4	3 1/8	4 1/8	1 3/16	1 1/2
	2	3 1/4			
	2 1/2, 3, 3 1/2, 4, 4 1/2, 5 & 5 1/2	3 1/2			
12	2	3 1/4	4 5/8	1 3/16	1 1/2
	2 1/2, 3, 3 1/2, 4, 4 1/2, 5 & 5 1/2	3 1/2			
14	All	3 13/16	5 1/2	1 9/16	1 7/8

Rod End Data

Rod end dimension symbols as shown comply with the National Fluid Power Association dimensional code. The following chart indicates the symbols used in this catalog.

Description	Symbol
Thread diameter and pitch	KK or CC
Length of thread	A
Length of rod extension from face of gland retainer to end of retracted rod	A + W (Male Thread) W (Female Thread)

Three rod ends for Schrader Bellows cylinders are offered as shown on the dimension pages of this catalog. They are Schrader Bellows styles 2, 3 and 4, and all three are optional without price penalty. If a rod end style is not specified, style 2 (N.F.P.A. Style SM) will be supplied. Style 2 is supplied with high strength rolled thread studs on piston rods through 2" diameter. Longer studs in standard sizes are available, see table below.

Warning!

Piston rods are not normally designed to absorb bending moments or loads which are perpendicular to the axis of piston rod motion. These additional loads can cause the piston rod end to fail. If these types of additional loads are expected to be imposed on the piston rods, their magnitude should be made known to our Engineering Department so they may be properly addressed. Additionally, cylinder users should always make sure that the piston rod is securely attached to the machine member.

On occasion cylinders are ordered with double rods. In some cases a stop is threaded onto one of the piston rods and used as an external stroke adjuster. This can cause a potential safety concern and can also lead to premature piston rod failure. The external stop will create a pinch point and the cylinder user should consider appropriate use of guards. If an external stop is not parallel to the final contact surface it will place a bending moment on the piston rod. An external stop will also negate the effect of a cushion and will subject the piston rod to an impact loading. These two (2) conditions can cause piston rod failure. The use of external stroke adjusters should be reviewed with our Engineering Department.

Piston Rod End Threads

Standard piston rod end thread lengths are shown as dimension “A” in Catalog dimension pages. Special rod end threads which are two times standard length can be supplied at a small extra cost. Available thread lengths are shown in the table below. To order, add suffix “2” to piston rod model number code and specify as Style #22.

Optional Piston Rod End Studs

Piston Rod Dia.	Rod End Thread Style #2	
	Thread Dia. & Pitch (KK)	Length (= 2 x A)
5/8	7/16 - 20	1 1/2
1	3/4 - 16	2 1/4
1 3/8	1 - 14	3 1/4
1 3/4	1 1/4 - 12	4
2	1 1/2 - 12	4 1/2

International Rod End Threads

Piston rod threads to meet international requirements are available at extra cost. Schrader Bellows cylinders can be supplied with British standard fine (W) or metric (M). To order, specify in model number. For dimensions, consult factory.

Special Rod Ends

If a rod end configuration other than the standard styles 2, 3 and 4 is required, such special rod ends can be provided. The designation “Style 0” is assigned to such specials and is incorporated in the cylinder model number. To order, specify “Style 0” and give desired dimensions for CC or KK, A, LA or LAF, or W if female end. If otherwise special, send a dimensioned sketch.

Special Assemblies from Standard Parts

Each dimensioned drawing in this catalog has position numbers shown on the end view to identify the four sides of the cylinder. These aid in communications and simplify the writing of specifications that cover changes in port positions, etc. Following are several suggested special assemblies that can be made up from standard parts.

a) By calling out the position numbers for the desired locations for head and cap ports, many mounting styles can be assembled with ports located at 90° or 180° from standard. In such special assemblies, the cushion needle and check valves are also repositioned since their relation with the port position does not change.

b) The cushion needle valve can be assembled on side position 4 with the check valve on side 2 or most mounting styles when the port is in the standard side position 1.

On mounting styles MT1, MT2 and MT4, the cushion needle valves are provided only on the side position 3 on the head or cap which accommodates the mounting. The opposite head or cap can be rotated.

c) Standard mountings in different combinations can be specified on either head or cap end. Consult factory for details.

Single-Acting Cylinders

Double-acting cylinders are supplied as standard. They can also be used a single-acting cylinders where fluid force is applied to only one side of the piston, with the load or other external forces acting to “return” the piston after pressure is exhausted.

Spring-Returned, Single-Acting Cylinders – Single-acting, spring-returned models can also be provided. Load conditions and friction factors must be considered in supplying the proper spring for the application. In addition, it is necessary that information be supplied as to which side of the piston the spring should act upon. Specify "Spring to return piston rod” or “Spring to advance piston rod.”

On longer stroke spring-returned cylinders, it is recommended that tie rod extensions be specified on the cylinder end in which the spring is located so that the cap or head against which the spring is acting can be “backed-off” slowly until compression of the spring is relieved. In such cases it should also be specified that the tie rod nuts be welded to the tie rods at the opposite end of the cylinder to further insure safe disassembly.

Consult factory when ordering spring-returned cylinders.

C

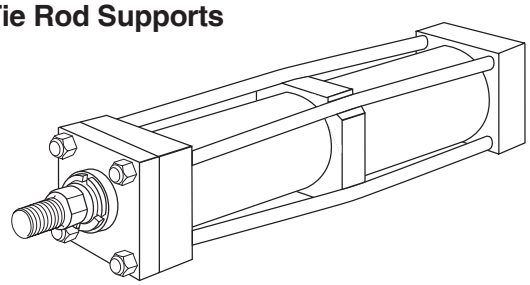
Stroke Data

Schrader Bellows cylinders are available in any practical stroke length. The following information should prove helpful to you in selecting the proper stroke for your cylinder application.

Stroke Tolerances

Stroke length tolerances are required due to buildup of tolerances of piston, head, cap and cylinder body. Standard production stroke tolerances run +1/32" to -1/64" up to 20" stroke, +1/32" to -.20" for 21" to 60" and +1/32" to -1/32" for greater than 60" stroke. For closer tolerances on stroke length, it is necessary to specify the required tolerance plus the operating pressure and temperature at which the cylinder will operate. Stroke tolerances smaller than .015" are not generally practical due to elasticity of cylinders. If machine design requires such close tolerances, use of a stroke adjuster (at right) may achieve the desired result.

Tie Rod Supports



Rigidity of Envelope

The pre-stressed tie rod construction of Schrader Bellows cylinders has advantages in rigidity within the limits of the cylinder tube to resist buckling. For long stroke cylinders within practical limits, Schrader Bellows provides exclusive TIE ROD SUPPORTS (see table below) which move the tie rod centerlines radially outward.

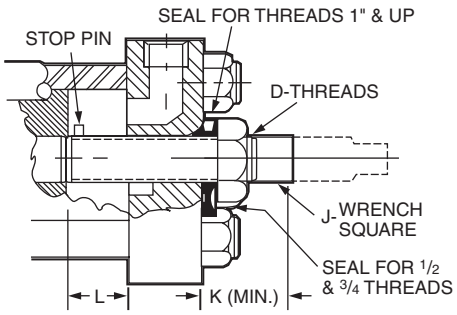
Standard tie rod supports are kept within the envelope dimensions of the head and cap, and generally do not interfere with mounting a long cylinder.

Number of Supports Required	Stroke (Inches)												
Bore	**36**	**48**	**60**	**72**	**84**	**96**	**108**	**120**	**132**	**144**	**156**	**168**
1	—	1	1	1	2	Consult Factory						
1 1/2	—	—	1	1	1	2	2	2	3	3	3	4
2	—	—	—	1	1	1	1	2	2	2	2	3
2 1/2	—	—	—	—	—	1	1	1	1	1	2	2
3 1/4	—	—	—	—	—	—	—	1	1	1	1	1
4	—	—	—	—	—	—	—	—	—	1	1	1

Note: 5" through 14" bore sizes — no supports required.

Stroke Adjusters

For the requirement where adjusting the stroke is specified, Schrader Bellows has several designs to offer, one of which is illustrated below. This is suitable for infrequent adjustment and is economical.*



Here a "retracting stroke adjuster" must be called for in specifications, and the length *of the adjustment must be specified.*

Where frequent adjustment or cushions at the cap end are required, other designs are available according to application needs.

Bore Size					
PA-2 PL-2 Series	**PH-2 Series**	**D**	**J**	**K**	**L (Max.)**
1 1/2, 2	1 1/2	1/2 - 20	5/16	15/16	5
2 1/2, 3 1/4, 4	2	3/4 - 16	7/16	1 1/4	8
5, 6	2 1/2, 3 1/4	1 - 14	5/8	1 11/16	9
8	4	1 1/2 - 12	15/16	2 1/8	18
10	5	2-12	1 5/16	2 11/16	20
12, 14	6	2 1/2 - 12	1 11/16	3 1/8	20
—	7	3-12	2	3 1/4	20
—	8	3 1/2 - 12	2 3/8	3 1/2	20

* Infrequent is defined by positioning the retract stroke in a couple of attempts at original machine set-up. The frequent stroke adjuster is recommended when adjustments may be required by the end user.

Rod Gland Drain

Rod gland drains permit capture of fluid that may accumulate between the primary rod seal and the wiperseal. A 1/8 NPTF port is provided in the gland retainer or cylinder head (see table below) for connection of plumbing that flows oil back to the reservoir. Use of translucent tubing as the drain to reservoir line can provide visual indication of a need for rod seal service when the cylinder gland is not easily visible within the equipment. Specify rod gland drain port option and the drain port location, position 1, 2, 3, or 4.

Drain Port Location

Bore	Rod Dia.	MX2, MX0, MF2, MF6, ME6, MS2 (no key), MS4 (no key), MT1, MT2, MP1, MT4, MPU3	MX1 MX3	MF1 MF5	ME5	MS2, MS4 With Thrust Key Plate
1 1/2	5/8	Head	Head	Head	Head	Head
	1	Full	Full	Flange	Head	Key
2	1	Bolted	Full	Flange	Head	Key
	1 3/8	Full	Full	Flange	Head	Key
2 1/2	1	Bolted	Bolted	Flange	Head	Head
	1 3/8	Bolted	Bolted	Flange	Head	Head
	1 3/4	Bolted	Bolted	Flange	Head	Key
3 1/4	All	Bolted	Bolted	Flange	Head	Head
4	All	Bolted	Bolted	Head	Head	Head
5	2 - 3	Bolted	Bolted	Head	Head	Head
	3 1/2	Bolted	Bolted	Flange	Head	Key
6 - 8	All*	Bolted	Bolted	Head	Head	Head

* On 5½" diameter piston rods, with drain in position 2 or 4, the port will be offset 18 degrees clockwise from the position specified.

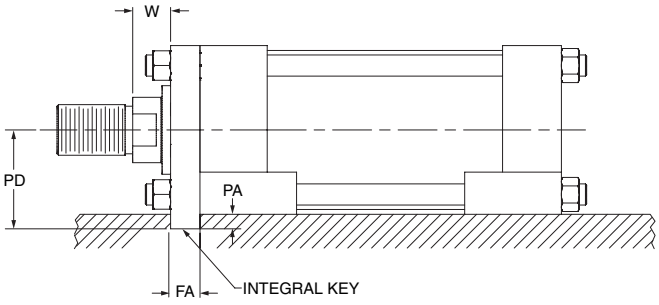
Bolted = Bolted Retainer
Flange = Flange Retainer
Full = Full Retainer
Key = Key Retainer

The full square retainer, key retainer, or mounting flange thickness is increased on bore and rod combinations listed in the table below. The piston rod is extended on MX1, MX3, MF5, and MF1 mounts to provide the standard 'W' dimension.

Bore	Rod Dia.	Retainer or Mounting Flange Thickness
1 1/2	1	5/8
2	1 3/8	3/4
2 1/2	1 3/4	7/8
3 1/4	1 3/4 & 2	7/8

Thrust Key Mountings

Thrust key mountings eliminate the need of using fitted bolts or external keys on side mounted cylinders. Schrader Bellows cylinders in mounting styles MS2 and MS4 can be provided with the gland retainer plate extended below the mounting side of the cylinder (see illustration below). This extended retainer plate can then be fitted into a keyway milled into the mounting surface of the machine member.



PA-2, PN and PL-2 Series

Bore	Dim. FA	Dim. PA	Dim. PD Mtg. Styles MS2, MS4
1	.312 +.000 -.002	3/16	15/16
1 1/2			1 3/16
2			1 7/16
2 1/2			1 11/16
3 1/4	.562 +.000 -.002	5/16	2 3/16
4			2 9/16
5			3 1/16
6	.687 +.000 -.002	3/8	3 5/8

PH-2, PH-3 Series (7" & 8") Cylinders

Bore	+.000 / -.001 Dim. FA	Dim. PA	Dim. PD Mtg. Styles MS2, MS4
1 1/2	.361	3/16	1 7/16
2	.611	5/16	1 13/16
2 1/2	.611	5/16	2 1/16
3 1/4	.736	3/8	2 5/8
4	.861	7/16	2 15/16
5	.861	7/16	3 11/16
6	.986	1/2	4 1/4
7	.986	1/2	4 3/4
8	.986	1/2	5 1/4

C

Stroke Data

Schrader Bellows cylinders are available in any practical stroke length. The following information should prove helpful to you in selecting the proper stroke for your cylinder application.

Stroke Tolerances

Stroke length tolerances are required due to buildup of tolerances of piston, head, cap and cylinder tube. Standard production of stroke tolerances run +.031" to -.015" up to 20" stroke, +.031" to -.020" for 21" to 60" and +.031" to -.031" for greater than 60" stroke. For closer tolerances on stroke length, it is necessary to specify the required tolerance plus the pressure and temperature at which the cylinder will operate. Stroke tolerances smaller than .015" are not generally practical due to elasticity of cylinders. If machine design requires such close tolerances, use of a stroke adjuster may achieve the desire result.

Mounting Groups

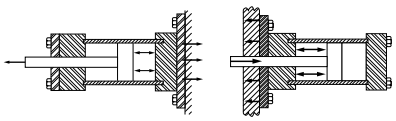
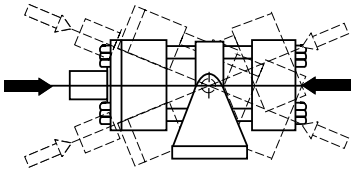
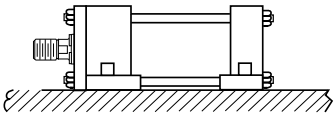
Standard mountings for fluid power cylinders fall into three basic groups. The groups can be summarized as follows:

Group 1 Straight Line Force Transfer with fixed mounts which absorb force on cylinder centerline.

Group 2 Pivot Force Transfer. Pivot mountings permit a cylinder to change its alignment in one plane.

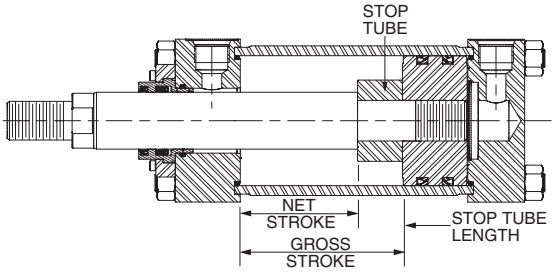
Group 3 Straight Line Force Transfer with fixed mounts which do not absorb force on cylinder centerline.

Because a cylinder's mounting directly affects the maximum pressure at which the cylinder can be used, the chart below should be helpful in selection of the proper mounting combination for your application. Stroke length, piston rod connection to load, extra piston rod length over standard, etc., should be considered for thrust loads. Alloy steel mounting bolts are recommended for all mounting styles, and thrust keys are recommended for Styles MS2 and MS4.

Group 1 FIXED MOUNTS which absorb force on cylinder centerline.	
	
Heavy-Duty Service For Thrust Loads For Tension Loads	Styles MF6, MX2 Styles MF5, ME5, MX3
Medium-Duty Service For Thrust Loads For Tension Loads	Styles MF2, MF6 Styles MF1, MF5
Light-Duty Service For Thrust Loads For Tension Loads	Style MF2 Style MF1
Group 2 PIVOT MOUNTS which absorb force on cylinder centerline.	
	
Heavy-Duty Service For Thrust Loads For Tension Loads	Styles MT4, MT1 Styles MP1, MT4, MT1, MT2
Medium-Duty Service For Thrust Loads For Tension Loads	Styles MP1, MPU3 Styles MP1, MPU3
Group 3 FIXED MOUNTS which do not absorb force on the centerline.	
	
Heavy-Duty Service For Thrust Loads For Tension Loads	Styles MS2 Styles MS2
Medium-Duty Service For Thrust Loads For Tension Loads	Styles MS4 Styles MS4

Stop Tubing

Stop tube is recommended to lengthen the distance between the rod bearing and piston bearing to reduce bearing loads on long push stroke cylinders when the cylinder is fully extended. This is especially true of horizontally mounted cylinders. As part of the piston assembly and positioned between the piston and head, a stop tube restricts the extended position of the rod using the increased distance to achieve additional stability.



Use the following steps to determine the need for stop tube and, if required, how long it should be.

1. Examine the groups of cylinder illustrations below and determine which mounting and rod guiding group type match the required cylinder application.
2. Establish the Basic Length (L), with the piston rod fully extended, for the selected illustration by using the dimensional tables on previous pages of this catalog. For pivot mounted cylinders, the pin-to-pin dimension with the piston rod fully extended must be used. Regardless of mounting style, be sure to include any extended piston rod length beyond the catalog standard.
3. In the Stop Tube Table select the column for the appropriate mounting style and rod end guiding type. In the Basic Length (L) column, find the row with the range that includes the value calculated in Step 2. The next respective column to the right has the required length of stop tube.

Note: Mounting Styles MP1, MT2, MF2, MF6, ME6 and MPU3 that are mounted horizontally should also be checked for turning moments and loads between the rod bearing and piston to ensure they are not excessive. Weight of oil must be included in determining bearing loads.

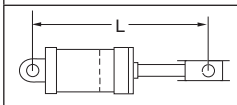
When specifying cylinders with stop tube be sure to call out the net stroke and the length of the stop tube. Machine design can be continued without delay by laying in a cylinder equivalent in length to the NET STROKE PLUS STOP TUBE LENGTH, which is referred to as GROSS STROKE.

Stop Tube Length vs Basic Length (L)

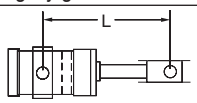
Pivot Mounts (MP1, MT1, MT2, MT4 and MPU3)		**Fixed Mounts (MS2, MS4, MF2, MF6, ME6, MF1, MF5, ME5, MX1, MX2, MX3)**					
Pivoted and Rigidly Guided Rod End		**Fixed & Rigidly Guided Rod End**		**Pivoted & Rigidly Guided Rod End**		**Unguided Rod End**	
Basic Length (L)	**Stop Tube Length**	**Basic Length (L)**	**Stop Tube Length**	**Basic Length (L)**	**Stop Tube Length**	**Basic Length (L)**	**Stop Tube Length**
0 - 40	0	0 - 80	0	0 - 57	0	0 - 20	0
41 - 50	1	81 - 100	1	58 - 71	1	21 - 25	1
51 - 60	2	101 - 120	2	72 - 86	2	26 - 30	2
61 - 70	3	121 - 140	3	87 - 100	3	31 - 35	3
71 - 80	4	141 - 160	4	101 - 114	4	36 - 40	4
81 - 90	5	161 - 180	5	115 - 129	5	41 - 45	5
91 - 100	6	181 - 200	6	130 - 143	6	46 - 50	6
101 - 110	7	201 - 220	7	144 - 157	7	51 - 55	7
111 - 120	8	221 - 240	8	158 - 171	8	56 - 60	8
121 - 130	9	241 - 260	9	172 - 186	9	61 - 65	9
131 - 140	10	261 - 280	10	187 - 200	10	66 - 70	10
141 - 150	11	281 - 300	11	201 - 214	11	71 - 75	11
151 - 160	12	Consult Factory		215 - 229	12	76 - 80	12
161 - 170	13			230 - 243	13	81 - 85	13
171 - 180	14			244 - 257	14	86 - 90	14
181 - 190	15			258 - 271	15	91 - 95	15
191 - 200	16			272 - 286	16	96 - 100	16
201 - 210	17			287 - 300	17	101 - 105	17
211 - 220	18			Consult Factory		106 - 110	18
221 - 230	19					111 - 115	19
231 - 240	20					116 - 120	20
241 - 250	21					121 - 125	21
251 - 260	22					126 - 130	22
261 - 270	23					131 - 135	23
271 - 280	24					136 - 140	24
281 - 290	25					141 - 145	25
291 - 300	26					146 - 150	26
Consult Factory						Consult Factory	

Cylinder Mounting and Rod Guiding Groups

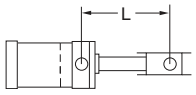
Pivot Mount – Pivoted and rigidly guided rod end



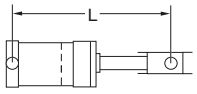
Styles MP1, MPU3



Style MT4

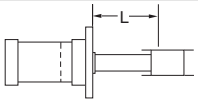


Style MT1

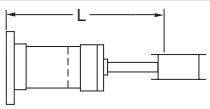


Style MT2

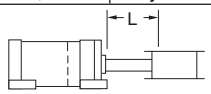
Fixed Mount – Fixed and rigidly guided rod end



Styles MF1, MF5, ME5

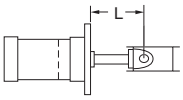


Styles MF1, MF6, ME6

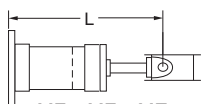


Styles MS2, MS4

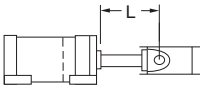
Fixed Mount – Pivoted and rigidly guided rod end



Styles MF1, MF5, ME5

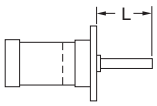


MF2, MF6, ME6

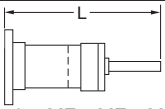


Styles MS2, MS4

Fixed Mount – Unguided rod end



Styles MF1, MF5, ME5



Styles MF2, MF6, ME6

C

Piston Rod Diameter Selection

Long stroke cylinders that work on push with the piston rod loaded in compression should be checked, using the following steps, to ensure an appropriate piston rod diameter is specified.

1. First, determine whether stop tubing is required as described on the previous page.
2. Use the Basic Length (L) that was established for determining the stop tube length and then add the required stop tube length to the Basic Length to obtain an Adjusted Basic Length (L_A).
3. In the table below, for the mounting style and rod end guiding condition that will be used, find the row for the Bore and Rod combination that is required.
4. Follow the Bore and Rod row to the right and find the Operating Pressure column that is closest, but exceeds the system pressure. The intersection of the Bore and Rod row and Operating Pressure column displays the maximum allowable L_A. If L_A in the table is greater than or equal to the calculated L_A, the rod diameter selected is satisfactory for the application.
5. If L_A in the table is less than the calculated Adjusted Basic Length move down the column to a rod diameter with an L_A that exceeds the requirement.
6. If the L_A specifies a rod diameter in a larger bore then restart the process of sizing the stop tube and re-check the rod diameter. Contact the factory if L_A exceeds 300 inches.

Note: Data in these tables assume standard rod extension (W dimension) and standard rod end accessories. If different, consult factory.

PH-2 & PH-3 Series Maximum Basic Lengths (L) (all dimensions in inches)

Bore Ø	Rod Ø	Front and Side Fixed Mounts (MF1[1], MF5[1], ME5, MX1, MX3, MS2, MS4)																	
		Fixed and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:						Pivoted and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:						Unguided Rod End Max. Allowable Basic Length (L_A) at psi:					
		500	1000	1500	2000	2500	3000	500	1000	1500	2000	2500	3000	500	1000	1500	2000	2500	3000
1.50	0.625	50	35	29	25	22	20	36	25	21	18	16	15	13	9	7	6	6	5
	1.000	128	91	74	64	57	52	92	65	53	46	41	37	32	23	19	16	14	13
2.00	1.000	96	68	56	48	43	39	69	49	40	34	31	28	24	17	14	12	11	10
	1.375	182	129	105	91	81	74	130	92	75	65	58	53	45	32	26	23	20	19
2.50	1.000	77	54	44	38	34	31	55	39	32	27	25	22	19	14	11	10	9	8
	1.375	146	103	84	73	65	59	104	73	60	52	46	42	36	26	21	18	16	15
	1.750	236	167	136	118	105	96	168	119	97	84	75	69	59	42	34	29	26	24
3.25	1.375	112	79	65	56	50	46	80	57	46	40	36	33	28	20	16	14	13	11
	1.750	181	128	105	91	81	74	130	92	75	65	58	53	45	32	26	23	20	19
	2.000	237	167	137	118	106	97	169	120	98	85	76	69	59	42	34	30	26	24
4.00	1.750	147	104	85	74	66	60	105	74	61	53	47	43	37	26	21	18	16	15
	2.000	192	136	111	96	86	79	137	97	79	69	61	56	48	34	28	24	22	20
	2.500	300	213	174	150	134	123	215	152	124	107	96	88	75	53	43	38	34	31
5.00	2.000	154	109	89	77	69	63	110	78	63	55	49	45	38	27	22	19	17	16
	2.500	241	170	139	120	108	98	172	121	99	86	77	70	60	43	35	30	27	25
	3.000	300	245	200	173	155	141	247	175	143	124	111	101	87	61	50	43	39	35
	3.500	300	300	272	236	211	192	300	238	194	168	151	137	118	83	68	59	53	48
6.00	2.500	200	142	116	100	90	82	143	101	83	72	64	58	50	35	29	25	22	20
	3.000	289	204	167	144	129	118	206	146	119	103	92	84	72	51	42	36	32	29
	3.500	300	278	227	196	176	160	281	198	162	140	125	115	98	69	57	49	44	40
	4.000	300	300	296	257	229	209	300	259	212	183	164	150	128	91	74	64	57	52
7.00	3.000	247	175	143	124	111	101	177	125	102	88	79	72	62	44	36	31	28	25
	3.500	300	238	194	168	151	137	241	170	139	120	108	98	84	60	49	42	38	34
	4.000	300	300	254	220	197	180	300	222	181	157	140	128	110	78	63	55	49	45
	4.500	300	300	300	278	249	227	300	281	230	199	178	162	139	98	80	70	62	57
	5.000	300	300	300	300	300	281	300	300	283	245	220	200	172	121	99	86	77	70
8.00	3.500	295	208	170	147	132	120	210	149	122	105	94	86	74	52	43	37	33	30
	4.000	300	272	222	192	172	157	275	194	159	137	123	112	96	68	56	48	43	39
	4.500	300	300	281	244	218	199	300	246	201	174	156	142	122	86	70	61	54	50
	5.000	300	300	300	300	269	245	300	300	248	215	192	175	150	106	87	75	67	61
	5.500	300	300	300	300	300	297	300	300	300	260	232	212	182	129	105	91	81	74
10.00	4.500	300	276	225	195	174	159	278	197	161	139	124	114	97	69	56	49	44	40
	5.000	300	300	278	241	215	196	300	243	198	172	154	140	120	85	69	60	54	49
	5.500	300	300	300	291	260	238	300	294	240	208	186	170	146	103	84	73	65	59
	7.000	300	300	300	300	300	300	300	300	300	300	300	275	236	167	136	118	105	96
12.00	5.500	300	300	280	243	217	198	300	245	200	173	155	141	121	86	70	61	54	50
	7.000	300	300	300	300	300	300	300	300	300	281	251	229	196	139	113	98	88	80
	8.000	300	300	300	300	300	300	300	300	300	300	300	299	257	181	148	128	115	105
14.00	7.000	300	300	300	300	300	275	300	300	278	241	215	196	168	119	97	84	75	69
	8.000	300	300	300	300	300	300	300	300	300	300	281	256	220	155	127	110	98	90
	10.000	300	300	300	300	300	300	300	300	300	300	300	300	300	243	198	172	154	140
16.00	8.000	300	300	300	300	300	300	300	300	300	275	246	224	192	136	111	96	86	79
	9.000	300	300	300	300	300	300	300	300	300	300	300	284	244	172	141	122	109	99
	10.000	300	300	300	300	300	300	300	300	300	300	300	300	300	213	174	150	134	123
18.00	9.000	300	300	300	300	300	300	300	300	300	300	277	252	216	153	125	108	97	88
	10.000	300	300	300	300	300	300	300	300	300	300	300	300	267	189	154	134	120	109
20.00	10.000	300	300	300	300	300	300	300	300	300	300	300	281	241	170	139	120	108	98

[1] Maximum operating pressure is limited for Mounting Styles MF1 and MF5. Please refer to maximum operating pressure per bore in Pressure Ratings table located on the dimension page for each of these mounting styles.

PH-2 & PH-3 Series Maximum Basic Lengths (L_A) (all dimensions in inches)

Bore Ø	Rod Ø	Rear Fixed Mounts (MF2[1], MF6[1], ME6, MX2)																	
		Fixed and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:						Pivoted and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:						Unguided Rod End Max. Allowable Basic Length (L_A) at psi:					
		500	1000	1500	2000	2500	3000	500	1000	1500	2000	2500	3000	500	1000	1500	2000	2500	3000
1.50	0.625	70	50	40	35	31	29	50	35	29	25	22	20	18	12	10	9	8	7
	1.000	170	120	98	85	76	69	121	86	70	61	54	50	42	30	25	21	19	17
2.00	1.000	132	93	76	66	59	54	94	67	54	47	42	38	33	23	19	16	15	13
	1.375	232	164	134	116	104	95	166	117	96	83	74	68	58	41	33	29	26	24
2.50	1.000	107	76	62	54	48	44	77	54	44	38	34	31	27	19	16	13	12	11
	1.375	197	140	114	99	88	81	141	100	81	70	63	58	49	35	28	25	22	20
	1.750	300	213	174	151	135	123	215	152	124	108	96	88	75	53	43	38	34	31
3.25	1.375	156	110	90	78	70	64	111	79	64	56	50	45	39	28	22	19	17	16
	1.750	246	174	142	123	110	100	176	124	102	88	79	72	62	44	36	31	28	25
	2.000	300	221	181	157	140	128	224	158	129	112	100	91	78	55	45	39	35	32
4.00	1.750	203	144	117	102	91	83	145	103	84	73	65	59	51	36	29	25	23	21
	2.000	261	185	151	131	117	107	187	132	108	93	83	76	65	46	38	33	29	27
	2.500	300	274	224	194	173	158	277	196	160	138	124	113	97	69	56	48	43	40
5.00	2.000	214	151	123	107	96	87	153	108	88	76	68	62	53	38	31	27	24	22
	2.500	300	231	188	163	146	133	233	165	135	117	104	95	82	58	47	41	36	33
	3.000	300	300	261	226	202	184	300	228	186	161	144	132	113	80	65	56	50	46
	3.500	300	300	300	289	259	236	300	292	239	207	185	169	145	102	83	72	65	59
6.00	2.500	278	197	161	139	124	114	199	141	115	99	89	81	70	49	40	35	31	28
	3.000	300	278	227	197	176	161	281	199	162	140	126	115	98	70	57	49	44	40
	3.500	300	300	300	260	233	212	300	263	215	186	166	152	130	92	75	65	58	53
	4.000	300	300	300	300	292	266	300	300	269	233	208	190	163	115	94	82	73	67
7.00	3.000	300	241	197	171	153	139	244	172	141	122	109	100	85	60	49	43	38	35
	3.500	300	300	263	228	204	186	300	230	188	163	146	133	114	81	66	57	51	46
	4.000	300	300	300	289	259	236	300	292	239	207	185	169	145	102	83	72	65	59
	4.500	300	300	300	300	300	288	300	300	290	252	225	205	176	124	102	88	79	72
	5.000	300	300	300	300	300	300	300	300	300	296	264	241	207	146	119	103	93	84
8.00	3.500	300	288	235	203	182	166	291	205	168	145	130	119	102	72	59	51	45	42
	4.000	300	300	300	261	234	213	300	264	216	187	167	152	131	92	75	65	58	53
	4.500	300	300	300	300	290	264	300	300	267	231	207	189	162	114	93	81	72	66
	5.000	300	300	300	300	300	300	300	300	300	277	248	226	194	137	112	97	87	79
	5.500	300	300	300	300	300	300	300	300	300	300	289	264	226	160	131	113	101	92
10.00	4.500	300	300	300	269	241	220	300	272	222	192	172	157	135	95	78	67	60	55
	5.000	300	300	300	300	300	300	300	300	300	300	300	300	296	209	171	148	132	121
	5.500	300	300	300	300	294	268	300	300	271	235	210	192	164	116	95	82	73	67
	7.000	300	300	300	300	300	300	300	300	300	280	250	229	196	139	113	98	88	80
12.00	5.500	300	300	300	300	299	273	300	300	276	239	213	195	167	118	96	84	75	68
	7.000	300	300	300	300	300	300	300	300	300	300	300	300	300	231	189	163	146	133
	8.000	300	300	300	300	300	300	300	300	300	300	300	300	260	184	150	130	116	106
14.00	7.000	300	300	300	300	300	300	300	300	300	300	291	266	228	161	132	114	102	93
	8.000	300	300	300	300	300	300	300	300	300	300	300	300	300	293	240	207	186	169
	10.000	300	300	300	300	300	300	300	300	300	300	300	300	290	205	167	145	129	118
16.00	8.000	300	300	300	300	300	300	300	300	300	300	300	300	260	184	150	130	116	106
	9.000	300	300	300	300	300	300	300	300	300	300	300	300	300	227	186	161	144	131
	10.000	300	300	300	300	300	300	300	300	300	300	300	300	300	272	222	192	172	157
18.00	9.000	300	300	300	300	300	300	300	300	300	300	300	300	293	207	169	146	131	119
	10.000	300	300	300	300	300	300	300	300	300	300	300	300	300	250	204	177	158	144
20.00	10.000	300	300	300	300	300	300	300	300	300	300	300	300	300	231	188	163	146	133

[1] Maximum operating pressure is limited for Mounting Styles MF2 and MF6. Please refer to maximum operating pressure per bore in Pressure Ratings table located on the dimension page for each of these mounting styles.

C

PH-2 & PH-3 Series Maximum Basic Lengths (L_A) (all dimensions in inches)

Bore Ø	Rod Ø	Rear Pivot Mounts (MP1, MPU3[1], MT2)						Front and Intermediate Pivot Mounts (MT1, MT4)					
		Pivoted & Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:						Pivoted & Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:					
		500	1000	1500	2000	2500	3000	500	1000	1500	2000	2500	3000
1.50	0.625	35	25	20	18	16	14	25	18	14	13	11	10
	1.000	85	60	49	42	38	35	64	45	37	32	29	26
2.00	1.000	66	47	38	33	29	27	48	34	28	24	22	20
	1.375	116	82	67	58	52	47	91	64	53	45	41	37
2.50	1.000	54	38	31	27	24	22	38	27	22	19	17	16
	1.375	99	70	57	49	44	40	73	51	42	36	33	30
	1.750	151	106	87	75	67	61	118	83	68	59	53	48
3.25	1.375	78	55	45	39	35	32	56	40	32	28	25	23
	1.750	123	87	71	62	55	50	91	64	52	45	41	37
	2.000	157	111	90	78	70	64	118	84	68	59	53	48
4.00	1.750	102	72	59	51	45	41	74	52	43	37	33	30
	2.000	131	92	75	65	58	53	96	68	56	48	43	39
	2.500	194	137	112	97	87	79	150	106	87	75	67	61
5.00	2.000	107	76	62	53	48	44	77	54	44	38	34	31
	2.500	163	115	94	82	73	67	120	85	69	60	54	49
	3.000	226	160	130	113	101	92	173	122	100	87	77	71
	3.500	289	204	167	145	129	118	236	167	136	118	105	96
6.00	2.500	139	98	80	70	62	57	100	71	58	50	45	41
	3.000	197	139	114	98	88	80	144	102	83	72	65	59
	3.500	260	184	150	130	116	106	196	139	113	98	88	80
	4.000	300	231	188	163	146	133	257	181	148	128	115	105
7.00	3.000	171	121	99	85	76	70	124	87	71	62	55	50
	3.500	228	161	132	114	102	93	168	119	97	84	75	69
	4.000	289	204	167	145	129	118	220	155	127	110	98	90
	4.500	300	249	203	176	157	144	278	197	161	139	124	114
	5.000	300	293	239	207	185	169	300	243	198	172	154	140
8.00	3.500	203	144	117	102	91	83	147	104	85	74	66	60
	4.000	261	185	151	131	117	107	192	136	111	96	86	79
	4.500	300	229	187	162	145	132	244	172	141	122	109	99
	5.000	300	274	224	194	174	158	300	213	174	150	134	123
	5.500	300	300	261	226	202	185	300	257	210	182	163	149
10.00	4.500	269	190	155	135	120	110	195	138	112	97	87	80
	5.000	300	300	300	296	265	242	241	170	139	120	108	98
	5.500	300	232	190	164	147	134	291	206	168	146	130	119
	7.000	300	277	226	196	175	160	300	300	272	236	211	192
12.00	5.500	300	236	193	167	149	136	243	171	140	121	108	99
	7.000	300	300	300	300	292	267	300	278	227	196	176	160
	8.000	300	300	300	260	233	213	300	300	296	257	229	209
14.00	7.000	300	300	263	228	204	186	300	238	194	168	151	137
	8.000	300	300	300	300	300	300	300	300	254	220	197	180
	10.000	300	300	300	290	259	236	300	300	300	300	300	281
16.00	8.000	300	300	300	260	233	213	300	272	222	192	172	157
	9.000	300	300	300	300	288	263	300	300	281	244	218	199
	10.000	300	300	300	300	300	300	300	300	300	300	269	245
18.00	9.000	300	300	300	293	262	239	300	300	250	216	194	177
	10.000	300	300	300	300	300	289	300	300	300	267	239	218
20.00	10.000	300	300	300	300	292	267	300	300	278	241	215	196

[1] Maximum operating pressure is limited for Mounting Style MPU3. Please refer to maximum operating pressure per bore in Pressure Ratings table located on the dimension page for Mounting Styles MPU3.

PL-2 & PA-2 Series Maximum Basic Lengths (L_A) (all dimensions in inches)

Notes: Operating Pressure column values are different for bore size ranges 1.00 - 3.25 and 4.00 - 8.00.

These tables can be used for PA-2 Series operating at 125 and 250 psi. Contact the factory to size piston rods for lower operating pressures, longer strokes and larger bore size PA-2 Series cylinders.

Bore Ø	Rod Ø	Front and Side Fixed Mounts (MF1[1], MF5, MX1, MX3, MS2)																							
		Fixed and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:								Pivoted and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:								Unguided Rod End Max. Allowable Basic Length (L_A) at psi:							
		250	500	750	1000	1250	1500	1750	2000	250	500	750	1000	1250	1500	1750	2000	250	500	750	1000	1250	1500	1750	2000
1.00	0.500	68	48	39	34	30	28	26	24	49	34	28	24	22	20	18	17	17	12	10	9	8	7	6	6
	0.625	106	75	61	53	48	43	40	38	76	54	44	38	34	31	29	27	27	19	15	13	12	11	10	9
1.50	0.625	71	50	41	35	32	29	27	25	51	36	29	25	23	21	19	18	18	13	10	9	8	7	7	6
	1.000	181	128	105	91	81	74	69	64	130	92	75	65	58	53	49	46	45	32	26	23	20	19	17	16
2.00	0.625	53	38	31	27	-	-	-	-	38	27	22	19	-	-	-	-	13	9	8	7	-	-	-	-
	1.000	136	96	79	68	61	56	51	48	97	69	56	49	43	40	37	34	34	24	20	17	15	14	13	12
	1.375	257	182	149	129	115	105	97	91	184	130	106	92	82	75	69	65	64	45	37	32	29	26	24	23
2.50	0.625	43	30	25	-	-	-	-	-	30	21	18	-	-	-	-	-	11	8	6	-	-	-	-	-
	1.000	109	77	63	54	49	44	-	-	78	55	45	39	35	32	-	-	27	19	16	14	12	11	-	-
	1.375	206	146	119	103	92	84	-	-	147	104	85	73	66	60	-	-	51	36	30	26	23	21	-	-
	1.750	300	236	192	167	149	136	-	-	238	168	137	119	106	97	-	-	83	59	48	42	37	34	-	-
3.25	1.000	84	59	48	42	37	-	-	-	60	42	35	30	27	-	-	-	21	15	12	10	9	-	-	-
	1.375	158	112	91	79	71	-	-	-	113	80	65	57	51	-	-	-	40	28	23	20	18	-	-	-
	1.750	256	181	148	128	115	-	-	-	183	130	106	92	82	-	-	-	64	45	37	32	29	-	-	-
	2.000	300	237	193	167	150	-	-	-	239	169	138	120	107	-	-	-	84	59	48	42	37	-	-	-
Bore Ø	**Rod Ø**	**Max. Allowable Basic Length (L_A) at psi:**								**Max. Allowable Basic Length (L_A) at psi:**								**Max. Allowable Basic Length (L_A) at psi:**							
		125	**250**	**375**	**500**	**625**	**750**	**875**	**1000**	**125**	**250**	**375**	**500**	**625**	**750**	**875**	**1000**	**125**	**250**	**375**	**500**	**625**	**750**	**875**	**1000**
4.00	1.000	96	68	56	48	43	39	36	34	69	49	40	34	31	28	26	24	24	17	14	12	11	10	9	9
	1.375	182	129	105	91	81	74	69	64	130	92	75	65	58	53	49	46	45	32	26	23	20	19	17	16
	1.750	295	208	170	147	132	120	111	104	210	149	122	105	94	86	80	74	74	52	43	37	33	30	28	26
	2.000	300	272	222	192	172	157	145	136	275	194	159	137	123	112	104	97	96	68	56	48	43	39	36	34
	2.500	300	300	300	300	269	245	227	213	300	300	248	215	192	175	162	152	150	106	87	75	67	61	57	53
5.00	1.000	77	54	44	38	34	-	-	-	55	39	32	27	25	-	-	-	19	14	11	10	9	-	-	-
	1.375	146	103	84	73	65	59	55	51	104	73	60	52	46	42	39	37	36	26	21	18	16	15	14	13
	1.750	236	167	136	118	105	96	89	83	168	119	97	84	75	69	64	60	59	42	34	29	26	24	22	21
	2.000	300	218	178	154	138	126	116	109	220	155	127	110	98	90	83	78	77	54	44	38	34	31	29	27
	2.500	300	300	278	241	215	196	182	170	300	243	198	172	154	140	130	121	120	85	69	60	54	49	45	43
	3.000	300	300	300	300	300	283	262	245	300	300	286	247	221	202	187	175	173	122	100	87	77	71	65	61
	3.500	300	300	300	300	300	300	300	300	300	300	300	300	300	275	255	238	236	167	136	118	105	96	89	83
6.00	1.375	121	86	70	61	54	50	-	-	87	61	50	43	39	35	-	-	30	21	18	15	14	12	-	-
	1.750	196	139	113	98	88	80	-	-	140	99	81	70	63	57	-	-	49	35	28	25	22	20	-	-
	2.000	257	181	148	128	115	105	-	-	183	130	106	92	82	75	-	-	64	45	37	32	29	26	-	-
	2.500	300	283	231	200	179	164	-	-	286	202	165	143	128	117	-	-	100	71	58	50	45	41	-	-
	3.000	300	300	300	289	258	236	-	-	300	292	238	206	184	168	-	-	144	102	83	72	65	59	-	-
	3.500	300	300	300	300	300	300	-	-	300	300	300	281	251	229	-	-	196	139	113	98	88	80	-	-
	4.000	300	300	300	300	300	300	-	-	300	300	300	300	300	299	-	-	257	181	148	128	115	105	-	-
8.00	1.375	91	64	53	-	-	-	-	-	65	46	38	-	-	-	-	-	23	16	13	-	-	-	-	-
	1.750	147	104	85	74	66	-	-	-	105	74	61	53	47	-	-	-	37	26	21	18	16	-	-	-
	2.000	192	136	111	96	86	-	-	-	137	97	79	69	61	-	-	-	48	34	28	24	22	-	-	-
	2.500	300	213	174	150	134	-	-	-	215	152	124	107	96	-	-	-	75	53	43	38	34	-	-	-
	3.000	300	300	250	216	194	-	-	-	300	219	179	155	138	-	-	-	108	77	62	54	48	-	-	-
	3.500	300	300	300	295	264	-	-	-	300	298	243	210	188	-	-	-	147	104	85	74	66	-	-	-
	4.000	300	300	300	300	300	-	-	-	300	300	300	275	246	-	-	-	192	136	111	96	86	-	-	-
	4.500	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	244	172	141	122	109	-	-	-
	5.000	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	300	213	174	150	134	-	-	-
	5.500	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	300	257	210	182	163	-	-	-

[1] Maximum operating pressure is limited for PL-2 Series Mounting Style MF1. Please refer to maximum operating pressure per bore in Pressure Ratings table located on the dimension page for PL-2 Series Mounting Style MF1.

C

PL-2 & PA-2 Series Maximum Basic Lengths (L_A) (all dimensions in inches)

Notes: Operating Pressure column values are different for bore size ranges 1.00 - 3.25 and 4.00 - 8.00.

These tables can be used for PA-2 Series operating at 125 and 250 psi. Contact the factory to size piston rods for lower operating pressures, longer strokes and larger bore size PA-2 Series cylinders.

Bore Ø	Rod Ø	Rear Fixed Mounts (MF2, MF6, MX2)																							
		Fixed and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:								Pivoted and Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:								Unguided Rod End Max. Allowable Basic Length (L_A) at psi:							
		250	500	750	1000	1250	1500	1750	2000	250	500	750	1000	1250	1500	1750	2000	250	500	750	1000	1250	1500	1750	2000
1.00	0.500	94	66	54	47	42	38	36	33	67	47	39	34	30	27	25	24	23	17	14	12	11	10	9	8
	0.625	142	101	82	71	64	58	54	50	102	72	59	51	45	42	38	36	36	25	21	18	16	15	13	13
1.50	0.625	98	69	57	49	44	40	37	35	70	50	41	35	31	29	27	25	25	17	14	12	11	10	9	9
	1.000	230	162	133	115	103	94	87	81	164	116	95	82	73	67	62	58	57	41	33	29	26	23	22	20
2.00	0.625	74	53	43	37	-	-	-	-	53	38	31	27	-	-	-	-	19	13	11	9	-	-	-	-
	1.000	182	129	105	91	82	74	69	65	130	92	75	65	58	53	49	46	46	32	26	23	20	19	17	16
	1.375	300	218	178	154	138	126	116	109	220	155	127	110	98	90	83	78	77	54	44	38	34	31	29	27
2.50	0.625	60	42	35	-	-	-	-	-	43	30	25	-	-	-	-	-	15	11	9	-	-	-	-	-
	1.000	149	106	86	75	67	61	-	-	107	75	62	53	48	44	-	-	37	26	22	19	17	15	-	-
	1.375	264	187	153	132	118	108	-	-	189	134	109	94	84	77	-	-	66	47	38	33	30	27	-	-
	1.750	300	268	219	189	169	155	-	-	270	191	156	135	121	110	-	-	95	67	55	47	42	39	-	-
3.25	1.000	117	83	67	58	52	48	-	-	83	59	48	42	37	34	-	-	29	21	17	15	13	12	-	-
	1.375	213	151	123	107	95	87	-	-	152	108	88	76	68	62	-	-	53	38	31	27	24	22	-	-
	1.750	300	228	186	161	144	132	-	-	231	163	133	115	103	94	-	-	81	57	47	40	36	33	-	-
	2.000	300	279	228	197	176	161	-	-	282	199	163	141	126	115	-	-	99	70	57	49	44	40	-	-
Bore Ø	**Rod Ø**	**Max. Allowable Basic Length (L_A) at psi:**								**Max. Allowable Basic Length (L_A) at psi:**								**Max. Allowable Basic Length (L_A) at psi:**							
		125	**250**	**375**	**500**	**625**	**750**	**875**	**1000**	**125**	**250**	**375**	**500**	**625**	**750**	**875**	**1000**	**125**	**250**	**375**	**500**	**625**	**750**	**875**	**1000**
4.00	1.000	135	96	78	68	60	55	51	48	96	68	56	48	43	39	36	34	34	24	19	17	15	14	13	12
	1.375	251	178	145	126	112	103	95	89	180	127	104	90	80	73	68	64	63	44	36	31	28	26	24	22
	1.750	300	279	228	197	176	161	149	139	281	199	163	141	126	115	106	100	99	70	57	49	44	40	37	35
	2.000	300	300	287	248	222	203	188	176	300	251	205	177	159	145	134	125	124	88	72	62	56	51	47	44
	2.500	300	300	300	300	300	285	264	247	300	300	288	249	223	204	188	176	174	123	101	87	78	71	66	62
5.00	1.000	108	77	63	54	48	-	-	-	77	55	45	39	35	-	-	-	27	19	16	14	12	-	-	-
	1.375	203	144	117	102	91	83	77	72	145	103	84	73	65	59	55	51	51	36	29	25	23	21	19	18
	1.750	300	229	187	162	145	132	122	114	231	163	133	115	103	94	87	82	81	57	47	40	36	33	31	29
	2.000	300	293	239	207	185	169	157	146	296	209	171	148	132	121	112	105	104	73	60	52	46	42	39	37
	2.500	300	300	300	300	272	248	230	215	300	300	250	217	194	177	164	153	152	107	88	76	68	62	57	54
	3.000	300	300	300	300	300	300	300	280	300	300	300	283	253	231	214	200	198	140	114	99	89	81	75	70
	3.500	300	300	300	300	300	300	300	300	300	300	300	300	300	277	256	240	237	168	137	119	106	97	90	84
6.00	1.375	170	120	98	85	76	70	-	-	122	86	70	61	54	50	-	-	43	30	25	21	19	17	-	-
	1.750	274	193	158	137	122	112	-	-	195	138	113	98	87	80	-	-	68	48	39	34	31	28	-	-
	2.000	300	250	204	177	158	144	-	-	253	179	146	126	113	103	-	-	88	63	51	44	40	36	-	-
	2.500	300	300	300	268	239	219	-	-	300	270	221	191	171	156	-	-	134	95	77	67	60	55	-	-
	3.000	300	300	300	300	300	298	-	-	300	300	300	261	233	213	-	-	183	129	105	91	82	75	-	-
	3.500	300	300	300	300	300	300	-	-	300	300	300	300	294	268	-	-	230	163	133	115	103	94	-	-
	4.000	300	300	300	300	300	300	-	-	300	300	300	300	300	300	-	-	272	192	157	136	122	111	-	-
8.00	1.375	128	91	74	-	-	-	-	-	92	65	53	-	-	-	-	-	32	23	19	-	-	-	-	-
	1.750	207	146	120	104	93	-	-	-	148	105	85	74	66	-	-	-	52	37	30	26	23	-	-	-
	2.000	270	191	156	135	121	-	-	-	193	136	111	96	86	-	-	-	67	48	39	34	30	-	-	-
	2.500	300	294	240	208	186	-	-	-	297	210	172	149	133	-	-	-	104	74	60	52	47	-	-	-
	3.000	300	300	300	294	263	-	-	-	300	296	242	210	188	-	-	-	147	104	85	73	66	-	-	-
	3.500	300	300	300	300	300	-	-	-	300	300	300	276	247	-	-	-	193	137	112	97	86	-	-	-
	4.000	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	241	171	139	121	108	-	-	-
	4.500	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	287	203	166	144	129	-	-	-
	5.000	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	300	233	190	165	147	-	-	-
	5.500	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-	300	259	212	183	164	-	-	-

PL-2 & PA-2 Series Maximum Basic Lengths (L_A) (all dimensions in inches)

Notes: Operating Pressure column values are different for bore size ranges 1.00 - 3.25 and 4.00 - 8.00.

These tables can be used for PA-2 Series operating at 125 and 250 psi. Contact the factory to size piston rods for lower operating pressures, longer strokes and larger bore size PA-2 Series cylinders.

Bore Ø	Rod Ø	Rear Pivot Mounts (MP1, MPU3[1], MT2) Pivoted & Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:								Front and Intermediate Pivot Mounts (D, DD) Pivoted & Rigidly Guided Rod End Max. Allowable Basic Length (L_A) at psi:							
		250	500	750	1000	1250	1500	1750	2000	250	500	750	1000	1250	1500	1750	2000
1.00	0.500	47	33	27	23	21	19	18	17	34	24	20	17	15	14	13	12
	0.625	71	50	41	36	32	29	27	25	53	38	31	27	24	22	20	19
1.50	0.625	49	35	28	25	22	20	19	17	35	25	20	18	16	14	13	13
	1.000	115	81	66	57	51	47	43	41	91	64	52	45	41	37	34	32
2.00	0.625	37	26	21	19	-	-	-	-	27	19	15	13	-	-	-	-
	1.000	91	65	53	46	41	37	34	32	68	48	39	34	30	28	26	24
	1.375	154	109	89	77	69	63	58	54	129	91	74	64	58	53	49	45
2.50	0.625	30	21	17	-	-	-	-	-	21	15	12	-	-	-	-	-
	1.000	75	53	43	37	33	31	-	-	54	38	31	27	24	22	-	-
	1.375	132	93	76	66	59	54	-	-	103	73	59	51	46	42	-	-
	1.750	189	134	109	95	85	77	-	-	167	118	96	83	75	68	-	-
3.25	1.000	58	41	34	29	26	24	-	-	42	30	24	21	19	17	-	-
	1.375	107	75	62	53	48	44	-	-	79	56	46	40	35	32	-	-
	1.750	161	114	93	81	72	66	-	-	128	91	74	64	57	52	-	-
	2.000	197	139	114	99	88	80	-	-	167	118	97	84	75	68	-	-
Bore Ø	**Rod Ø**	**Max. Allowable Basic Length (L_A) at psi:**								**Max. Allowable Basic Length (L_A) at psi:**							
		125	**250**	**375**	**500**	**625**	**750**	**875**	**1000**	**125**	**250**	**375**	**500**	**625**	**750**	**875**	**1000**
4.00	1.000	68	48	39	34	30	28	26	24	48	34	28	24	22	20	18	17
	1.375	126	89	73	63	56	51	48	44	91	64	53	45	41	37	34	32
	1.750	197	139	114	99	88	80	74	70	147	104	85	74	66	60	56	52
	2.000	248	176	143	124	111	101	94	88	192	136	111	96	86	79	73	68
	2.500	300	247	201	174	156	142	132	123	300	213	174	150	134	123	114	106
5.00	1.000	54	38	31	27	24	-	-	-	38	27	22	19	17	-	-	-
	1.375	102	72	59	51	45	41	38	36	73	51	42	36	33	30	27	26
	1.750	162	114	93	81	72	66	61	57	118	83	68	59	53	48	45	42
	2.000	207	146	120	104	93	85	78	73	154	109	89	77	69	63	58	54
	2.500	300	215	175	152	136	124	115	107	241	170	139	120	108	98	91	85
	3.000	300	280	229	198	177	162	150	140	300	245	200	173	155	141	131	122
	3.500	300	300	274	237	212	194	179	168	300	300	272	236	211	192	178	167
6.00	1.375	85	60	49	43	38	35	-	-	61	43	35	30	27	25	-	-
	1.750	137	97	79	68	61	56	-	-	98	69	57	49	44	40	-	-
	2.000	177	125	102	88	79	72	-	-	128	91	74	64	57	52	-	-
	2.500	268	189	155	134	120	109	-	-	200	142	116	100	90	82	-	-
	3.000	300	258	211	183	163	149	-	-	289	204	167	144	129	118	-	-
	3.500	300	300	266	230	206	188	-	-	300	278	227	196	176	160	-	-
	4.000	300	300	300	272	243	222	-	-	300	300	296	257	229	209	-	-
8.00	1.375	64	45	37	-	-	-	-	-	45	32	26	-	-	-	-	-
	1.750	104	73	60	52	46	-	-	-	74	52	43	37	33	-	-	-
	2.000	135	95	78	67	60	-	-	-	96	68	56	48	43	-	-	-
	2.500	208	147	120	104	93	-	-	-	150	106	87	75	67	-	-	-
	3.000	294	208	169	147	131	-	-	-	216	153	125	108	97	-	-	-
	3.500	300	273	223	193	173	-	-	-	295	208	170	147	132	-	-	-
	4.000	300	300	278	241	216	-	-	-	300	272	222	192	172	-	-	-
	4.500	300	300	300	287	257	-	-	-	300	300	281	244	218	-	-	-
	5.000	300	300	300	300	295	-	-	-	300	300	300	300	269	-	-	-
	5.500	300	300	300	300	300	-	-	-	300	300	300	300	300	-	-	-

[1] Maximum operating pressure is limited for PL-2 Series Mounting Style MPU3. Please refer to maximum operating pressure per bore in Pressure Ratings table located on the dimension page for PL-2 Series Mounting Style MPU3.

C

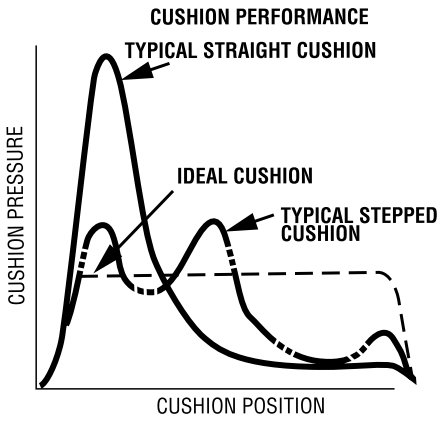
NOTES

An Introduction to Cushioning

Cushioning is recommended as a means of controlling the deceleration of masses, or for applications where piston speed is in excess of 4 in/sec and the piston will make full stroke. Cushioning extends cylinder life and reduces undesirable noise and hydraulic shock. Built-in "cushions" are optional and can be supplied at the head and cap ends of a cylinder without affecting its envelope or mounting dimensions.

Standard Cushioning

Ideal cushion performance shows an almost uniform absorption of energy along the cushioning length, as shown. Many forms of cushioning exist, and each has its own specific merits and advantages.



In order to cover the majority of applications, PH-2/PH-3 cylinders are supplied with profiled cushioning as standard. Final speed may be adjusted using the cushion screw. The performance of profiled cushioning is indicated on the diagram.

Note: Cushion performance will be affected by the use of water or high water based fluids. Please consult factory for details.

Cushion Length

Where specified, PH-2/PH-3 cylinder incorporates the longest cushion sleeve and spear that can be accommodated within the standard envelope without reducing the rod bearing and piston bearing length. See cushion lengths on the next page. Cushions are adjustable via recessed needle valves.

Cushion Calculation

The charts on the next page show the energy absorption capacity for each bore/rod combination at the head (annulus) and the cap (full bore) ends of cylinder. The charts are valid for piston velocities within a range of 0.33 to 1 ft/s. For velocities between 1ft/s and 1.64 ft/s the energy values derived from the charts should be reduced by 25%. For velocities less than 0.33 ft/s where large masses are involved, and for velocities greater than 1.60 ft/s, a special cushion profile may be required. Please consult the factory for details.

The cushion capacity of the head end is less than the cap, and reduces to zero at high drive pressures due to the pressure intensification effect across the piston.

The energy absorption capacity of the cushion decreases with drive pressure.

Formula

Cushioning calculations are based on the formula $E=(1/2)\ mv^2$ for horizontal applications. For inclined or vertically downward or upward applications, this is modified to:

$E = (1/2)mv^2 + mg(L/12) \times \sin(a)$
(for inclined or vertically downward direction of mass)

$E = (1/2)mv^2 - mg(L/12) \times \sin(a)$
(for inclined vertically upward direction of mass)

where:

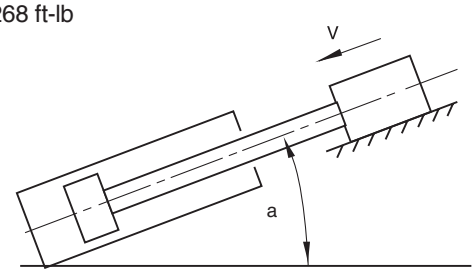
E = energy absorbed in lb-ft
g = acceleration due to gravity = 32.2 ft/s^2
v = velocity in ft/s
L = length of cushion in inches
m = mass of load in slug (including piston, rod and rod end accessories.
a = angle to the horizontal in degrees
p = pressure in psi

Example:

The following example shows how to calculate the energy developed by masses moving in a straight line. For non-linear motion, other calculations are required; please consult the factory. The example assumes that the bore and rod diameter are already appropriate for the application. The effects of friction on the cylinder and load have been ignored.

Selected bore/rod 6" bore x 2 1/2" rod (No. 1 rod)

Cushion at the cap end.
Pressure = 2,500 psi
Mass = 685 slugs = weight in lb / (32.2 ft/s^2)
Velocity = 1.3 ft/s
Cushion length = 1.313 inch
a = 45°
Sin (a) = 0.70
$E = (1/2)mv^2 + mgl/12 \times \text{Sin (a)}$
$= (1/2) \times 685 \times 1.3^2 + 685 \times 32.2 \times 1.313/12 \times 0.70$
= 2,268 ft-lb



Note: In the above example velocity is greater than 1 ft./s. Therefore, a de-rating factor of 0.75 must be applied to the calculated value of E. Applying this correction factor will increase the energy value to 3024 lb-ft (2268/0.75 = 3024 lb-ft). A review of the graph for the cap end cushion of a 6 inch bore x 2½" rod cylinder operating at 2500 psi indicates that it can absorb approximately 3200 lb-ft maximum of energy. Since 3024 lb-ft is less than the maximum allowable of 3200 lb-ft, the cylinder can be applied as indicated. If the calculated energy exceeds the value shown on the curve, select a larger bore cylinder and/or reduce the operating pressure and recalculate the energy. Compare the newly calculated energy value to the appropriate curve to ensure it does not exceed the maximum allowable energy.

C

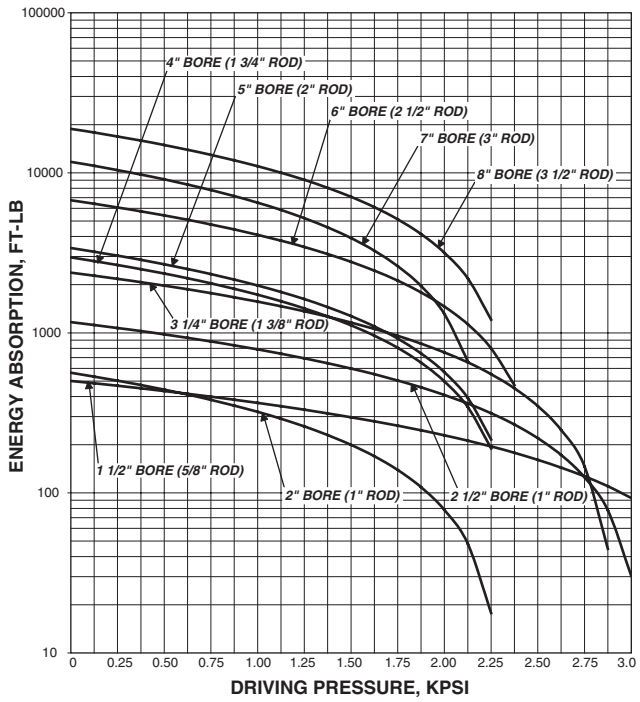
BORE	ROD DIA.	CUSHION LENGTH (MINIMUM)	
		HEAD	CAP
1.5	0.625	0.924	1.000
	1.000	0.927	1.000
2	1.000	0.927	0.938
	1.375	0.925	0.938
2.5	1.000	0.927	0.938
	1.750	0.928	0.938
	1.375	0.925	0.938
3.25	1.375	1.175	1.125
	2.000	0.862	1.125
	1.750	1.178	1.125
4	1.750	1.178	1.063
	2.500	0.869	1.063
	2.000	0.862	1.063
5	2.000	0.862	0.938
	3.500	0.869	0.938
	2.500	0.869	0.938
	3.000	0.869	0.938
6	2.500	1.119	1.313
	4.000	1.119	1.313
	3.000	1.119	1.313
	3.500	0.869	1.313
7	3.000	1.619	1.750
	5.000	1.496	1.750
	3.500	1.619	1.750
	4.000	1.119	1.750
	4.500	1.496	1.750
8	3.500	1.869	1.813
	5.500	1.745	1.813
	4.000	1.119	1.813
	4.500	1.496	1.813
	5.000	1.496	1.813

Cushion Energy Absorption Capacity Data

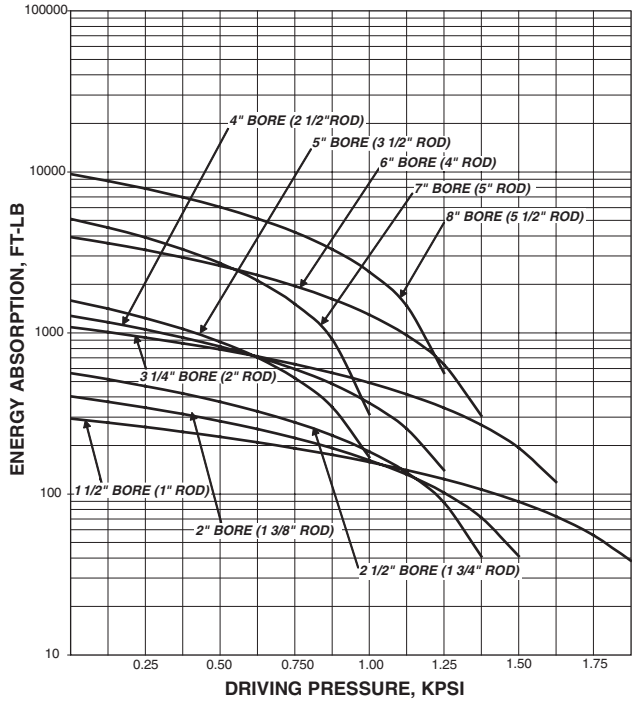
The cushion energy absorption data shown below is based on the maximum fatigue-free pressure developed in the tube. For application with a life cycle of less than 10^6 cycles, greater energy absorption figures can be applied. Please consult the factory if further information is required.

Head End

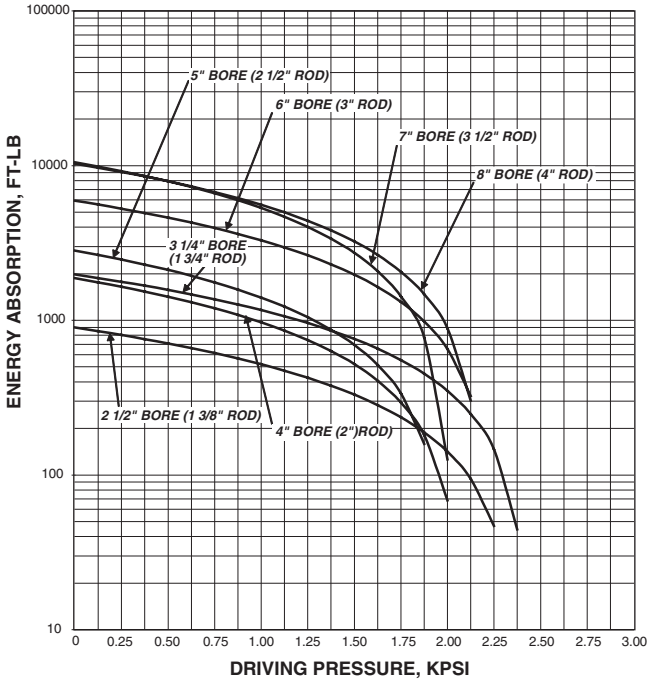
STANDARD ROD DIA.



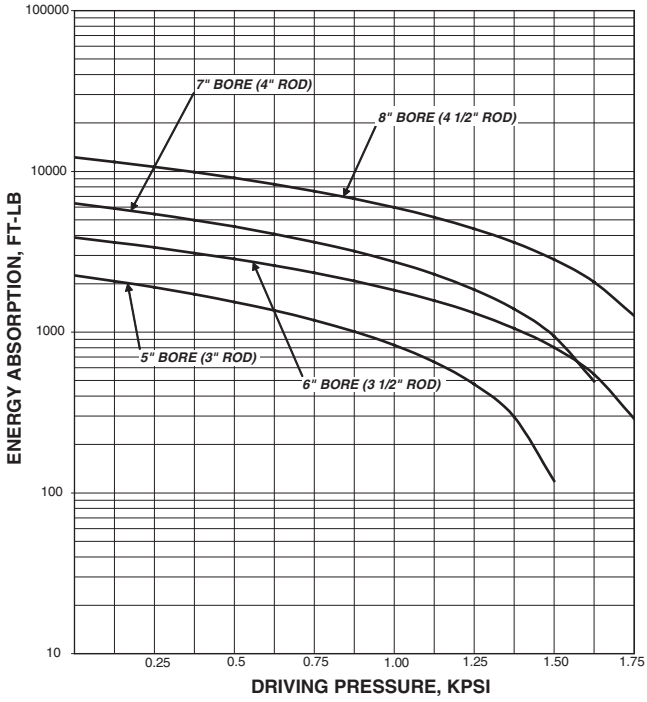
MAXIMUM ROD DIA



FIRST OVERSIZE ROD DIA.



SECOND OVERSIZE ROD DIA.



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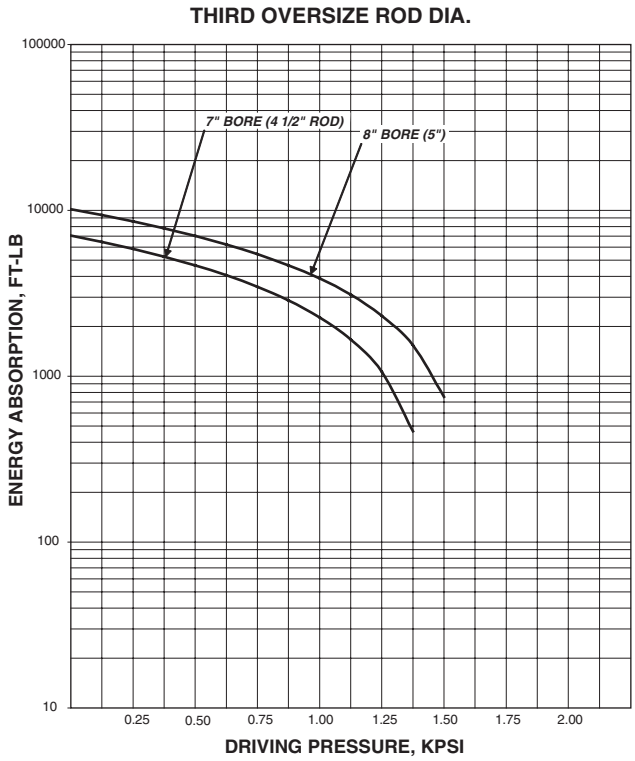
Cushion Energy Absorption Capacity Data

The cushion energy absorption data shown below is based on the maximum fatigue-free pressure developed in the tube. For application with a life cycle of less than 10^6 cycles, greater energy absorption figures can be applied. Please consult the factory if further information is required.

Head End

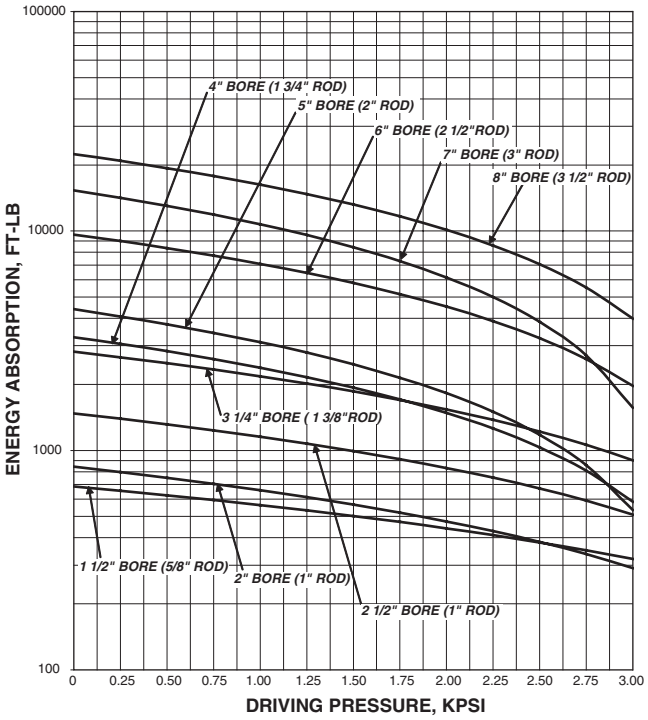


Cushion Energy Absorption Capacity Data

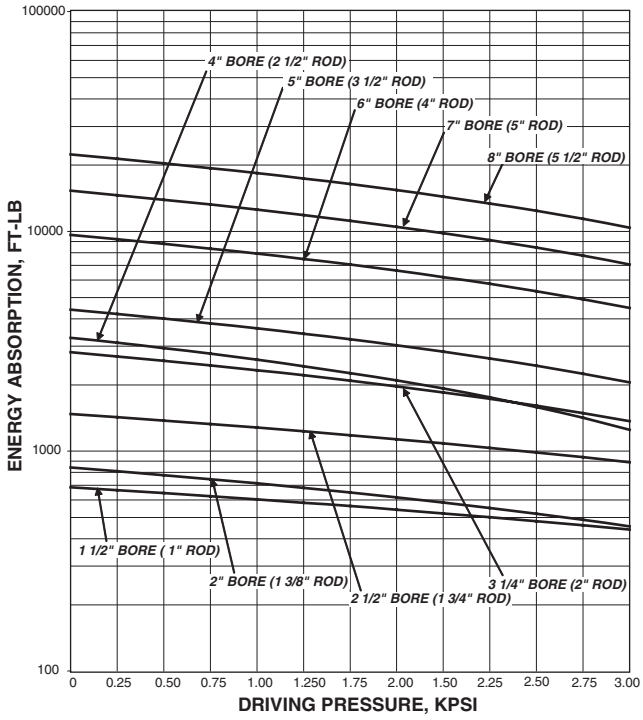
The cushion energy absorption data shown below is based on the maximum fatigue-free pressure developed in the tube. For application with a life cycle of less than 10^6 cycles, greater energy absorption figures can be applied. Please consult the factory if further information is required.

Cap End

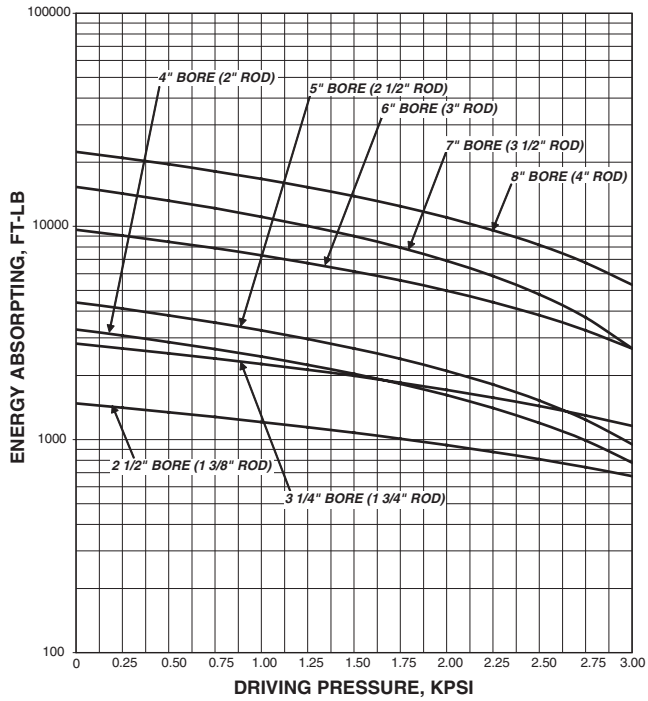
STANDARD ROD DIA



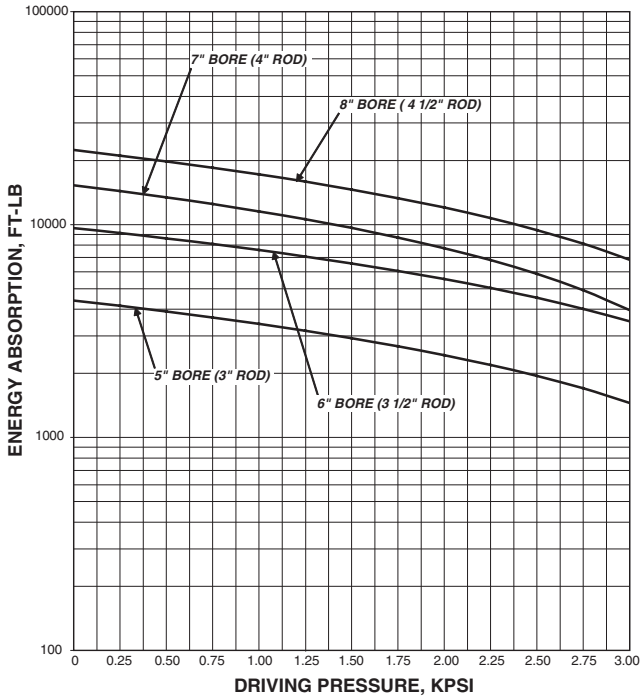
MAXIMUM OVERSIZE ROD DIA.



FIRST OVERSIZE ROD DIA.



SECOND OVERSIZE ROD DIA.

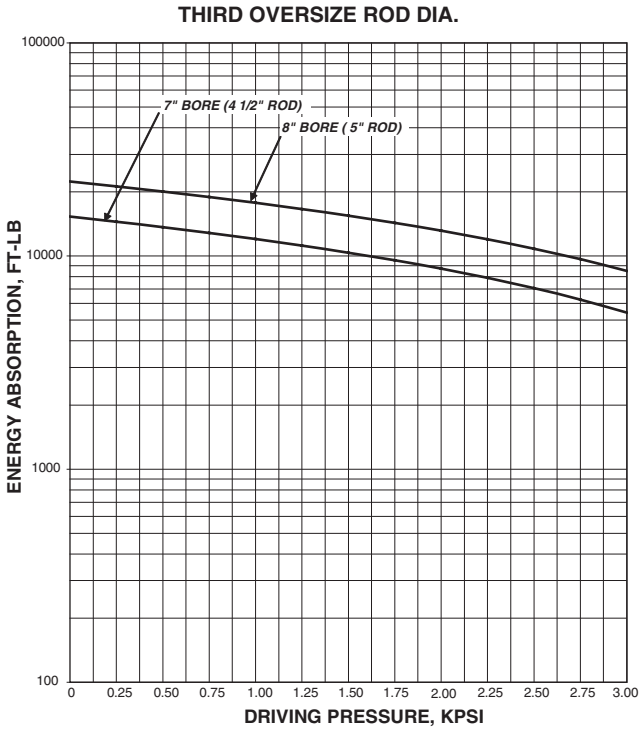


C

Cushion Energy Absorption Capacity Data

The cushion energy absorption data shown below is based on the maximum fatigue-free pressure developed in the tube. For application with a life cycle of less than 10^6 cycles, greater energy absorption figures can be applied. Please consult the factory if further information is required.

Cap End



Acceleration and Deceleration Force Determination

The uniform acceleration force factor chart and the accompanying formula can be used to rapidly determine the forces required to accelerate and decelerate a cylinder load. To determine these forces, the following factors must be known: total weight to be moved, maximum piston speed, distance available to start or stop the weight (load), direction of movement, i.e. horizontal or vertical, and load friction. By use of the known factors and the "g" factor from chart, the force necessary to accelerate or decelerate a cylinder load may be found by solving the formula (as shown in chart below) application to a given set of conditions.

Nomenclature

V = Velocity in feet per minute
S = Distance in inches
F = Force in lbs.
W = Weight of load in lbs.
g = Force factor
f = Friction of load on machine ways in lbs.

To determine the force factor "g" from the chart, locate the intersection of the maximum piston velocity line and the line representing the available distance. Project downward to locate "g" on the horizontal axis. To calculate the "g" factor for distances and velocities exceeding those shown on the chart, the following formula can be used:

$g = v^2/s \times .0000517$

Example: Horizontal motion of a free moving 6,000 lb. load is required with a distance of ½" to a maximum speed of 120 feet per minute.

Formula (1) F = Wg should be used.

F = 6,000 pounds x 1.50 (from chart) = 9,000 lbs.

Assuming a maximum available pump pressure of 1,000 psi, a 4" bore cylinder should be selected, operating on push stroke at approximately 750 psi pressure at the cylinder to allow for pressure losses from the pump to the cylinder.

Assume the same load to be sliding on ways with a coefficient of friction of 0.15. The resultant friction load would be 6,000 x 0.15 = 900 lbs.

Formula (2) F = Wg + f should be used.

F = 6,000 lbs. x 1.5 (from chart) + 900 = 9,900 lbs.

Again allowing 750 psi pressure at the cylinder, a 5" bore cylinder is indicated.

Example: Horizontal deceleration of a 5000 pound load is required by using a 1" long cushion in a 5" bore cylinder having a 1¾" diameter piston rod. Cylinder bore area (19.64 sq. in.) minus the rod area results in a minor area of 17.23 sq. in. at head end of cylinder. A pump delivering 500 psi at the cylinder is used to push the load at 120 feet per minute. Friction coefficient is 0.15 or 750 lbs.

In this example, the total deceleration force is the sum of the force needed to decelerate the 5,000 lb. load, and the force required to counteract the thrust produced by the pump.

W = Load in lbs. = 5000
S = Deceleration distance in inches = 1"
V = Maximum piston speed in feet per minute = 120
g = .74 (from chart)
f = 750 pounds

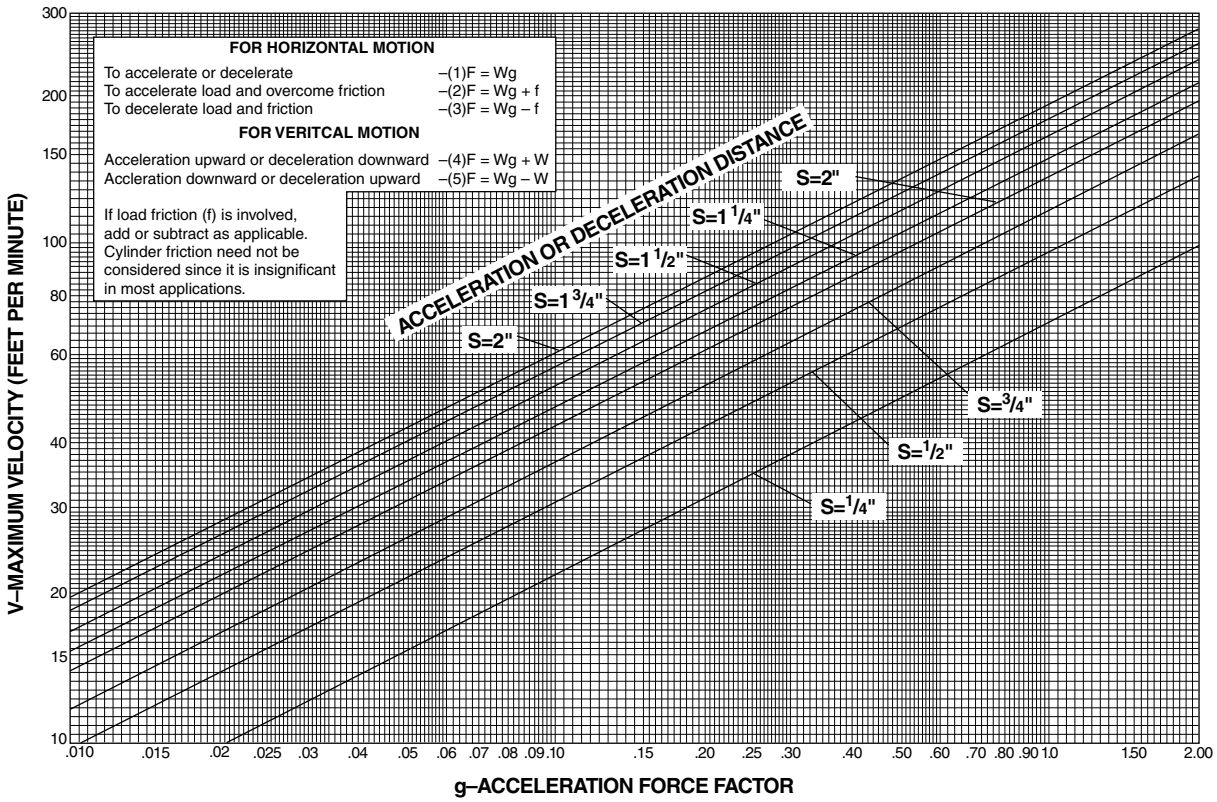
Use formula (3) F = Wg - f

(F = Wg - f) = (F = 5000 x .74 - 750) = 2,950 lbs.

The pump is delivering 500 psi acting on the 19.64 sq. in. piston area producing a force (F2) of 9820 lbs. This force must be included in our calculations. Thus F + F2 = 2950 + 9820 = 12,770 lbs. total force to be decelerated.

The total deceleration force is developed by the fluid trapped between the piston and the head. The fluid pressure is equal to the force (12,770 lbs.) divided by the minor area (17.23 sq. in.) equals 741 psi. This pressure should not exceed the non-shock rating of the cylinder.

Cushioning practice is to select a "g" factor between .2 and 1.5.



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One of the factors involved in determining the speed of a hydraulic cylinder piston is fluid flow in connecting lines, generally measured in gallons per minute, introduced to, or expelled from, cap end cylinder port. (Due to piston rod displacement, the flow at head end port will be less than at cap end.) Fluid velocity, however, is measured in feet per second. In connecting lines this velocity should generally be limited to 15 feet per second to minimize fluid turbulence, pressure loss and hydraulic shock.

Piston speed for cylinders can be calculated from data shown in **table b-5**. The table shows fluid velocity flow for major cylinder areas as well as for the net area at the rod end for cylinders 1" through 14" bore size.

If desired piston speed results in fluid flow in excess of 15 feet per second in connecting lines, consider the use of larger lines up to cylinder port, using either oversized ports or two ports per cap.

If heavy loads are involved or piston speeds are in excess of 20 feet per minute and the piston will make a full stroke, cushions are recommended. Cushions increase cylinder life and reduce undesirable noise.

Table b-5

Cylinder Bore (Inches)	Piston Rod Dia. (Inches)	Piston Rod Area (Sq. In.)	Cylinder Net Area (Sq. In.)	Fluid Displacement at 10 Ft. Per Min. Piston Velocity GPM	Fluid Displacement at 10 Ft. Per Min. Piston Velocity CFM	Fluid Velocity (In Feet Per Second) Through Extra Heavy Pipe at 10 F.P.M. Piston Speed. For Series PH-2 Cylinders Standard Port Size is First to Left of Heavy Black Line. 1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
1	0	0	.785	.41	.054	1.82	.92	.56	.30	.183	.102	.074	.045	—
	1/2	.196	.589	.30	.041	1.33	.68	.41	.21	.134	.075	.055	.033	—
	5/8	.307	.478	.16	.033	.71	.36	.22	.12	.071	.040	.029	.017	—
1 1/2	0	.0	1.77	.92	.123	4.09	2.09	1.259	.680	.410	.230	.167	.100	—
	5/8	.307	1.46	.76	.101	3.38	1.73	1.040	.562	.338	.190	.138	.082	—
	1	.785	.98	.51	.068	2.27	1.16	.699	.378	.228	.128	.093	.055	—
2	0	0	3.14	1.63	.218	7.27	3.71	2.238	1.209	.728	.408	.296	.177	—
	5/8	.307	2.84	1.48	.197	6.56	3.35	2.019	1.091	.657	.368	.267	.160	—
	1	.785	2.36	1.23	.164	5.45	2.79	1.678	.907	.546	.306	.222	.133	—
	1 3/8	1.485	1.66	.86	.115	3.84	1.96	1.180	.638	.384	.215	.156	.094	—
2 1/2	0	0	4.91	2.55	.341	11.36	5.80	3.496	1.890	1.138	.638	.463	.277	—
	5/8	.307	4.60	2.39	.319	10.65	5.44	3.278	1.771	1.067	.598	.434	.260	—
	1	.785	4.12	2.14	.286	9.54	4.87	2.937	1.587	.956	.536	.389	.233	—
	1 3/8	1.485	3.42	1.78	.237	7.93	4.05	2.439	1.318	.794	.445	.323	.193	—
	1 3/4	2.405	2.50	1.30	.174	5.96	2.96	1.783	.963	.580	.325	.236	.141	—
3 1/4	0	0	8.30	4.31	.576	19.20	9.81	5.909	3.193	1.923	1.078	.783	.468	—
	1	.785	7.51	3.90	.521	17.38	8.88	5.349	2.891	1.741	.976	.708	.424	—
	1 3/8	1.485	6.81	3.54	.473	15.77	8.05	4.851	2.622	1.579	.885	.642	.384	—
	1 3/4	2.405	5.89	3.06	.409	13.64	6.96	4.196	2.268	1.366	.765	.556	.333	—
	2	3.142	5.15	2.68	.357	11.93	6.09	3.671	1.984	1.195	.670	.486	.291	—
4	0	0	12.57	6.53	.872	29.09	14.85	8.95	4.84	2.91	1.63	1.19	.709	—
	1	.785	11.78	6.12	.818	27.27	13.93	8.39	4.54	2.73	1.53	1.11	.665	—
	1 3/8	1.485	11.08	5.76	.769	25.65	13.10	7.89	4.27	2.57	1.44	1.05	.625	—
	1 3/4	2.405	10.16	5.28	.705	23.52	12.01	7.24	3.91	2.36	1.32	.96	.574	—
	2	3.142	9.42	4.89	.654	21.82	11.14	6.71	3.63	2.19	1.22	.89	.532	—
	2 1/2	4.909	7.66	3.98	.532	17.73	9.05	5.45	2.95	1.78	1.00	.72	.432	—
5	0	0	19.64	10.20	1.363	45.45	23.21	13.99	7.56	4.55	2.55	1.85	1.108	—
	1	.785	18.85	9.79	1.308	43.64	22.28	13.43	7.26	4.37	2.45	1.78	1.064	—
	1 3/8	1.485	18.15	9.43	1.260	42.01	21.45	12.93	6.99	4.21	2.36	1.71	1.024	—
	1 3/4	2.405	17.23	8.95	1.196	39.88	20.37	12.27	6.63	3.99	2.24	1.63	.973	—
	2	3.142	16.49	8.57	1.144	38.18	19.50	11.75	6.35	3.82	2.14	1.56	.931	—
	2 1/2	4.909	14.73	7.65	1.022	34.09	17.41	10.49	5.67	3.41	1.91	1.39	.831	—
	3	7.069	12.57	6.53	.872	29.09	14.85	8.95	4.84	2.91	1.63	1.19	.709	—
	3 1/2	9.621	10.01	5.21	.695	23.18	11.84	7.13	3.86	2.32	1.30	.95	.565	—
6	0	0	28.27	14.69	1.962	65.45	33.42	20.14	10.88	6.55	3.67	2.67	1.596	—
	1 3/8	1.485	26.79	13.92	1.859	62.01	31.67	19.08	10.31	6.21	3.48	2.53	1.512	—
	1 3/4	2.405	25.87	13.44	1.795	59.88	30.58	18.43	9.96	5.60	3.36	2.44	1.460	—
	2	3.142	25.13	13.06	1.744	58.18	29.71	17.90	9.67	5.83	3.27	2.37	1.418	—
	2 1/2	4.909	23.37	12.14	1.622	54.1	27.6	16.64	8.99	5.42	3.04	2.20	1.32	—
	3	7.069	21.21	11.02	1.472	49.1	25.1	15.10	8.16	4.92	2.76	2.00	1.20	—
	3 1/2	9.621	18.65	9.69	1.294	43.2	22.1	13.29	7.18	4.32	2.42	1.76	1.05	—
	4	12.566	15.71	8.16	1.09	36.4	18.6	11.19	6.05	3.64	2.04	1.48	.89	—

Table b-5 (cont.)

Cylinder Bore (Inches)	Piston Rod Dia. (Inches)	Piston Rod Area (Sq. In.)	Cylinder Net Area (Sq. In.)	Fluid Displacement at 10 Ft. Per Min. Piston Velocity GPM	Fluid Displacement at 10 Ft. Per Min. Piston Velocity CFM	Fluid Velocity (In Feet Per Second) Through Extra Heavy Pipe at 10 F.P.M. Piston Speed. For Series PH-2 Cylinders Standard Port Size is first to Left of Heavy Black Line. 1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
7	0	0	38.49	20.00	2.671	89.1	45.5	27.41	14.81	8.92	5.00	3.63	2.17	—
	1 3/8	1.485	37.00	19.22	2.568	85.7	43.7	26.35	14.24	8.58	4.81	3.49	2.09	—
	1 3/4	2.405	36.08	18.74	2.504	83.5	42.7	25.70	13.89	8.36	4.69	3.40	2.04	—
	2	3.142	35.34	18.36	2.453	81.8	41.8	25.17	13.60	8.19	4.59	3.33	2.00	—
	2 1/2	4.909	33.58	17.44	2.330	77.7	39.7	23.92	12.92	7.78	4.36	3.17	1.90	—
	3	7.069	31.42	16.32	2.181	72.7	37.1	22.38	12.09	7.28	4.08	2.96	1.77	—
	3 1/2	9.621	28.86	14.99	2.003	66.8	34.1	20.56	11.11	6.69	3.75	2.72	1.63	—
	4	12.566	25.92	13.47	1.799	60.0	30.6	18.46	9.98	6.01	3.37	2.45	1.46	—
	4 1/2	15.904	22.58	11.73	1.567	52.3	26.7	16.08	8.69	5.23	2.93	2.12	1.28	—
	5	19.635	18.85	9.79	1.308	43.6	22.3	13.43	7.26	4.37	2.45	1.78	1.06	—
8	0	0	50.27	26.12	3.489	116.4	59.4	35.80	19.35	11.65	6.53	4.74	2.84	1.977
	1 3/8	1.485	48.78	25.34	3.385	112.9	57.7	34.74	18.78	11.31	6.34	4.60	2.75	1.918
	1 3/4	2.405	47.86	24.86	3.321	110.8	56.6	34.09	18.42	11.09	6.22	4.51	2.70	1.882
	2	3.142	47.12	24.48	3.270	109.1	55.7	33.56	18.14	10.92	6.12	4.45	2.66	1.853
	2 1/2	4.909	45.36	23.57	3.149	105.0	53.61	32.31	17.46	10.51	5.892	4.278	2.560	1.784
	3	7.069	43.20	22.44	2.998	100.0	51.06	30.77	16.63	10.01	5.612	4.074	2.438	1.699
	3 1/2	9.621	40.65	21.12	2.821	94.1	48.04	28.95	15.65	9.42	5.279	3.834	2.294	1.598
	4	12.566	37.70	19.59	2.616	87.3	44.56	26.85	14.51	8.74	4.897	3.556	2.128	1.483
	4 1/2	15.904	34.36	17.85	2.385	79.5	40.62	24.47	13.23	8.20	4.464	3.241	1.939	1.351
	5	19.635	30.63	15.91	2.126	70.9	36.21	21.82	11.79	7.10	3.979	2.889	1.729	1.205
	5 1/2	23.758	26.51	13.77	1.840	61.4	31.33	18.88	10.20	6.15	3.444	2.500	1.496	1.043
10	0	0	78.54	40.80	5.451	181.8	92.84	55.94	30.23	18.21	10.203	7.408	4.433	3.089
	1 3/4	2.405	76.14	39.56	5.284	176.2	89.99	54.23	29.31	17.65	9.890	7.181	4.297	2.994
	2	3.142	75.40	39.17	5.233	174.5	89.12	53.70	29.02	17.48	9.795	7.112	4.255	2.965
	2 1/2	4.909	73.63	38.25	5.110	170.4	87.03	52.44	28.34	17.07	9.565	6.945	4.156	2.896
	3	7.069	71.47	37.13	4.960	165.4	84.48	50.91	27.51	16.57	9.284	6.741	4.034	2.811
	3 1/2	9.621	68.92	35.80	4.783	159.5	81.47	49.09	26.53	15.98	8.953	6.501	3.890	2.710
	4	12.566	65.97	34.27	4.578	152.7	77.98	46.99	25.39	15.29	8.570	6.223	3.724	2.595
	4 1/2	15.904	62.64	32.54	4.347	145.0	74.04	44.61	24.11	14.52	8.137	5.908	3.535	2.463
	5	19.635	58.91	30.60	4.088	136.4	69.63	41.96	22.67	13.65	7.652	5.556	3.325	2.317
	5 1/2	23.758	54.78	28.46	3.802	126.8	64.75	39.02	21.09	12.70	7.116	5.167	3.092	2.154
	6	28.274	50.27	26.12	3.489	116.4	59.42	35.80	19.35	11.65	6.530	4.741	2.837	1.977
	6 1/2	33.183	45.36	23.57	3.148	105.0	53.6	32.31	17.46	10.52	5.89	4.278	2.560	1.784
	7	38.485	40.06	20.81	2.780	92.7	47.4	28.53	15.42	9.29	5.20	3.778	2.261	1.575
12	0	0	113.10	58.76	7.849	261.8	133.7	80.55	43.53	26.22	14.69	10.668	6.383	4.448
	2	3.142	109.96	57.12	7.631	254.5	130.0	78.32	42.32	25.49	14.28	10.371	6.206	4.324
	2 1/2	4.909	108.19	56.21	7.508	250.4	127.9	77.06	41.64	25.08	14.05	10.205	6.106	4.255
	3	7.069	106.03	55.08	7.359	245.4	125.3	75.52	40.81	24.58	13.77	10.001	5.984	4.170
	3 1/2	9.621	103.48	53.76	7.182	239.5	122.3	73.70	39.83	23.99	13.44	9.760	5.840	4.069
	4	12.566	100.53	52.23	6.977	232.7	118.8	71.60	38.70	23.30	13.06	9.482	5.674	3.954
	4 1/2	15.904	97.19	50.49	6.745	225.0	114.9	69.23	37.41	22.53	12.63	9.168	5.486	3.822
	5	19.635	93.46	48.55	6.486	216.4	110.5	66.57	35.98	21.67	12.14	8.816	5.275	3.676
	5 1/2	23.758	89.34	46.41	6.200	206.8	105.6	63.63	34.39	20.71	11.61	8.427	5.042	3.513
	6	28.274	84.82	44.06	5.887	196.4	100.3	60.42	32.65	19.66	11.02	8.001	4.787	3.336
	6 1/2	33.183	79.92	41.52	5.547	185.0	94.5	56.92	30.76	18.53	10.38	7.538	4.510	3.143
	7	38.485	74.61	38.77	5.179	172.7	88.2	53.14	28.72	17.30	9.69	7.038	4.211	2.934
	7 1/2	44.179	68.92	35.80	4.783	159.5	81.5	49.09	26.53	15.98	8.95	6.501	3.890	2.710
	8	50.266	62.83	32.64	4.360	145.4	74.3	44.75	24.19	14.57	8.16	5.926	3.546	2.471
	8 1/2	56.745	56.35	29.27	3.911	130.5	66.6	40.14	21.69	13.06	7.32	5.315	3.181	2.216
14	0	0	153.94	79.97	10.683	356.3	182.0	109.6	59.25	35.68	20.00	14.52	8.688	6.054
	2 1/2	4.909	149.03	77.42	10.343	345.0	176.2	106.2	57.36	34.55	19.36	14.06	8.411	5.861
	3	7.069	146.87	76.30	10.193	340.0	173.6	104.6	56.53	34.05	19.08	13.85	8.289	5.776
	3 1/2	9.621	144.32	74.97	10.016	334.1	170.6	102.8	55.55	33.45	18.75	13.61	8.145	5.676
	4	12.566	141.37	73.44	9.811	327.3	167.1	100.7	54.42	32.77	18.37	13.33	7.979	5.560
	4 1/2	15.904	138.03	71.71	9.579	319.5	163.2	98.3	53.13	32.00	17.93	13.02	7.791	5.428
	5	19.635	134.30	69.77	9.320	310.9	158.8	95.7	51.70	31.13	17.45	12.67	7.580	5.282
	5 1/2	23.758	130.18	67.63	9.035	301.3	153.9	92.7	50.11	30.18	16.91	12.28	7.347	5.120

C

Flow Velocity and Pressure Drop Data for Hydraulic Systems

The chart below may be used to calculate pressure loss in connecting lines at various flow velocities. The data is useful when determining hydraulic cylinder size and port size for applications where cylinder force and speed requirements are known.

S = Standard (Schedule 40) Pipe
H = Extra Strong (Schedule 80) Pipe
EH = Double Extra Strong Pipe

Tabulations based on a hydraulic oil having a viscosity of 155 SSU at 100°F — specific gravity of .87.

To determine tubing or hose losses, use I.D. closest to tubing or hose I.D.

Pressure drop does not vary with operating pressure. Avoid high pressure losses in low pressure systems. Use largest pipe size practical. Avoid flow velocities greater than 15 Ft./Sec. to reduce hydraulic line shock.

Clean Steel Pipe						Pressure Loss (Pounds Per Square Inch Per Foot Length) in Pipes at Average Flow Velocity (Feet per Second)									
Nominal Size		O.D.	I .D.	Wall Thick-ness	I.D. Area	5 (fps)		7 (fps)		10 (fps)		15 (fps)		20 (fps)	
Inches		Inches	Inches	Inch	Sq. In.	Loss	Gal. Min.	Loss	Gal. Min.	Loss	Gal. Min.	Loss	Gal. Min.	Loss	Gal. Min.
1	S	1.315	1.049	0.133	0.863	0.10	13.45	0.13	18.85	0.34	26.90	0.57	40.35	1.42	53.80
	H		0.957	0.179	0.719	0.11	11.21	0.15	15.70	0.24	22.42	0.62	33.63	1.23	44.84
	EH		0.599	0.358	0.282	0.26	4.39	0.37	6.16	0.53	8.78	0.67	13.17	2.25	17.56
1 1/4	S	1.660	1.380	0.140	1.496	0.05	23.35	0.08	31.68	0.25	46.70	0.39	70.05	0.78	93.40
	H		1.278	0.191	1.280	0.07	19.95	0.09	28.06	0.26	39.90	0.44	58.85	0.85	79.80
	EH		0.896	0.382	0.630	0.13	9.83	0.16	13.75	0.24	19.66	0.71	29.49	1.35	39.32
1 1/2	S	1.900	1.610	0.145	2.036	0.04	31.75	0.11	44.49	0.19	63.50	0.33	95.25	0.64	127.00
	H		1.500	0.200	1.767	0.04	27.55	0.08	38.62	0.21	55.10	0.36	82.65	0.71	110.20
	EH		1.100	0.400	0.950	0.09	14.81	0.09	20.75	0.32	29.62	0.51	44.43	1.05	59.24
2	S	2.375	2.067	0.154	3.355	0.04	52.30	0.08	73.45	0.14	104.60	0.24	159.20	0.48	209.20
	H		1.939	0.218	2.953	0.03	46.00	0.09	64.60	0.15	92.00	0.26	138.00	0.52	184.00
	EH		1.503	0.436	1.773	0.04	27.65	0.12	38.78	0.21	55.30	0.36	82.95	0.72	110.60
2 1/2	S	2.875	2.469	0.203	4.788	0.03	74.75	0.07	104.80	0.11	149.50	0.20	224.25	0.37	299.00
	H		2.323	0.276	4.238	0.04	66.11	0.07	92.60	0.12	132.22	0.21	198.33	0.39	164.44
	EH		1.771	0.552	2.464	0.03	38.45	0.10	53.40	0.17	76.90	0.30	115.35	0.59	153.80

Clean Steel Pipe						Pressure Loss (Pounds Per Square Inch Per Foot Length) in Pipes at Average Flow Velocity (Feet per Second)				Equivalent Straight Pipe Length (Feet) for Circuit Components*					
Nominal Size		O.D.	I .D.	Wall Thick-ness	I.D. Area	25 (fps)		30 (fps)		Tee			Elbow		
Inches		Inches	Inches	Inch	Sq. In.	Loss	Gal. Min.	Loss	Gal. Min.				Std. 	Sq. 	45° 
1	S	1.315	1.049	0.133	0.863	1.64	67.25	2.24	80.70	5.7	1.7	5.7	2.6	5.7	1.2
	H		0.957	0.179	0.719	1.84	56.05	2.93	67.26	5.2	1.6	5.2	2.5	5.2	1.1
	EH		0.599	0.358	0.282	3.29	21.95	3.30	26.34	3.0	1.0	3.0	1.5	3.0	.75
1 1/4	S	1.660	1.380	0.140	1.496	1.18	116.75	1.47	140.10	7.5	2.4	7.5	3.7	7.5	1.6
	H		1.278	0.191	1.280	1.27	99.75	1.80	119.70	7.0	2.1	7.0	3.5	7.0	1.5
	EH		0.896	0.382	0.630	2.01	49.15	2.76	58.98	4.9	1.5	4.9	2.3	4.9	1.05
1 1/2	S	1.900	1.610	0.145	2.036	0.96	158.75	1.26	190.50	9.0	2.8	9.0	4.3	9.0	2.0
	H		1.500	0.200	1.767	1.06	137.75	1.36	145.30	8.2	2.6	8.2	4.0	8.2	1.8
	EH		1.100	0.400	0.950	1.51	74.05	2.14	88.86	6.5	2.0	6.5	3.0	6.5	1.4
2	S	2.375	2.067	0.154	3.355	0.69	261.50	0.85	313.80	11.0	3.5	11.0	5.5	11.0	2.5
	H		1.939	0.218	2.953	0.73	230.00	0.98	276.00	10.8	3.4	10.8	5.0	10.8	2.4
	EH		1.503	0.436	1.773	1.34	138.25	1.36	165.90	8.2	2.6	8.2	4.0	8.2	1.8
2 1/2	S	2.875	2.469	0.203	4.788	0.53	373.75	0.72	448.50	14.0	4.2	14.0	6.5	14.0	3.0
	H		2.323	0.276	4.238	0.57	330.55	0.87	396.66	13.0	4.0	13.0	6.1	13.0	2.9
	EH		1.771	0.552	2.464	0.79	192.25	1.15	230.70	10.3	3.1	10.3	4.8	10.3	2.2

*Consult valve manufacturer for pressure drops in a particular type of valve and port-to-port flow pattern.

Cushion ratings for **Air Cylinders Only** are described in **table b-7** and **graph b-3** below. To determine whether a cylinder will adequately stop a load without damage to the cylinder, the weight of the load (including the weight of the piston and the piston rod from **table b-6**) and the maximum speed of the piston rod must first be determined. Once these two factors are known, the **Kinetic Energy Graph** may be used. Enter the graph at its base for the value of weight determined, and project vertically to the required speed value. The point of intersection of these two lines will be the cushion rating number required for the application.

To determine the total load to be moved, the weight of the piston and rod must be included.

Total Weight = weight of the piston and non-stroke rod length (column 1) + weight of the rod per inch of stroke x the inches of stroke (Column 2) + the load to be move.

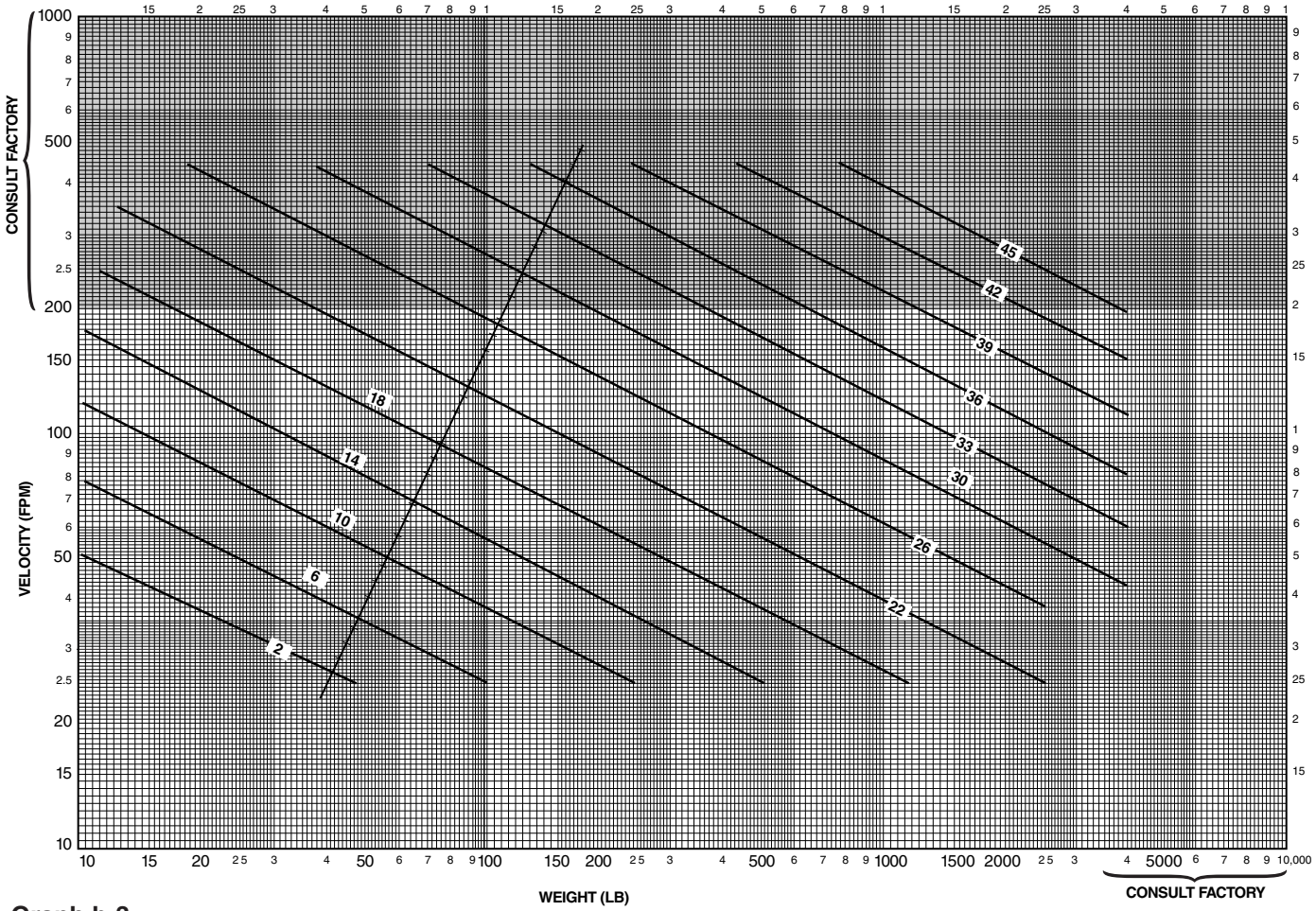
Weight Table

Bore Dia.	Column 1 Basic Wgt. (lbs.) for Piston & Non-Stroke Rod	Rod Dia.	Column 2 Basic Wgt. (lbs.) for 1" Stroke
1 1/2	1.5	5/8	.087
2	3.0	1	.223
2 1/2	5.4	1 3/8	.421
3 1/4	8.3	1 3/4	.682
4	14.2	2	.89
5	29.0	2 1/2	1.39
6	41.0	3	2.0
8	89.0	3 1/2	2.73
10	115.0	4	3.56
12	161.0	5	5.56
14	207.0	5 1/2	6.73

Table b-6

Example: *a 3 1/4" bore cylinder, having a 1" diameter rod and 25" stroke; load to be moved is 85 lbs. Total load to be moved is then 8.3 lbs. + .223 lbs./in. x 25 in. + 85 lbs. or a total of 99 lbs.*

Kinetic Energy Graph – Air Cylinders



Graph b-3

C

Now refer to **table b-7** below and find the cushion ratings, using bore size and rod diameter of the cylinder selected. If a simple circuit is used, with no meter out or speed control, use the "no back pressure, Column A" values. If a meter out or speed control is to be used, use the back pressure column values. If the cushion rating found in **table b-7**, **below**, is **greater** than the number determined in **graph b-3,** then the cylinder will stop the load adequately. If the cushion rating in **table b-7** is **smaller** than the number found in **graph b-3**, then a larger bore cylinder should be used. In those applications where back pressures exist in the exhaust lines, it is possible to exceed the cushion ratings shown in **table b-7**. In these cases, consult the factory and advise the amount of back pressure.

Air Cylinder Cushion Ratings Table

Bore Dia.	Rod Dia.	Rating With No Back Pressure	Rating With Back Pressure	Bore Dia.	Rod Dia.	Rating With No Back Pressure	Rating With Back Pressure
1 1/2	Cap End	12	17	7	3	24	30
	5/8	8	14		3 1/2	24	30
	1	3	8		4	23	29
2	Cap End	14	20		4 1/2	22	28
	5/8	12	18		5	21	27
	1	9	15	8	Cap End	29	35
	1 3/8	6	11		1 3/8	29	35
2 1/2	Cap End	17	23		1 3/4	29	34
	5/8	14	20		2	27	33
	1	14	19		2 1/2	26	32
	1 3/8	12	18		3	26	32
	1 3/4	8	13		3 1/2	26	32
3 1/4	Cap End	21	26		4	25	31
	1	18	24		5	23	29
	1 3/8	17	23		5 1/2	22	28
	1 3/4	16	22	10	Cap End	33	39
	2	13	19		1 3/4	32	38
4	Cap End	23	28		2	31	37
	1	20	27		2 1/2	31	36
	1 3/8	20	26		3	30	36
	1 3/4	19	25		3 1/2	30	36
	2	17	23		4	30	36
	2 1/2	17	22		5	28	34
5	Cap End	26	31		5 1/2	27	33
	1	23	28	12	Cap End	35	41
	1 3/8	23	28		2	33	39
	1 3/4	22	28		2 1/2	33	38
	2	20	26		3	33	38
	2 1/2	19	25		3 1/2	32	38
	3	18	24		4	32	38
	3 1/2	15	20		5	31	36
6	Cap End	26	31		5 1/2	31	36
	1 3/8	26	31	14	Cap End	38	43
	1 3/4	26	31		2 1/2	37	42
	2	24	29		3	36	42
	2 1/2	24	29		3 1/2	36	41
	3	22	28		4	36	41
	3 1/2	21	27		5	35	40
	4	20	26		5 1/2	34	40
7	Cap End	28	33				
	1 3/8	28	33				
	1 3/4	28	33				
	2	26	31				
	2 1/2	25	30				

Table b-7

Air Requirement Per Inch of Cylinder Stroke

The amount of air required to operate a cylinder is determined from the volume of the cylinder and its cycle in strokes per minute. This may be determined by use of the following formulae which apply to a single-acting cylinder.

$$V = \frac{3.1416\ L\ D^2}{4} \qquad C = \frac{fV}{1728}$$

Where: V = Cylinder volume, cu. in.
L = Cylinder stroke length, in.
D = Internal diameter of cylinder in.
C = Air required, cfm
f = Number of strokes per minute

The air requirements for a double-acting cylinder is almost double that of a single-acting cylinder, except for the volume of the piston rod.

The air flow requirements of a cylinder in terms of cfm should not be confused with compressor ratings which are given in terms of free air. If compressor capacity is involved in the consideration of cylinder air requirements it will be necessary to convert cfm values to free air values. This relationship varies for different gauge pressures.

Thrust (pounds) = operating pressure x area of cylinder bore.

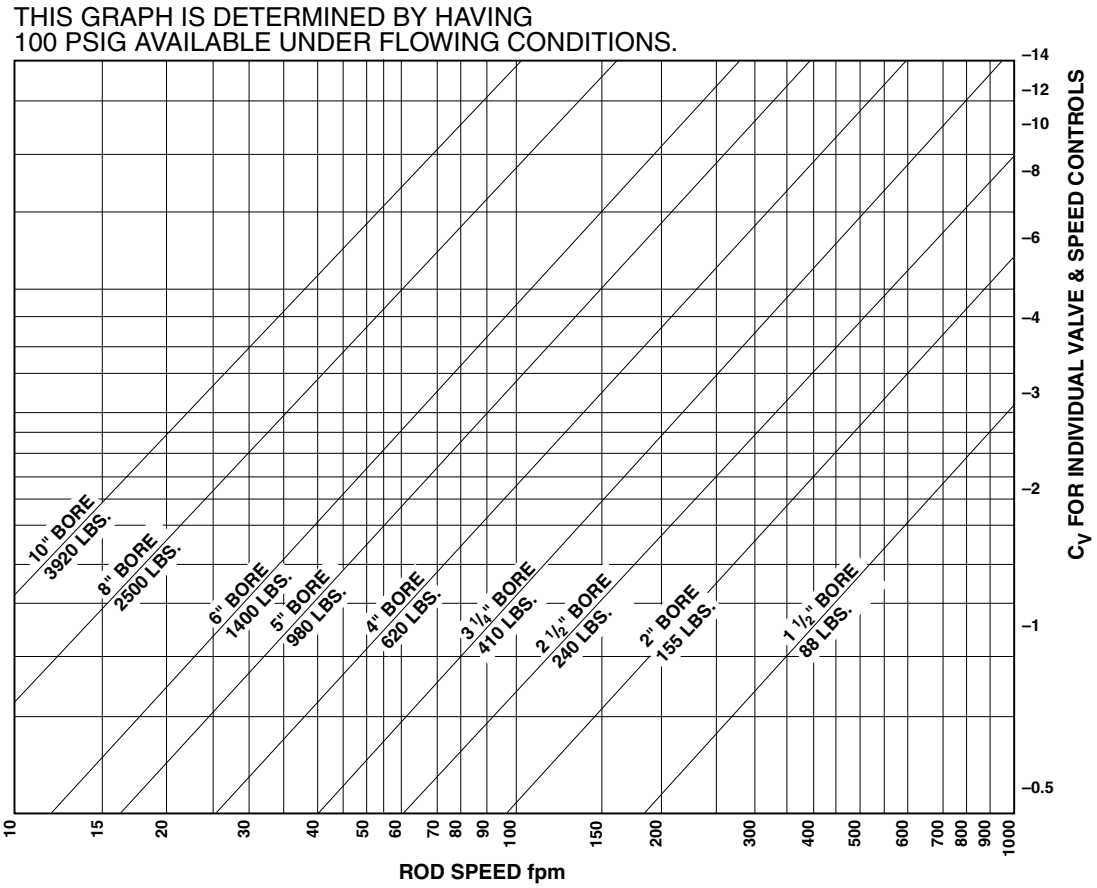
Note: *That on the "out" stroke the air pressure is working on the entire piston area but on the "in" stroke the air pressure works on the piston area less the rod area.*

Graph b-4 and **b-5** offer a simple means to select pneumatic components for dynamic cylinder applications. It is only necessary to know the force required, the desired speed and the pressure which can be maintained at the inlet to the F-R-L "Combo." The graphs assume average conditions relative to air line sizes, system layout, friction, etc. At higher speeds, consider appropriate cushioning of cylinders.

The general procedure to follow when using these graphs is:

1. Select the appropriate graph depending upon the pressure which can be maintained to the system – **graph b-4** for 100 psig and **graph b-5** for 80 psig.

2. Determine appropriate cylinder bore. Values underneath the diagonal cylinder bore lines indicate the maximum recommended dynamic thrust developed while the cylinder is in motion. The data in the table at the bottom of each graph indicates available static force applications in which clamping force is a prime consideration in determining cylinder bore.



graph b-4

Table b-8
Thrust Developed

BORE SIZE	1 1/2"	2"	2 1/2"	3 1/4"	4"	5"	6"	8"	10"
DYNAMIC THRUST (lbs.)	88	155	240	410	620	980	1400	2500	3920
STATIC THRUST (lbs.)	177	314	491	830	1250	1960	2820	5020	7850

C

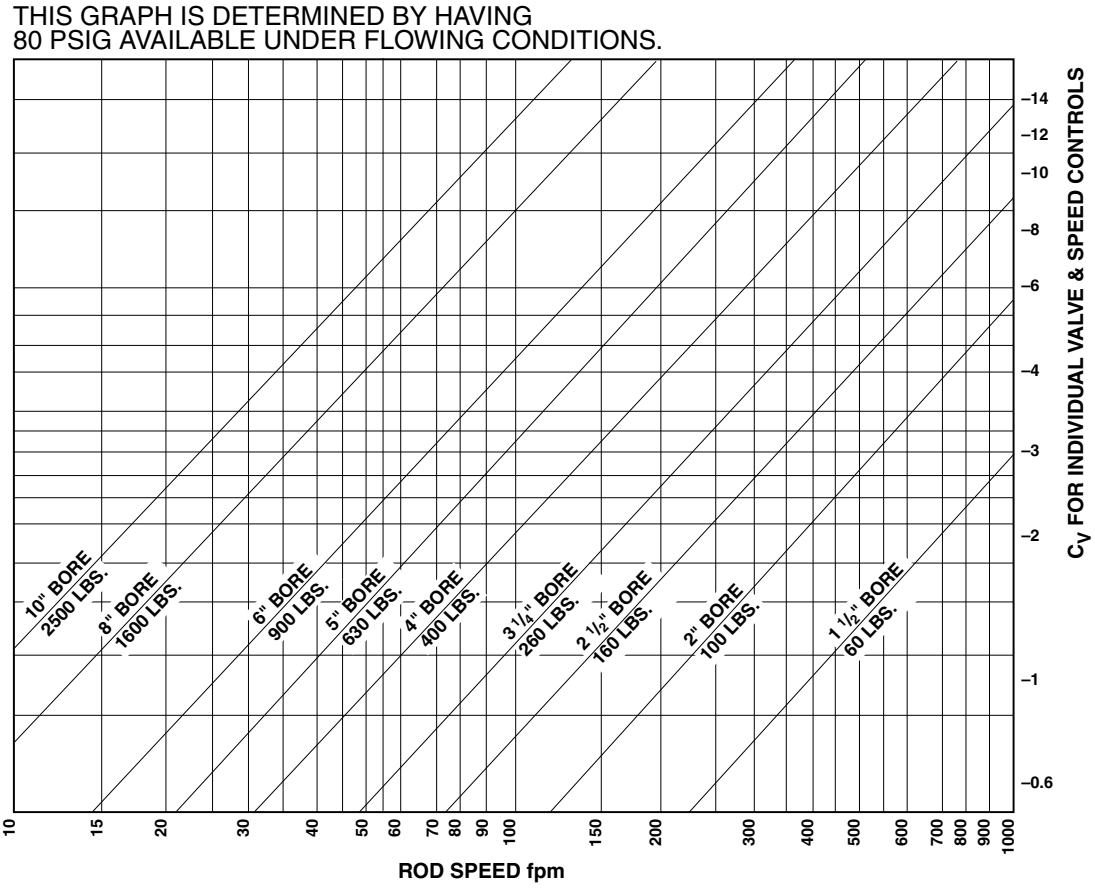
3. Read upward on appropriate rod speed line to intersection with diagonal cylinder bore line. Read right from intersection point to determine the required C_v of the valve and the speed controls. Both the valve and speed controls must have this C_v.

The following examples illustrate use of the graphs:

Example 1: *Assume it is necessary to raise a 900-pound load 24 inches in two seconds. With 100 psig maintained at the inlet to the F-R-L, use* **graph b-4**. *The 5-inch bore cylinder is capable of developing the required thrust while in motion. Since 24 inches in two seconds is equal to 60 fpm, read upward on the 60 fpm line to the intersection of the 5-inch bore diagonal line. Reading to the right indicates that the required valve and speed controls must each have a C_v of over 1.9.*

Example 2: *Assume similar conditions to Example 1 except that only 80- psig will be available under flowing conditions. Using* **graph b-5**, *a 6-inch bore cylinder is indicated. Read upward on the 60 fpm line to the intersection point. Interpolation of the right-hand scale indicates a required valve and speed control C_v of over 2.8.*

Example 3: *Assume similar conditions to Example 1 except that the load is being moved in a horizontal plane with a coefficient of sliding friction of 0.2. Only a 180-pound thrust is now required (900 lb. x 0.2). Consult* **graph b-4**. *The 2-1/2 inch bore cylinder will develop sufficient thrust, and at 60 fpm requires a valve and speed control C_v of about 0.5.*



graph b-5

Table b-9
Thrust Developed

BORE SIZE	1 1/2	2	2 1/2	3 1/4	4	5	6	8	10
DYNAMIC THRUST (lbs.)	60	100	160	260	400	630	900	1600	2500
STATIC THRUST (lbs.)	141	251	393	663	1000	1570	2260	4010	6280

Modifications: The following modifications can be supplied on most Schrader Bellows cylinders. For specific availability see Modification Chart.

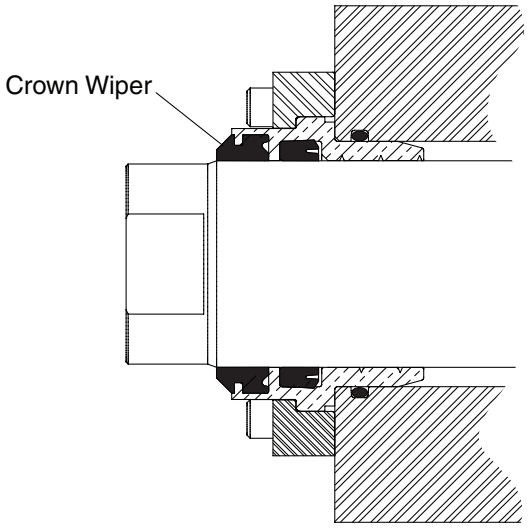
Metallic Rod Wiper

When specified metallic rod wipers can be supplied instead of the standard synthetic rubber wiperseal. Recommended in applications where contaminants tend to cling to the extended piston rod and would damage the synthetic rubber wiperseal. Installation of metallic rod wiper does not affect cylinder dimensions. It is available at extra cost.

Crown Wiper™ for Series PH-2 and 7" & 8" bore PH-3

For environments that contain fine abrasive particulate specify the Crown Wiper option. The Crown Wiper is a proven superior alternative to piston rod end boots or metallic wipers that can ingest particulate. It has a sharp leading edge to effectively clean the piston rod and a beveled shape to prevent contaminant intrusion by channeling it away from the gland. It also acts as a secondary seal to wipe clean any oil film adhering to the rod on the extend stroke.

Standard Crown Wiper material for Seal Class 1 and 2 service is durable polyurethane. Optional FKM material is available for Class 5 service. The Crown Wiper requires a unique gland but does not change cylinder mounting dimensions



Air Bleeds

In most hydraulic circuits, cylinders are considered self-bleeding when cycled full stroke. If air bleeds are required and specified, 1/8" NPTF Air Bleed Ports for venting air can be provided at both ends of the cylinder body, or on the head or cap. To order, specify "Bleed Port", and indicate position desired.

Rod End Boots

Cylinders have a hardened bearing surface on the piston rod to resist external damage, and are equipped with the high efficiency "Wiperseal" to remove external dust and dirt. Exposed piston rods that are subjected to contaminants with air hardening properties, such as paint, should be protected. In such applications, the use of a collapsing cover should be considered. This is commonly referred to as a "boot". Calculate the longer rod end required to accommodate the collapsed length of the boot from the following data.

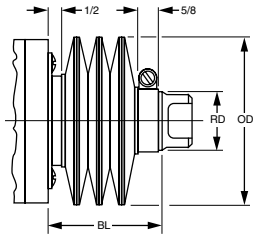
LF	.13	.13	.13	.13	.13	.13	.13	.10	.10	.10	.10	.10
OD	2 1/4	2 1/4	2 5/8	3	3 3/8	3 3/4	4 3/8	5 1/8	5 5/8	6 1/4	7	7 1/2
RD	1/2	5/8	1	1 3/8	1 3/4	2	2 1/2	3	3 1/2	4	5	5 1/2

To determine extra length of piston rod required to accommodate boot, calculate

BL = Stroke x LF + 1 1/8"

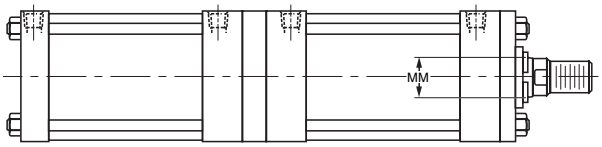
BL + Std. LA = length of piston rod to extend beyond the retainer.

NOTE: Check all Boot O.D's against std. "E" dimension from catalog. This may be critical on footmounted cylinders.



Tandem Cylinders

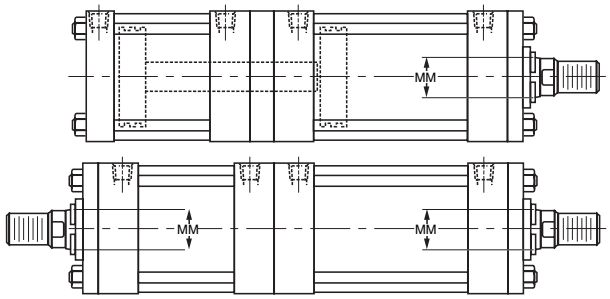
A tandem cylinder is made up of two cylinders mounted in line with pistons connected by a common piston rod and rod seals installed between the cylinders to permit double acting operation of each. Tandem cylinders allow increased output force when mounting width or height are restricted.



Reduced operating pressure is required for this construction. Please contact the factory.

Duplex Cylinders

A duplex cylinder is made up of two cylinders mounted in line with pistons not connected and with rod seals installed between the cylinders to permit double acting operation of each. Cylinders may be mounted with piston rod to piston (as shown) or back to back and are generally used to provide three position operation.



Reduced operating pressure is required for this construction. Please contact the factory.

C

The weights shown on this and the following pages are for Schrader Bellows PH-2, PH-3, PL-2, PA-2 and PN Series cylinders with various piston rod diameters. To determine the net weight of a cylinder, first select the proper basic weight for zero stroke, then calculate the weight of the cylinder stroke and add the result to the basic weight. For extra rod extension, use weights per inch shown in Piston Rod Weights table. Weights of cylinders with intermediate rods may be estimated from table below by taking the difference between the piston rod weights per inch and adding it to the standard diameter rod weight for the cylinder bore size involved.

Cylinder Weights, in pounds, for PH-2 & PH-3 Series (7.00" & 8.00") Hydraulic Cylinders

Bore Size	Rod Dia.	Rod Code	Single Rod Cylinders Basic Wt. Zero Stroke		Add Per Inch of Stroke	Double Rod Cylinders Basic Wt. Zero Stroke		Add Per Inch of Stroke
			MF1, MF2, MF5, MF6, MS4 MX0, MX1, MX2, MX3	ME5, ME6, MP1, MS2, MT1, MT2, MT4		MDF1, MDF5, MDS4 MDX0, MDX1, MDX3	MDE5, MDS2 MDT1, MDT4	
1 1/2"	5/8"	1	7.8	9.0	.5	9.7	10.8	.6
	1"	2	8.4	9.3	.6	9.1	10.7	.8
2"	1"	1	11.6	13.2	.8	14.6	16.8	1.0
	1 3/8"	2	13.5	17.1	1.0	19.4	20.6	1.4
2 1/2"	1"	1	17.0	19.5	1.1	21.0	24.5	1.3
	1 3/4"	2	22.5	25.5	1.5	27.0	30.0	2.2
3 1/4"	1 3/8"	1	32.0	41.0	1.8	43.0	52.0	2.2
	2"	2	37.0	46.0	2.2	48.0	57.0	3.1
4"	1 3/4"	1	48.0	53.0	2.5	59.0	63.0	3.2
	2 1/2"	2	52.0	58.0	3.2	92.0	97.0	4.6
5"	2"	1	76.0	82.0	3.4	96.0	102.0	4.8
	3 1/2"	2	88.0	86.0	5.2	117.0	123.0	7.9
6"	2 1/2"	1	125.0	133.0	5.2	153.0	159.0	6.6
	4"	2	133.0	140.0	7.3	182.0	190.0	10.9
7"	3"	1	233.0	242.0	6.7	320.0	339.0	8.7
	5"	2	240.0	253.0	10.3	341.0	360.0	15.9
8"	3 1/2"	1	262.0	276.0	9.0	323.0	331.0	11.7
	5 1/2"	2	300.0	309.0	13.0	390.0	411.0	19.7

Cylinder Weights, in pounds, for PH-3 Series Large Bore Hydraulic Cylinders

Bore Size	Rod Ø (In.)	Rod Code	Single Rod Cylinders Basic Wt. Zero Stroke				Add Per In. of Stroke	Double Rod Cylinders Basic Weight Zero Stroke Add to All Mtg. Styles	Add Per In. of Stroke
			MT1, MT2	MT4, ME5, ME6	MF5, MF6	MP1, MS2, MS3			
10.00	4 1/2	1	562	646	684	607	15	43	20
	5	3	574	656	695	619	16	50	21
	5 1/2	4	583	667	705	628	17	64	24
	7	2	620	704	742	665	21	101	32
12.00	5 1/2	1	924	1057	1136	1000	22	64	29
	7	3	961	1094	1173	1036	26	101	37
	8	2	1022	1155	1234	1097	29	162	43
14.00	7	1	1335	1520	1582	1485	28	101	39
	8	3	1396	1581	1643	1546	31	162	45
	10	2	1496	1681	1743	1646	39	262	61

Bore Ø	Rod Ø	Rod Code	Single Rod Cylinders Basic Wt. Zero Stroke				Double Rod Cylinders	
			ME5, ME6	MF5, MF6	MP1	Add Per Inch of Stroke	Basic Wt. Zero Stroke Add to All Mtg. Styles	Add Per Inch of Stroke
16.00	8.000	1	2073	2257	2226	35	149	49
	9.000	3	2122	2305	2275	39	198	57
	10.000	4	2181	2364	2334	43	257	65
18.00	9.000	1	3165	3256	3330	45	198	63
	10.000	3	3224	3315	3390	50	257	72
20.00	10.000	1	4231	4406	4551	57	257	79

Piston Rod Weights, in pounds

Rod Ø	Piston Rod Wt. Per Inch	Rod Ø	Piston Rod Wt. Per Inch	Rod Ø	Piston Rod Wt. Per Inch
0.625	0.09	2.500	1.40	5.000	5.56
1.000	0.22	3.000	2.00	5.500	6.72
1.375	0.42	3.500	2.72	7.000	10.89
1.750	0.68	4.000	3.56	8.000	14.22
2.000	0.89	4.500	4.51	10.000	22.23

Cylinder Weights, in pounds, for PA-2, PN, PL-2 Series cylinders

Bore Size	Rod Dia.	Single Rod Cylinders Basic Wt. Zero Stroke		Add Per Inch of Stroke	Double Rod Cylinders Basic Wt. Zero Stroke		Add Per Inch of Stroke
		MF1, MF2, MS4 MX0, MX1, MX2, MX3	MF5, MF6, MP1, MS2 MT1, MT2, MT4		MDF1, MDS4 MDX0, MDX1, MDX3	MDF5, MDS2 MDT1, MDT4	
1"	1/2"	2.5	2.9	.20	4.7	5.5	.40
	5/8"	2.6	3.0	.23	4.9	5.7	.46
1 1/2"	5/8"	3.7	4.3	.3	4.2	4.8	.6
	1"	4.5	5.1	.4	5.8	6.7	.8
2"	5/8"	6.5	6.9	.5	8.2	8.6	1.0
	1"	7.0	7.5	.63	9.0	9.5	1.3
	1 3/8"	8.5	8.9	.8	11.2	11.6	1.6
2 1/2"	5/8"	9.0	9.7	.6	11.4	12.1	1.2
	1"	9.5	10.0	.73	12.0	12.5	1.5
	1 3/4"	13.2	13.6	1.1	19.8	20.5	2.2
3 1/4"	1"	16.5	17.5	.8	22.0	23.0	1.6
	1 3/8"	17.0	18.0	1.0	22.5	23.5	2.0
	2"	27.0	28.0	1.4	43.0	44.0	2.8
4"	1"	26.0	31.0	1.0	33.0	38.0	2.0
	1 3/8"	26.5	31.5	1.2	33.5	38.5	2.5
	2 1/2"	36.0	42.0	2.0	53.0	58.0	4.0
5"	1"	39.0	46.0	1.1	48.0	55.0	2.2
	1 3/8"	39.5	46.5	1.3	48.5	55.5	2.6
	3 1/2"	63.0	66.0	3.6	96.0	103.0	7.2
6"	1 3/8"	68.0	77.0	1.5	80.0	89.0	3.0
	4"	100.0	102.0	4.5	144.0	153.0	9.0
7"	1 3/8"	80.0	85.0	2.0	92.0	97.0	4.0
	2"	82.0	87.0	3.5	96.0	101.0	7.0
8"	1 3/8"	94.0	99.0	2.0	108.0	113.0	4.0
	5 1/2"	168.0	172.0	8.0	256.0	261.0	16.0
10"	1 3/4"	182.0	188.0	2.5	178.0	184.0	5.0
	5 1/2"	258.0	264.0	8.5	330.0	335.0	17.0
12"	2"	274.0	282.0	3.5	270.0	280.0	7.0
	5 1/2"	350.0	358.0	9.5	420.0	430.0	19.0
14"	2 1/2"	435.0	448.0	4.5	440.0	655.0	9.0
	5 1/2"	510.0	519.0	10.0	490.0	705.0	20.0

Piston Rod Weights, in pounds

Rod Dia.	Piston Rod Wt. Per Inch	Rod Dia.	Piston Rod Wt. Per Inch	Rod Dia.	Piston Rod Wt. Per Inch
5/8"	.09	2"	.89	4"	3.56
1"	.22	2 1/2"	1.40	4 1/2"	4.51
1 3/8"	.42	3"	2.00	5"	5.56
1 3/4"	.68	3 1/2"	2.72	5 1/2"	6.72

C

Mounting Styles

General guidance for the selection of ISO mounting styles can be found in the SHM content of Section B. The notes which follow provide information for use in specific applications and should be read in conjunction with that information.

Trunnions

Trunnions require lubricated pillow blocks with minimum bearing clearances. Blocks should be aligned and mounted to eliminate bending moments on the trunnion pins. Self-aligning mounts must not be used to support the trunnions as bending forces can develop.

Intermediate trunnions may be positioned at any point on the cylinder body. This position, dimension XI, should be specified at the time of order. Trunnion position is not field adjustable.

Flange Mountings

Front flange-mounted (style JJ) cylinders incorporate a pilot diameter for accurate alignment on the mounting surface – see rod end dimensions for SHM cylinders. The gland retainer is integral with the head on 25, 32 and 40mm bore cylinders, while on 50mm bores and above, the circular retainer is bolted to the head.

Extended Tie Rods

Cylinders may be ordered with extended tie rods in addition to another mounting style. The extended tie rods may then be used for mounting other systems or machine components.

Pivot Mountings

Pivot pins are supplied with style BB cap fixed clevis mounted cylinders. Pivot pins are not supplied with the cap fixed eye mounting, style B, or the cap with spherical bearing, style SB, where pin length will be determined by the customer's equipment.

Spherical Bearings

The service life of a spherical bearing is influenced by such factors as bearing pressure, load direction, sliding velocity and frequency of lubrication. When considering severe or unusual working conditions, please consult the factory.

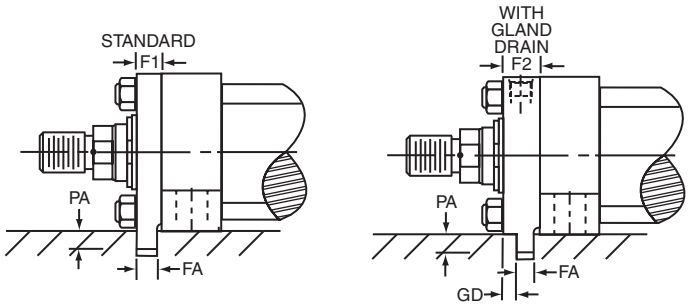
Foot Mountings and Thrust Keys

The bending moment which results from the application of force by a foot mounted cylinder must be resisted by secure mounting and effective guidance of the load. A thrust key modification is recommended to provide positive cylinder location.

Thrust key mountings eliminate the need for fitted bolts or external keys on Style C side mounted cylinders. The gland retainer plate of 25mm & 32mm bore cylinders is extended below the nominal mounting surface to fit into a keyway milled into the mounting surface of the machine member. To order a key retainer plate in 25mm & 32mm bores, specify P in the Mounting Modification field of the model code.

Bore Ø	Rod Ø	Nominal		FA -0.075	GD	PA -0.2
		F1 Standard	F2 w/Gland Drain			
25	All	10	10[1]	8	–	5
32	14	10	10[1]	8	–	5
	22	10	16	8	6	5

[1] Gland drain is in the head. See Optional Features page for additional details about gland drain ports.

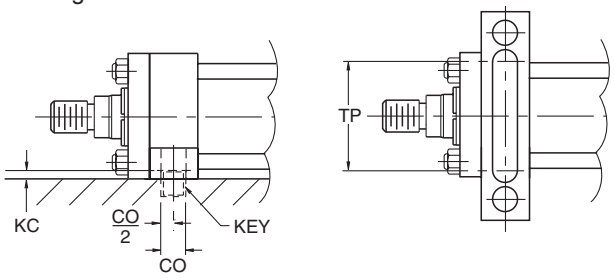


Profile of thrust key extension (with gland drain in retainer) for bore and rod combination 32mm x 22mm.

Integral Key – 25mm & 32mm Bores

All dimensions are in millimeters unless otherwise stated.

Cylinders 40mm to 200mm bore utilize a keyway milled into the Style C head on the mounting lug side. A key (supplied) fits into the cylinder keyway and a corresponding keyway in the mounting surface of the machine member. To order the milled keyway and key in 40mm to 200mm bores, specify K in the Mounting Modification field of the model code.



Milled Keyway – 40mm to 200mm Bore

Bore Ø	CO N9	KC +0.5	TP[2] min
40	12	4	55
50	12	4.5	70
63	16	4.5	80
80	16	5	105
100	16	6	120
125	20	6	155
160	32	8	190
200	40	8	220

[2] Suggested Key Length

Key				
Bore Ø	Width	Height	Length	Part No.
40	12	8	55	0941540040
50	12	8	70	0941540050
63	16	10	80	0941540063
80	16	10	105	0941540080
100	16	10	120	0941540100
125	20	12	155	0941540125
160	32[3]	18	190	0941540160
200	40	22	220	0941540200

[3] Not to ISO6020/2.

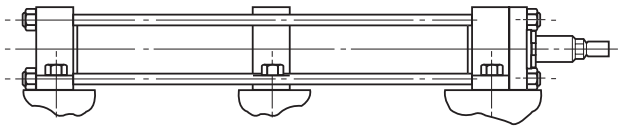
Mounting Bolts and Nuts

Parker recommends that mounting bolts with a minimum strength of ISO 898/1 grade 10.9 should be used for fixing cylinders to the machine or base. This recommendation is of particular importance where bolts are placed in tension or subjected to shear forces. Mounting bolts, with lubricated threads, should be torque loaded to their manufacturer's recommended figures. Tie rod mounting nuts should be to a minimum strength of ISO 898/2 grade 10, torque loaded to the figures shown.

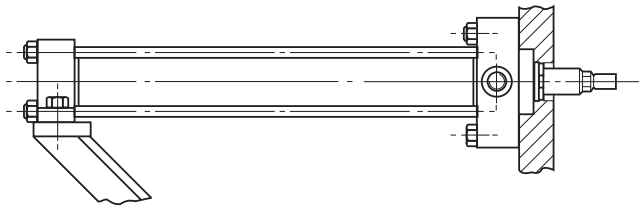
Bore Ø	Tie Rod Torque Nm
25	4.5-5.0
32	7.6-9.0
40	19.0-20.5
50	68-71
63	68-71
80	160-165
100	160-165
125	450-455
160	815-830
200	1140-1155

Intermediate or Additional Mountings

Long cylinders with fixed mountings such as extended tie rods may require additional support to counter sagging or the effects of vibration. This may be provided mid-way along the cylinder body in the form of an intermediate mounting or, with end-mounted cylinders, as an additional mounting supporting the free end of the cylinder. Please contact the factory for further information. The maximum unsupported stroke lengths which Parker recommends for each bore size are shown in the table below.



Intermediate Foot Mounting



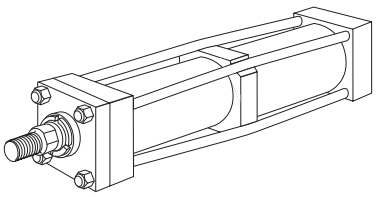
End Support Mounting

Maximum Stroke Lengths of Unsupported Cylinders (in mm)

Bore Ø	Intermediate Mounting	End Support Mounting
25, 32, 40	1500	1000
50, 63, 80	2000	1500
100, 125	3000	2000
160, 200	3500	2500

All dimensions are in millimeters unless otherwise stated.

Tie Rod Supports



To increase the resistance to buckling of long stroke cylinders, tie rod supports may be fitted. These move the tie rods radially outwards and allow longer than normal strokes to be used without the need for an additional mounting.

Bore Ø	Stroke (meters)												No. of Supports Required
	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	
25	1	1	2	Consult Factory									
32	-	1	1	2									
40	-	-	1	1	1	2	2						
50	-	-	-	1	1	1	2	2	2	2	2	3	
63	-	-	-	-	-	1	1	1	1	1	2	2	
80	-	-	-	-	-	-	-	1	1	1	1	1	
100	-	-	-	-	-	-	-	-	-	1	1	1	

Stroke Tolerances

Stroke length tolerances are required due to the build-up of tolerances of piston, head, cap and cylinder body. Standard production stroke tolerances are 0 to +2mm on all bore sizes and stroke lengths. For closer tolerances, please specify the required tolerance plus the operating temperature and pressure. Stroke tolerances of less than 0.4mm are generally impracticable due to the elasticity of cylinders. In these cases, the use of a stroke adjuster should be considered. Tolerances of stroke dependent dimensions for each mounting style are shown in the table below.

Stroke Dependent Tolerances

Mounting Style	Dimensions	Tolerance - for strokes up to 3m
All styles - port dimensions	Y	±2
	PJ	±1.25
ME5	ZB	max
ME6	ZJ	±1
MP1 MP3	XC	±1.25
MP5	XO	±1.25
MS2	XS ZB SS	±2 max ±1.25
MT1	XG ZB	±2 max
MT2	XJ ZB	±1.25 max
MT4	XV ZB	±2 max
MX1 MX2 MX3	BB	+3 0
MX3	ZB	max
MX1 MX3	WH	±2
MX1 MX2 MX3	ZJ	±1

C

Calculation of Cylinder Diameter

General Formula

The cylinder output forces are derived from the formula:

$$F = \frac{P \times A}{10000}$$

Where F = Force in kN.
P = Pressure at the cylinder in bar.
A = Effective area of cylinder piston in square mm.

Prior to selecting the cylinder bore size, properly size the piston rod for tension (pull) or compression (push) loading (see the Piston Rod Selection Chart).

If the piston rod is in compression, use the 'Push Force' table below, as follows:

1. Identify the operating pressure closest to that required.
2. In the same column, identify the force required to move the load (always rounding up).
3. In the same row, look along to the cylinder bore required.

If the cylinder envelope dimensions are too large for the application, increase the operating pressure, if possible, and repeat the exercise.

If the piston rod is in tension, use the 'Deduction for Pull Force' table. The procedure is the same but, due to the reduced area caused by the piston rod, the force available on the 'pull' stroke will be smaller. To determine the pull force:

1. Follow the procedure for 'push' applications as described above.
2. Using the 'pull' table, identify the force indicated according to the rod and pressure selected.
3. Deduct this from the original 'push' force. The resultant is the net force available to move the load.

If this force is not large enough, repeat the process and increase the system operating pressure or cylinder diameter if possible. For assistance, contact your local authorized Schrader Bellows distributor.

Push Force

Bore Ø	Bore Area	Cylinder Push Force in kN						
		10 bar	40 bar	63 bar	100 bar	125 bar	160 bar	210 bar
mm	sq. mm							
25	491	0.5	2.0	3.1	4.9	6.1	7.9	10.3
32	804	0.8	3.2	5.1	8.0	10.1	12.9	16.9
40	1257	1.3	5.0	7.9	12.6	15.7	20.1	26.4
50	1964	2.0	7.9	12.4	19.6	24.6	31.4	41.2
63	3118	3.1	12.5	19.6	31.2	39.0	49.9	65.5
80	5027	5.0	20.1	31.7	50.3	62.8	80.4	105.6
100	7855	7.9	31.4	49.5	78.6	98.2	125.7	165.0
125	12272	12.3	49.1	77.3	122.7	153.4	196.4	257.7
160	20106	20.1	80.4	126.7	201.1	251.3	321.7	422.2
200	31416	31.4	125.7	197.9	314.2	392.7	502.7	659.7

Deduction for Pull Force

Piston Rod Ø	Piston Rod Area	Reduction in Force in kN						
		10 bar	40 bar	63 bar	100 bar	125 bar	160 bar	210 bar
mm	sq. mm							
12	113	0.1	0.5	0.7	1.1	1.4	1.8	2.4
14	154	0.2	0.6	1.0	1.5	1.9	2.5	3.2
18	255	0.3	1.0	1.6	2.6	3.2	4.1	5.4
22	380	0.4	1.5	2.4	3.8	4.8	6.1	8.0
28	616	0.6	2.5	3.9	6.2	7.7	9.9	12.9
36	1018	1.0	4.1	6.4	10.2	12.7	16.3	21.4
45	1591	1.6	6.4	10.0	15.9	19.9	25.5	33.4
56	2463	2.5	9.9	15.6	24.6	30.8	39.4	51.7
70	3849	3.8	15.4	24.2	38.5	48.1	61.6	80.8
90	6363	6.4	25.5	40.1	63.6	79.6	101.8	133.6
110	9505	9.5	38.0	59.9	95.1	118.8	152.1	199.6
140	15396	15.4	61.6	97.0	154.0	192.5	246.3	323.3

Piston Rod Size Selection

To select a piston rod for thrust (push) applications, follow these steps:

1. Determine the type of cylinder mounting style and rod end connection to be used. Consult the Stroke Factor table and determine which factor corresponds to the application.
2. Using the appropriate stroke factor, determine the 'basic length' from the equation:

   Basic Length = Net Stroke x Stroke Factor

   (The graph is prepared for standard rod extensions beyond the face of the gland retainers. For rod extensions greater than standard, add the increases to the net stroke to arrive at the 'basic length'.)
3. Calculate the load imposed for the thrust application by multiplying the full bore area of the cylinder by the system pressure, or by referring to the Push and Pull Force charts.
4. Using the graph below, look along the values of 'basic length' and 'thrust' as found in 2 and 3 above, and note the point of intersection.

The correct piston rod size is read from the diagonally curved line labelled 'Rod Diameter' above the point of intersection.

Stop Tubes

The required length of stop tube, where necessary, is read from the vertical columns on the right of the graph below by following the horizontal band within which the point of intersection, determined in steps 2 and 3 opposite, lies.

Note that stop tube requirements differ for fixed and pivot mounted cylinders.

If the required length of stop tube is in the region labeled 'consult factory', please submit the following information:

1. Cylinder mounting style.
2. Rod end connection and method of guiding load.
3. Bore required, stroke, length of rod extension (dimensions WF) if greater than standard.
4. Mounting position of cylinder. (Note: if at an angle or vertical, specify the direction of the piston rod.)
5. Operating pressure of cylinder, if limited to less than the standard pressure for the cylinder selected.

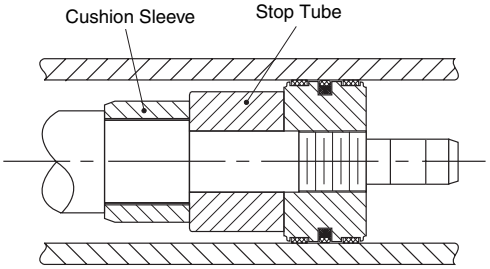
When specifying a cylinder with a stop tube, state the **gross** stroke of the cylinder and the length of the stop tube. The gross stroke is equal to the net (working) stroke of the cylinder plus the stop tube length. See the example below:

Ex. 80-JJ-SHM-R-E-S-14-M1375M1100

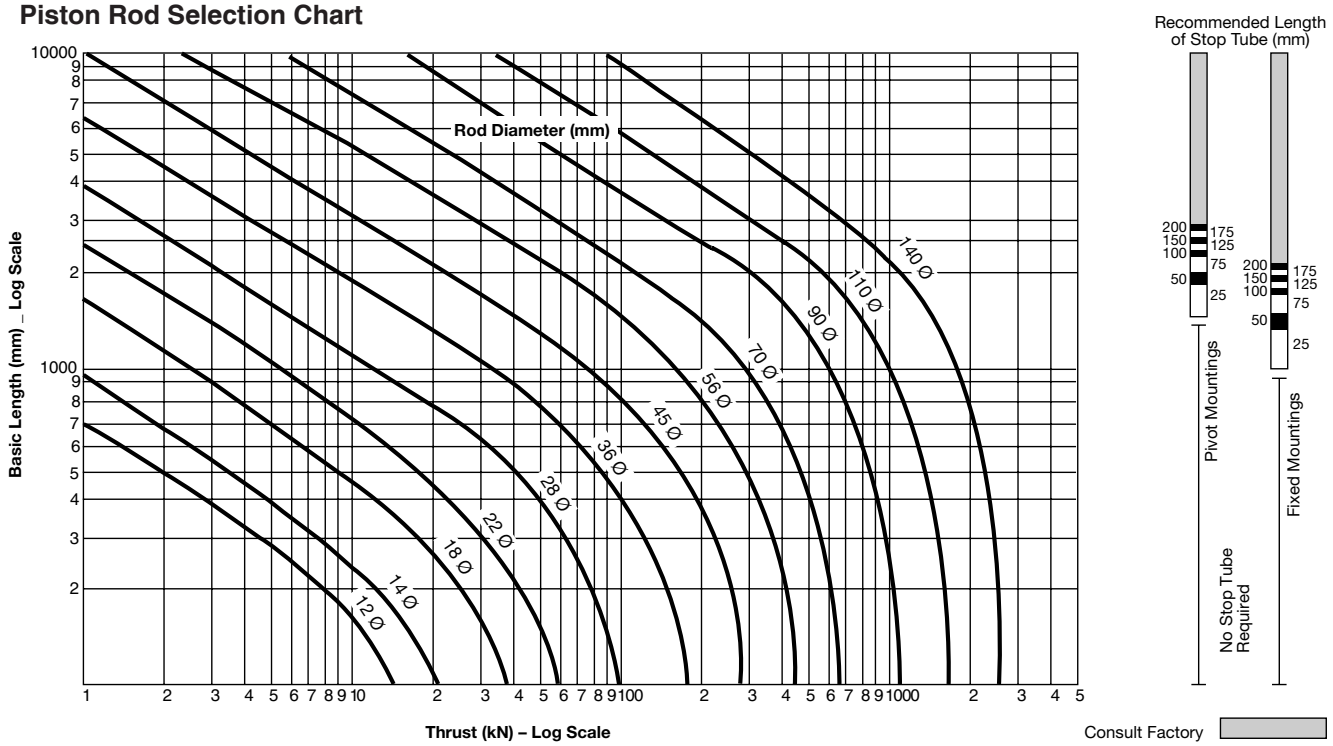
1) Stop tube = 175

2) Net stroke = 1200

– the cylinder net stroke will be 1200mm with 175mm of stop tube.



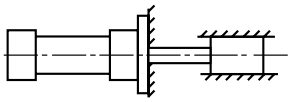
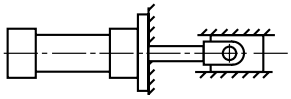
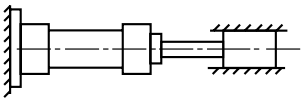
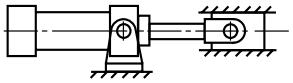
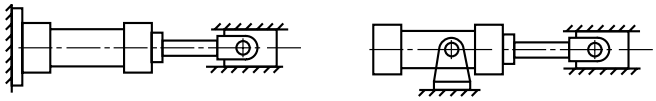
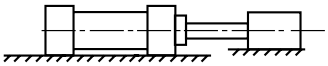
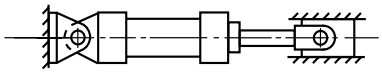
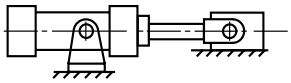
Piston Rod Selection Chart



C

Stroke Factors

The stroke factors below are used in the calculation of cylinder 'basic length' – see Piston Rod Size Selection.

Rod End Connection	Mounting Style	Type of Mounting	Stroke Factor
Fixed and Rigidly Guided	TB, TD, C, JJ		0.5
Pivoted and Rigidly Guided	TB, TD, C, JJ		0.7
Fixed and Rigidly Guided	TC, HH		1.0
Pivoted and Rigidly Guided	D		1.0
Pivoted and Rigidly Guided	TC, HH, DD		1.5
Supported but not Rigidly Guided	TB, TD, C JJ		2.0
Pivoted and Rigidly Guided	B, BB, DB, SB		2.0
Pivoted and Supported but not Rigidly Guided	DD		3.0

Long Stroke Cylinders

When considering the use of long stroke cylinders, the piston rod should be of sufficient diameter to provide the necessary column strength.

For tensile (pull) loads, the rod size is selected by specifying standard cylinders with standard rod diameters and using them at or below the rated pressure.

Stop tube is recommended to lengthen the distance between the gland and piston to reduce bearing loads when the cylinder is fully extended. This is especially true of horizontally mounted and long stroke cylinders. Long stroke cylinders achieve additional stability through the use of a stop tube.

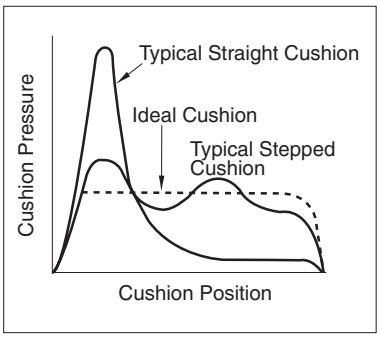
An Introduction to Cushioning

Cushioning is recommended as a means of controlling the deceleration of masses, or for applications where piston speeds are in excess of 0.1m/s and the piston will make a full stroke. Cushioning extends cylinder life and reduces undesirable noise and hydraulic shock.

Built-in 'cushions' are optional and can be supplied at the head and cap ends of the cylinder without affecting its envelope or mounting dimensions.

Standard Cushioning

Ideal cushion performance shows an almost uniform absorption of energy along the cushioning length, as shown. Many forms of cushioning exist, and each has its own specific merits and advantages. In order to cover the majority of applications, SHM cylinders are supplied with profiled cushioning as standard. Final speed may be adjusted using the cushion screws. The performance of profiled cushioning is indicated on the diagram, and cushion performance for each of the rod sizes available is illustrated graphically in the charts on the next page.



Note: Cushion performance will be affected by the use of water or high water based fluids. Please consult the factory for details.

Cushion Length

Where specified, SHM cylinders incorporate the longest cushion sleeve and spear that can be accommodated within the standard envelope without reducing the rod bearing and piston bearing lengths. See table of cushion lengths on the following pages. Cushions are adjustable via recessed needle valves.

Cushion Calculations

The charts on the next page show the energy absorption capacity for each bore/rod combination at the head (annulus) and the cap (full bore) ends of the cylinder. The charts are valid for piston velocities in the range 0.1 to 0.3m/s. For velocities between 0.3 and 0.5m/s, the energy values derived from the charts should be reduced by 25%. For velocities of less than 0.1m/s where large masses are involved, and for velocities of greater than 0.5m/s, a special cushion profile may be required. Please consult the factory for details.

The cushion capacity of the head end is less than that of the cap, and reduces to zero at high drive pressures due to the pressure intensification effect across the piston.

The energy absorption capacity of the cushion decreases with drive pressure.

Formula

Cushioning calculations are based on the formula $E = {}^1/_2mv^2$ for horizontal applications. For inclined or vertically downward or upward applications, this is modified to:

$E = {}^1/_2mv^2 + mgl \times 10^{-3} \times \sin(a)$

(for inclined or vertically downward direction of mass)

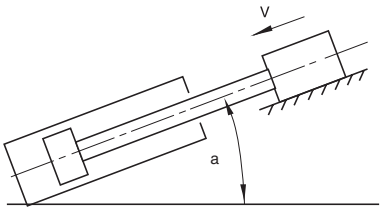
$E = {}^1/_2mv^2 - mgl \times 10^{-3} \times \sin(a)$

(for inclined or vertically upward direction of mass)

Where:
E = energy absorbed in Joules
g = acceleration due to gravity = 9.81m/s^2
v = velocity in meters/second
l = length of cushion in millimeters
m = mass of load in kilograms (including piston, rod and rod end accessories)
a = angle to the horizontal in degrees
p = pressure in bar

Example

The following example shows how to calculate the energy developed by masses moving in a straight line. For non-linear motion, other calculations are required; please consult the factory. The example assumes that the bore and rod diameters are already appropriate for the application. The effects of friction on the cylinder and load have been ignored.



Selected bore/rod 160/70mm (No.1 rod).
Cushioning at the cap end.

Pressure =	160 bar
Mass =	10000kg
Velocity =	0.4m/s
Cushion length =	41mm
a =	45°
Sin (a) =	0.70

$E = {}^1/_2mv^2 + mgl \times 10^{-3} \times \sin(a)$

$= \frac{10000 \times 0.4^2}{2} + 10000 \times 9.81 \times \frac{41}{10^3} \times 0.70$

$= 800 + 2815 = 3615$ Joules

Note that velocity is greater than 0.3m/s; therefore, a de-rating factor of 0.75 must be applied before comparison with the curves on the cushioning charts. Applying this factor to the calculated energy figure of 3615 Joules gives a corrected energy figure of:

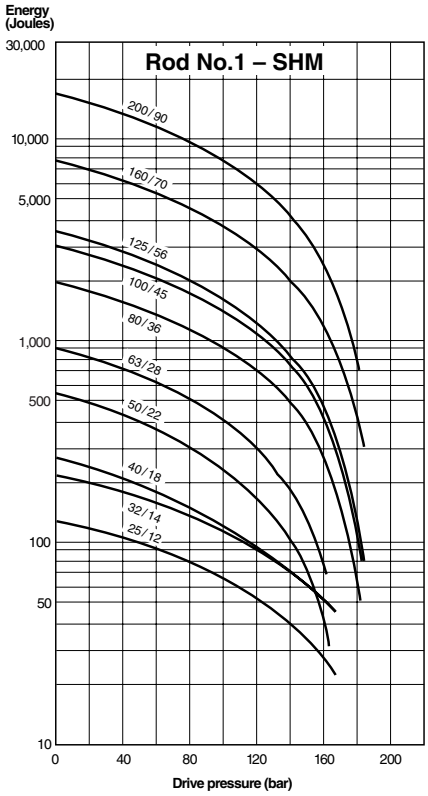
$\frac{3615}{0.75} = 4820$ Joules

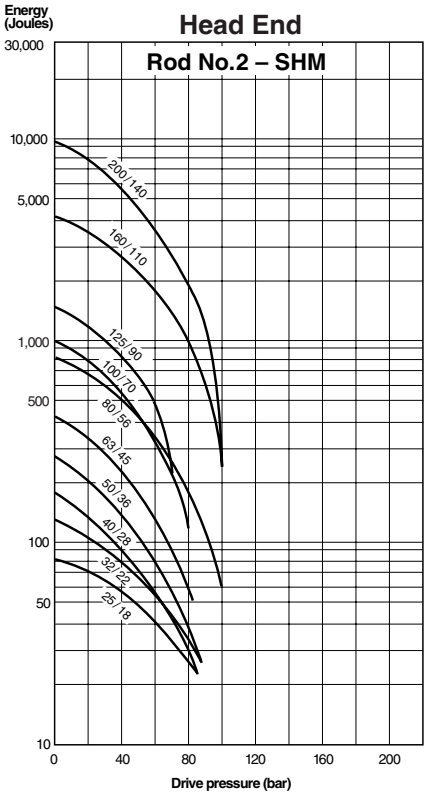
Comparison with the curve shows that the standard cushion can safely decelerate this load. If the calculated energy exceeds that indicated by the curve, select a larger bore cylinder and re-calculate.

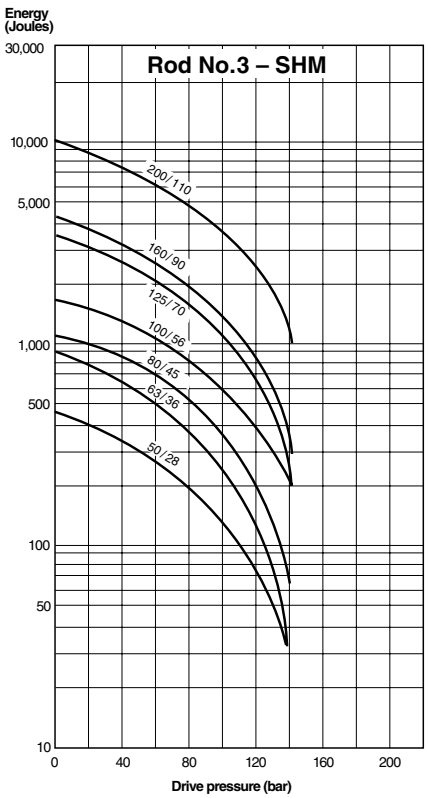
C

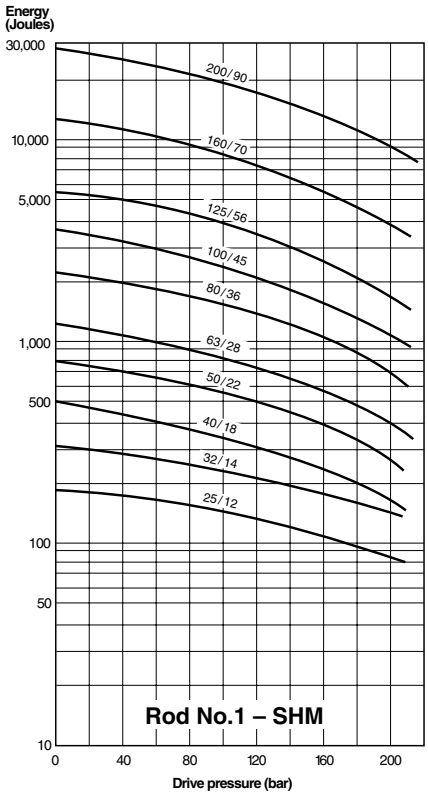
Cushion Energy Absorption Capacity Data

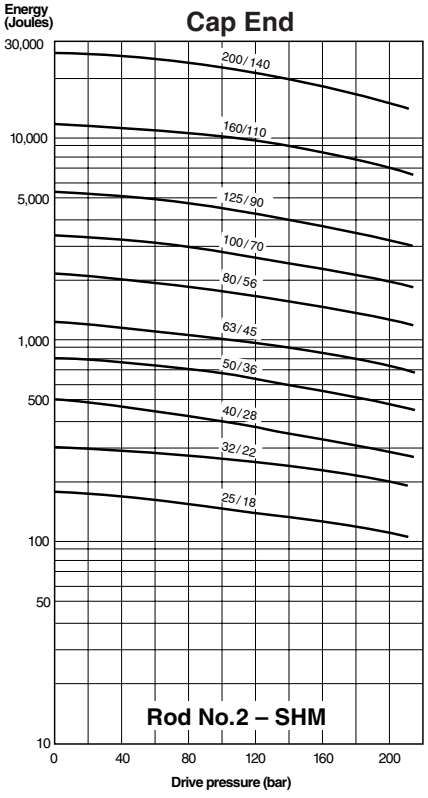
The cushion energy absorption capacity data shown below is based on the maximum fatigue-free pressure developed in the tube. For applications with a life cycle of less than 10^6 cycles, greater energy absorption figures can be applied. Please consult the factory if further information is required.

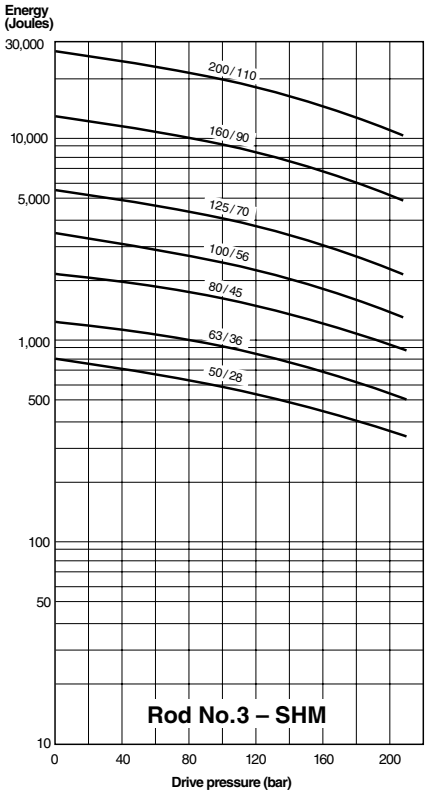












Cushion Length, Piston and Rod Mass

Bore Ø	Rod No.	Rod Ø	Cushion Length						Mass	
			Rod No. 1		Rod No. 2		Rod No. 3		Piston & Rod Zero Stroke kg	Rod Only per 10mm Stroke kg
			Head	Cap	Head	Cap	Head	Cap		
25	1	12	22	20	24	20	-	-	0.12	0.01
	2	18							0.16	0.02
32	1	14	24	20	24	20	-	-	0.23	0.01
	2	22							0.30	0.03
40	1	18	29	29	29	30	-	-	0.44	0.02
	2	28							0.60	0.05
50	1	22	29	29	29	29	29	29	0.70	0.03
	2	36							0.80	0.05
	3	28							0.95	0.08
63	1	28	29	29	29	29	29	29	1.20	0.05
	2	45							1.35	0.08
	3	36							1.60	0.12
80	1	36	35	32	27	32	35	32	2.30	0.08
	2	56							2.50	0.12
	3	45							2.90	0.19
100	1	45	35	32	26	32	29	32	4.00	0.12
	2	70							4.40	0.19
	3	56							5.10	0.30
125	1	56	28	32	27	32	27	32	7.10	0.19
	2	90							8.00	0.30
	3	70							9.40	0.50
160	1	70	34	41	34	41	34	41	13.70	0.30
	2	110							15.30	0.50
	3	90							17.20	0.75
200	1	90	46	56	49	56	50	56	27.00	0.50
	2	140							30.00	0.75
	3	110							34.00	1.23

Pressure Limitations – Introduction

The pressure limitations of a hydraulic cylinder must be reviewed when considering its application. To assist the designer in obtaining the optimum performance from a cylinder, the information which follows highlights the recommended minimum and maximum pressures according to application. If in doubt, please consult the factory.

Minimum Pressure

Due to factors such as seal friction, the minimum operating pressure for SHM cylinders is 5 bar. Below this pressure, low friction seals should be specified. If in doubt, please consult the factory.

Maximum Pressure

SHM cylinders are designed to the mounting dimensions specified in ISO 6020/2 for 160 bar cylinders but, due to the selection of materials, they can be used at higher pressures depending on the application and the choice of rod size and rod end style. As a result, the majority of these cylinders can be operated at 210 bar.

Cylinder Body (Pressure Envelope)

In many applications, the pressure developed within a cylinder may be greater than the working pressure, due to pressure intensification across the piston and cushioning. In most cases, this intensification does not affect the cylinder mountings or piston rod threads in the form of increased loading. It may, however, affect the cylinder body and induce fatigue failure or cause premature seal wear. It is important, therefore, that the pressure due to cushioning or intensification does not exceed the 340 bar fatigue limit of the cylinder body. The cushion energy absorption data on the previous page is based on this maximum induced pressure. If in doubt, please consult the factory.

C

All dimensions are in millimeters unless otherwise stated.

Standard Ports
SHM Series cylinders are supplied with BSP parallel threaded ports, of a size suitable for normal speed applications – see table opposite. SHM cylinders are also available with a variety of optional ports.

Oversize Ports
For higher speed applications. SHM Series cylinders are available with oversize BSP or metric ports to the sizes shown in the table opposite, or with extra ports in head or cap faces that are not used for mountings or cushion screws. On 25 mm and 32 mm bore cylinders, 20mm high port bosses are necessary to provide the full thread length at the cap end – see rod end dimensions for increased height at the head end. Note that Y and PJ dimensions may vary slightly to accommodate oversize ports – please contact the factory where these dimensions are critical.

Port Size and Piston Speed
One of the factors which influences the speed of a hydraulic cylinder is fluid flow in the connecting lines. Due to piston rod displacement, the flow at the cap end port will be greater than that at the head end, at the same piston speed. Fluid velocity in connecting lines should be limited to 5m/s to minimize fluid turbulence, pressure loss and hydraulic shock. The tables opposite are a guide for use when determining whether cylinder ports are adequate for the application. Data shown gives piston speeds for standard and oversize ports and connecting lines where the velocity of the fluid is 5m/s.

If the desired piston speed results in a fluid flow in excess of 5 m/s in connecting lines, larger lines with two ports per cap should be considered. Parker recommends that a flow rate of 12 m/s in connecting lines should not be exceeded.

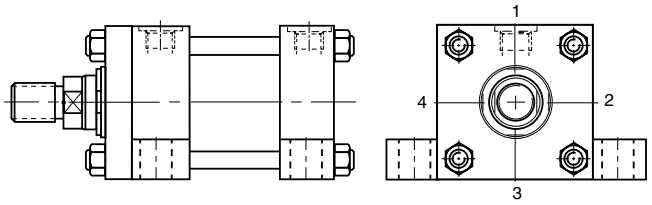
Speed Limitations
Where large masses are involved, or piston speeds exceed 0.1m/s and the piston will make a full stroke, cushions are recommended – see cushion information. For cylinders with oversize ports and with a flow exceeding 8m/s into the cap end, a 'non-floating cushion' should be specified. Please consult the factory.

Ports, Air Bleeds and Cushion Adjustment Location
The table below shows standard positions for ports, and cushion adjusting screws where fitted. Air bleeds (see optional features) may be fitted in unoccupied faces of the head or cap, depending on mounting.

Bore Ø	Standard Cylinder Ports				
	Port Size BSP/G Inches	Port Size Metric[1]	Bore of Connecting Lines	Cap End Flow in l/min @ 5m/s	Piston Speed m/s
25	1/4	M14x1.5	7	11.5	0.39
32	1/4	M14x1.5	7	11.5	0.24
40	3/8	M18x1.5	10	23.5	0.31
50	1/2	M22x1.5	13	40	0.34
63	1/2	M22x1.5	13	40	0.21
80	3/4	M27x2	15	53	0.18
100	3/4	M27x2	15	53	0.11
125	1	M33x2	19	85	0.12
160	1	M33x2	19	85	0.07
200	1 1/4	M42x2	24	136	0.07

Bore Ø	Oversize Cylinder Ports (Not to DIN)				
	Port Size BSP/G Inches	Port Size Metric[1]	Bore of Connecting Lines	Cap End Flow in l/min @ 5m/s	Piston Speed m/s
25	3/8[2]	M18x1.5[2,3]	10	23.5	0.80
32	3/8[2]	M18x1.5[2,3]	10	23.5	0.48
40	1/2	M22x1.5[3]	13	40	0.53
50	3/4	M27x2[3]	15	53	0.45
63	3/4	M27x2[3]	15	53	0.28
80[4]	1	M33x2	19	85	0.28
100[4]	1	M33x2	19	85	0.18
125[4]	1 1/4	M42x2	24	136	0.18
160[4]	1 1/4	M42x2	24	136	0.11
200[4]	1 1/2	M48x2	30	212	0.11

[1]Not to DIN 24 554
[2]20mm high port bosses fitted at cap end
[3]ISO 6149 ports are not available on some bore/rod combinations
[4]Consult factory – not normally available on these bore sizes
Not recommended for JJ mountings at pressures above 100 bar



Ports at position 2 or 4 in 25mm to 100mm bore sizes of mounting style C are offset toward position 1 and are not available in the head of 25mm and 32mm bores with number 2 rods. 25mm and 32mm bore heads will not be elongated 5mm toward position 2 or 4 when a port is specified at either of those two locations (the 5mm elongation at position 1 will remain). Contact the factory for the offset dimension.

Positions of Ports and Cushion Screws in Head and Cap		Mounting Styles																													
		TB, TC and TD				JJ				HH				C[5]			B and BB				SB				D			DB				DD			
Head	Port	1	2	3	4	1	2	3	4	1	2	3	4	1	2	4	1	2	3	4	1	2	3	4	1		3	1	2	3	4	1	2	3	4
	Cushion	2	3	4	1	3	3	1	1	3	4	1	2	2	4	2	2	3	4	1	2	3	4	1	3		1	3	4	1	2	3	4	1	2
Cap	Port	1	2	3	4	1	2	3	4	1	2	3	4	1	2	4	1	2	3	4	1	2	3	4	1	2	3	4	1		3	1	2	3	4
	Cushion	2	3	4	1	3	4	1	2	3	3	1	1	2	4	2	2	3	4	1	2	3	4	1	3	4	1	2	3		1	3	4	1	2

[5]Ports at position 2 or 4 in 25mm to 100mm bores are offset toward position 1.

All dimensions are in millimeters unless otherwise stated.

Cylinder Port Options

Option "T" SAE Straight Thread O-Ring Port. Recommended for most hydraulic applications.

Option "U" Conventional NPTF Ports (Dry-Seal Pipe Threads). Recommended for pneumatic applications only.

Option "R" BSPP Port (British Parallel Thread). ISO 228 port commonly used in Europe. See Figure R-G below.

Option "P" SAE Flange Ports Code 61 (3000 psi). Recommended for hydraulic applications requiring larger port sizes.

Option "B" BSPT (British Tapered Thread).

Option "M" Metric Straight Thread Port similar to Option "R" with metric thread. Popular in some European applications. See Figure R-G below.

Option "Y" ISO-6149-1 Metric Straight Thread Port. Recommended for all hydraulic applications designed per ISO standards. See Figure Y below.

Bore	"T" SAE	"U" NPTF Pipe Thread	"R" BSPP Parallel Thread (Standard)	"P" SAE 4-Bolt Flange Nom. Size	"B" BSPT Taper Thread	"M" Metric Straight Thread	"Y" ISO-6149-1 Metric Straight Thread
25	#6	1/4	1/4	N/A	1/4	M14 x 1.5	M14 x 1.5
32	#6	1/4	1/4	N/A	1/4	M14 x 1.5	M14 x 1.5
40	#6	3/8	3/8	N/A	3/8	M18 x 1.5	M18 x 1.5
50	#10	1/2	1/2	N/A	1/2	M22 x 1.5	M22 x 1.5
63	#10	1/2	1/2	1/2	1/2	M22 x 1.5	M22 x 1.5
80	#12	3/4	3/4	3/4	3/4	M27 x 2	M27 x 2
100	#12	3/4	3/4	3/4	3/4	M27 x 2	M27 x 2
125	#16	1	1	1	1	M33 x 2	M33 x 2
160	#16	1	1	1	1	M33 x 2	M33 x 2
200	#20	1-1/4	1-1/4	1-1/4	1-1/4	M42 x 2	M42 x 2

BSPP Port for SHM Series

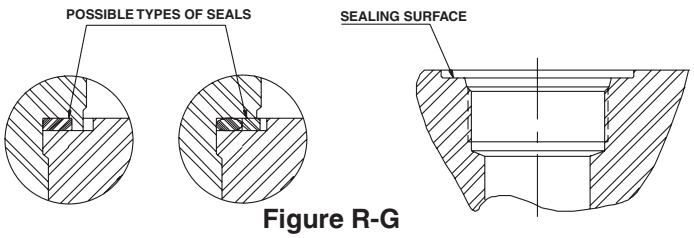


Figure R-G

ISO 6149-1 Port for SHM Series

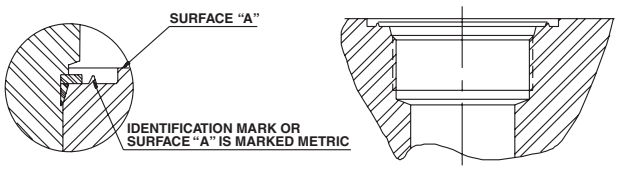


Figure Y

Weights – SHM Series Cylinders

Bore Ø	Rod Ø	Mounting Styles – Weight at Zero Stroke						Weight per 10mm Stroke
		TB, TC TD	C	JJ, HH	B,BB, SB	D, DB	DD	
		kg	kg	kg	kg	kg	kg	kg
25	12	1.2	1.4	1.5	1.4	1.3	1.5	0.05
	18						1.6	0.06
32	14	1.6	1.9	2.0	1.9	1.7	2.0	0.06
	22	1.7						0.08
40	18	3.7	4.0	4.7	4.2	3.9	4.6	0.09
	28	3.8	4.1	4.8	4.3	4.0	4.7	0.12
50	22	5.9	6.5	7.2	7.0	6.3	7.9	0.14
	28	6.0	6.6	7.3	7.1		8.0	0.16
	36				7.2	6.4		0.18
63	28	8.5	9.7	10.1	10.1	8.9	10.6	0.19
	36	8.6	9.8	10.2	10.2	9.0	10.7	0.22
	45	8.7	9.9	10.3	10.4	9.1	10.9	0.27
80	36	16.0	17.3	18.9	19.5	16.5	20.5	0.27
	45	16.1	17.4	19.0	19.6	16.6		0.32
	56	16.3	17.7	19.2	19.8	16.8	20.7	0.39

Bore Ø	Rod Ø	Mounting Styles – Weight at Zero Stroke						Weight per 10mm Stroke
		TB, TC TD	C	JJ, HH	B,BB, SB	D, DB	DD	
		kg	kg	kg	kg	kg	kg	kg
100	45	22.0	24.0	25.0	28.0	22.7	26.0	0.40
	56			26.0			27.0	0.47
	70	23.0	25.0		29.0	23.2		0.58
125	56	42.0	44.0	48.0	53.0	43.0	48.0	0.65
	70		45.0		54.0		49.0	0.76
	90	43.0		49.0		44.0	50.0	0.95
160	70	69.0	73.0	78.0	90.0	71.0	84.0	1.00
	90				91.0	72.0	85.0	1.20
	110	70.0	74.0	79.0	92.0			1.40
200	90	122.0	129.0	138.0	157.0	127.0	153.0	1.50
	110	123.0	130.0		158.0	128.0		1.80
	140	124.0	131.0	140.0	160.0	129.0	155.0	2.30

All dimensions are in millimeters unless otherwise stated.

C

Seals and Fluid Data

Group	Seal Materials – a combination of:	Fluid Medium to ISO 6743/4-1982	Temperature Range
1	Nitrile (NBR), PTFE, enhanced polyurethane (AU)	Mineral oil HH, HL, HLP, HLP-D, HM, HV, MIL-H-5606 oil, nitrogen	-20°C to + 80°C
5	Fluorocarbon elastomer (FPM) Fluorocarbon, PTFE	Fire resistant fluids based on phosphate esters (HFD-R) Also suitable for hydraulic oil at high temperatures/environments. **Not suitable for use with Skydrol.** See fluid manufacturer's recommendations.	-20°C to + 150°C

Operating Medium
Sealing materials used in the standard cylinder are suitable for use with most petroleum-based hydraulic fluids.

Special seals are available for use with water-glycol or water-in-oil emulsions, and with fluids such as fire-resistant synthetic phosphate ester and phosphate ester-based fluids.

If there is any doubt regarding seal compatibility with the operating medium, please consult the factory.

The table above is a guide to the sealing compounds and operating parameters of the materials used for standard and optional rod gland, piston and body seals

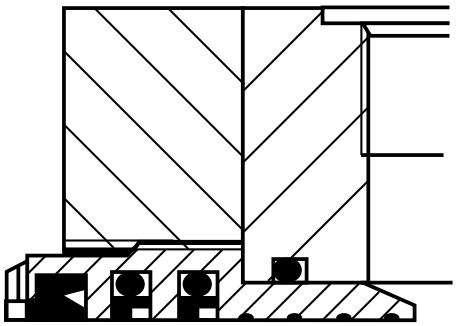
Temperature
Standard seals can be operated at temperatures between -20°C and +80°C. Where operating conditions result in temperatures which exceed these limits, special seal compounds may be required to ensure satisfactory service life – please consult the factory.

Special Seals
Group 1 seals are fitted as standard to SHM cylinders. For other duties, the optional seal group 5 is available – please see the cylinder order code for SHM (ISO) cylinders. Special seals, in addition to those shown in the table above, can also be supplied. Please insert an S (Special) in the order code and specify fluid medium when ordering.

Water Service
Special cylinders are available for use with water as the fluid medium. Modifications include a stainless steel piston rod with lipseal piston, and plating of internal surfaces. When ordering, please specify the maximum operating pressure or load/speed conditions.

Warranty
Schrader Bellows warrants cylinders modified for use with water or water base fluids to be free of defects in materials and workmanship, but cannot accept responsibility for premature failure caused by corrosion, electrolysis or mineral deposits in the cylinder.

Low Friction Seals
For applications where very low friction and an absence of stick-slip are important, the option of low friction seals is available. Please consult the factory.



Metallic Rod Wipers
Metallic rod wipers replace the standard wiper seal, and are recommended where dust or splashings might damage the wiper seal material. Metallic rod wipers do not affect cylinder dimensions.

Proximity Sensors
EPS proximity switches can be fitted to give reliable end of stroke signals.

Position Feedback
Linear position transducers of various types are available for SHM Series cylinders. Please contact the factory for further details.

Rod End Bellows
Unprotected piston rod surfaces which are exposed to contaminants with air hardening properties can be protected by rod end bellows. Longer rod extensions are required to accommodate the collapsed length of the bellows. Please consult the factory for further information.

Gland Drains

The tendency of hydraulic fluid to adhere to the piston rod can result in an accumulation of fluid in the cavity behind the gland wiperseal under certain operating conditions. This may occur with long stroke cylinders; where there is a constant back pressure as in differential circuitry, or where the ratio of the extend speed to the retract speed is greater than 2 to 1.

A gland drain port is provided in the retainer, except in mounting style JJ, style D in 100mm to 200mm bores, and regardless of mounting style, 25mm bore with all rod numbers, and 32mm to 40mm bores with number 1 rod. In these cases the drain port is located in the head. When the gland drain port in 25mm to 40mm bores is in the head of all mounting styles except JJ, it must be in the same position as the port (on the 5mm elongated side for 25mm & 32mm bores) and when specified in 25mm and 32mm bores of mounting style C it must be in position 1. On JJ mounting styles in 25mm and 32mm bores the drain port can be in position 2 or 4 and is not available in position 3. When the gland drain port is provided in the retainer, the thickness of the retainer is increased by 6mm in 32mm and 40mm bores with number 2 rod and by 4mm in 63mm bore cylinders with number 2 rod. Note that, on style JJ cylinders, drain ports cannot normally be positioned in the same face as ports or cushion valves – please consult the factory.

Gland Drain Port Location & Position Availability

Bore Ø	Rod Ø	Head (H) or Retainer (R) Location / Position			
		TB, TC, TD, HH, B, BB, SB, DB, DD	C	D	JJ
25	All	H / 1, 2, 3, 4	H / 1	H / 1, 3	H / 2, 4
32	14	H / 1, 2, 3, 4	H / 1	H / 1, 3	H / 2, 4
	22	R / 1, 2, 3, 4	R / 1, 2, 3[1], 4	R / 1, 2, 3, 4	H / 2, 4
40	18	H / 1, 2, 3, 4	H / 1	H / 1, 3	H / 2, 3, 4
	28	R / 1, 2, 3, 4	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 2, 3, 4
50	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 2, 3, 4
63	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 2, 3, 4
80	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 2, 3, 4
100	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 1, 3	H / 2, 3, 4
125	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 1, 3	H / 2, 3, 4
160	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 1, 3	H / 2, 3, 4
200	All	R / 1, 2, 3, 4	R / 1, 2, 3, 4	H / 1, 3	H / 2, 3, 4

[1] Gland drain is not available in position 3 when key plate is specified.

Gland drain ports will be the same type as the ports specified on the cylinder assembly except for non "JJ" mounts on bore sizes 25, 32, 40 and 50 mm. In these cases they will be 1/8 NPTF.

The size of the gland drain ports are as shown on the adjacent table.

Gland drains should be piped back to the fluid reservoir, which should be located below the level of the cylinder.

Port Type	Port Size
R (BSPP)	1/8 BSPP
T (SAE)	#4 (SAE)
U (Pipe Thread)	1/8 NPTF
M (Metric Straight)	M10 x 1
Y (ISO 6149-1)	M10 x 1
B (BSPT)	1/8 BSPT
P (SAE 4 Bolt Flange)	1/8 BSPP

Air Bleeds

The option of bleed screws is available at either or both ends of the cylinder, at any position except in the port face. The selected positions should be shown in the order code. Cylinders with bore sizes up to 40mm are fitted with M5 bleed screws; for bore sizes of 50mm and above, M8 bleed screws are fitted. Note that, for cylinders of 50mm bore and above, where it is essential to have the air bleed in the port face, bosses can be welded to the cylinder tube. Please contact the factory for details.

Spring-Returned, Single-Acting Cylinders

SHM Series single-acting cylinders can be supplied with an internal spring to return the piston after the pressure stroke. Please supply details of load conditions and friction factors, and advise whether the spring is required to advance or return the piston rod.

On spring-returned cylinders, tie rod extensions will be supplied to allow the spring to be 'backed off' until compression is relieved. Tie rod nuts will be welded to the tie rods at the opposite end of the cylinder, to further assure safe disassembly. Please contact the factory when ordering spring-returned cylinders.

Duplex and Tandem Cylinders

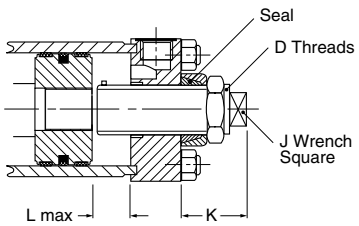
A tandem cylinder is made up of two cylinders mounted in line with pistons connected by a common piston rod and rod seals installed between the cylinders to permit double acting operation of each. Tandem cylinders allow increased output force when mounting width or height are restricted.

A duplex cylinder is made up of two cylinders mounted in line with pistons not connected with rod seals installed between the cylinders to permit double acting operation of each. Cylinders may be mounted with piston rod to piston or back to back and are generally used to provide three position operation.

Stroke Adjusters

Where absolute precision in stroke length is required, a screwed adjustable stop can be supplied. Several types are available – the illustration shows a design suitable for infrequent[2] adjustment at the uncushioned cap end of a cylinder. Please contact the factory, specifying details of the application and the adjustment required.

Bore Ø	D	J	K min	L max
40	M12x1.25	7	75	130
50	M20x1.5	12	75	200
63	M27x2	16	75	230
80	M33x2	20	85	230
100	M42x2	26	70	450
125	M48x2	30	70	500
160	M64x3	40	75	500
200	M80x3	50	80	500



All dimensions are in millimeters unless otherwise stated.

[2] Infrequent is defined by positioning the retract stroke in a couple of attempts at original machine set up. The frequent stroke adjuster is recommended for adjustments required after the original equipment has been adjusted by the original machine manufacturer.

C

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

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

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

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

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

1.0 General Instructions

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

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

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

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

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

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

2.0 Cylinder and Accessories Selection

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The rod end pressure is approximately equal to:

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

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

3.0 Cylinder and Accessories Installation and Mounting

3.1 Installation

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

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

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

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

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

3.2 Mounting Recommendations

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

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

3.2.3 – Tie Rod Mounting – Cylinders with tie rod mountings are recommended for applications where mounting space is limited. The standard tie rod extension is shown as BB in dimension tables. Longer or shorter extensions can be supplied. Nuts used for this mounting style should be torqued to the same value as the tie rods for that bore size.

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

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

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

4.0 Cylinder and Accessories Maintenance, Troubleshooting and Replacement

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

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

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

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

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

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

4.2 Cylinder Trouble Shooting

4.2.1 – External Leakage

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

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

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

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

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

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

4.2.2 – Internal Leakage

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

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

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

4.2.3 – Cylinder Fails to Move the Load

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

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

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

4.3 Erratic or Chatter Operation

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

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

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

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

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

C

NOTES

Offer of Sale

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

1. Terms and Conditions. Seller's willingness to offer Products, or accept an order for Products, to or from Buyer is subject to these Terms and Conditions or any newer version of the terms and conditions found on-line at www.parker.com/saleterms/. Seller objects to any contrary or additional terms or conditions of Buyer's order or any other document issued by Buyer.

2. Price Adjustments; Payments. Prices stated on Seller's quote or other documentation offered by Seller are valid for 30 days, and do not include any sales, use, or other taxes unless specifically stated. Unless otherwise specified by Seller, all prices are F.C.A. Seller's facility (INCOTERMS 2010). Payment is subject to credit approval and is due 30 days from the date of invoice or such other term as required by Seller's Credit Department, after which Buyer shall pay interest on any unpaid invoices at the rate of 1.5% per month or the maximum allowable rate under applicable law.

3. Delivery Dates; Title and Risk; Shipment. All delivery dates are approximate and Seller shall not be responsible for any damages resulting from any delay. Regardless of the manner of shipment, title to any products and risk of loss or damage shall pass to Buyer upon placement of the products with the shipment carrier at Seller's facility. Unless otherwise stated, Seller may exercise its judgment in choosing the carrier and means of delivery. No deferment of shipment at Buyers' request beyond the respective dates indicated will be made except on terms that will indemnify, defend and hold Seller harmless against all loss and additional expense. Buyer shall be responsible for any additional shipping charges incurred by Seller due to Buyer's acts or omissions.

4. Warranty. Seller warrants that the Products sold hereunder shall be free from defects in material or workmanship for a period of eighteen months from the date of delivery to Buyer. The prices charged for Seller's products are based upon the exclusive limited warranty stated above, and upon the following disclaimer: **DISCLAIMER OF WARRANTY: THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO PRODUCTS PROVIDED HEREUNDER. SELLER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS AND IMPLIED, INCLUDING DESIGN, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

5. Claims; Commencement of Actions. Buyer shall promptly inspect all Products upon delivery. No claims for shortages will be allowed unless reported to the Seller within 10 days of delivery. No other claims against Seller will be allowed unless asserted in writing within 30 days after delivery. Buyer shall notify Seller of any alleged breach of warranty within 30 days after the date the defect is or should have been discovered by Buyer. Any action based upon breach of this agreement or upon any other claim arising out of this sale (other than an action by Seller for an amount due on any invoice) must be commenced within 12 months from the date of the breach without regard to the date breach is discovered.

6. LIMITATION OF LIABILITY. UPON NOTIFICATION, SELLER WILL, AT ITS OPTION, REPAIR OR REPLACE A DEFECTIVE PRODUCT, OR REFUND THE PURCHASE PRICE. **IN NO EVENT SHALL SELLER BE LIABLE TO BUYER FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF, OR AS THE RESULT OF, THE SALE, DELIVERY, NON-DELIVERY, SERVICING, USE OR LOSS OF USE OF THE PRODUCTS OR ANY PART THEREOF, OR FOR ANY CHARGES OR EXPENSES OF ANY NATURE INCURRED WITHOUT SELLER'S WRITTEN CONSENT, EVEN IF SELLER HAS BEEN NEGLIGENT, WHETHER IN CONTRACT, TORT OR OTHER LEGAL THEORY. IN NO EVENT SHALL SELLER'S LIABILITY UNDER ANY CLAIM MADE BY BUYER EXCEED THE PURCHASE PRICE OF THE PRODUCTS.**

7. User Responsibility. The user, through its own analysis and testing, is solely responsible for making the final selection of the system and Product and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application and follow applicable industry standards and Product information. If Seller provides Product or system options, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the Products or systems.

8. Loss to 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, will be considered obsolete and may be destroyed by Seller after two consecutive years have elapsed without Buyer ordering the items 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. Special Tooling. A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture Products. 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 Products, 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.

10. Buyer's Obligation; Rights of Seller. To secure payment of all sums due or otherwise, Seller shall retain a security interest in the goods delivered and this agreement shall be deemed a Security Agreement under the Uniform Commercial Code. Buyer authorizes Seller as its attorney to execute and file on Buyer's behalf all documents Seller deems necessary to perfect its security interest.

11. Improper use and Indemnity. Buyer shall indemnify, defend, and hold Seller harmless from any claim, liability, damages, lawsuits, and costs (including attorney fees), whether for personal injury, property damage, patent, trademark or copyright infringement or any other claim, brought by or incurred by Buyer, Buyer's employees, or any other person, arising out of: (a) improper selection, improper application or other misuse of Products purchased by Buyer from Seller; (b) any act or omission, negligent or otherwise, of Buyer; (c) Seller's use of patterns, plans, drawings, or specifications furnished by Buyer to manufacture Product; or (d) Buyer's failure to comply with these terms and conditions. Seller shall not indemnify Buyer under any circumstance except as otherwise provided.

12. Cancellations and Changes. Orders shall not be subject to cancellation or change by Buyer for any reason, except with Seller's written consent and upon terms that will indemnify, defend and hold Seller harmless against all direct, incidental and consequential loss or damage. Seller may change product features, specifications, designs and availability with notice to Buyer.

13. Limitation on Assignment. Buyer may not assign its rights or obligations under this agreement without the prior written consent of Seller.

14. Force Majeure. Seller does not assume the risk 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, strikes or labor disputes, acts of any government or government agency, acts of nature, delays or failures in delivery from carriers or suppliers, shortages of materials, or any other cause beyond Seller's reasonable control.

15. Waiver and Severability. Failure to enforce any provision of this agreement will not waive that provision nor will any such failure prejudice Seller's right to enforce that provision in the future. Invalidation of any provision of this agreement by legislation or other rule of law shall not invalidate any other provision herein. The remaining provisions of this agreement will remain in full force and effect.

16. Termination. Seller may terminate this agreement for any reason and at any time by giving Buyer thirty (30) days written notice of termination. Seller may immediately terminate this agreement, in writing, if Buyer: (a) commits a breach of any provision of this agreement (b) appointments a trustee, receiver or custodian for all or any part of Buyer's property (c) files a petition for relief in bankruptcy on its own behalf, or by a third party (d) makes an assignment for the benefit of creditors, or (e) dissolves or liquidates all or a majority of its assets.

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

18. 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 Section. Seller will defend and indemnify Buyer against allegations of infringement of U.S. patents, U.S. trademarks, copyrights, trade dress and trade secrets ("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 a Product sold pursuant to this Agreement 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 a Product 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 the Product, replace or modify the Product so as to make it noninfringing, or offer to accept return of the Product 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 Products 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 Product sold hereunder. The foregoing provisions of this Section shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.

19. Entire Agreement. This agreement contains the entire agreement between the Buyer and Seller and constitutes the final, complete and exclusive expression of the terms of sale. All prior or contemporaneous written or oral agreements or negotiations with respect to the subject matter are herein merged.

20. Compliance with Law, U. K. Bribery Act and U.S. Foreign Corrupt Practices Act. Buyer agrees to comply with all applicable laws and regulations, including both those of the United Kingdom and the United States of America, and of the country or countries of the Territory in which Buyer may operate, including without limitation the U. K. Bribery Act, the U.S. Foreign Corrupt Practices Act ("FCPA") and the U.S. Anti-Kickback Act (the "Anti-Kickback Act"), and agrees to indemnify and hold harmless Seller from the consequences of any violation of such provisions by Buyer, its employees or agents. Buyer acknowledges that they are familiar with the provisions of the U. K. Bribery Act, the FCPA and the Anti-Kickback Act, and certifies that Buyer will adhere to the requirements thereof. In particular, Buyer represents and agrees that Buyer shall not make any payment or give anything of value, directly or indirectly to any governmental official, any foreign political party or official thereof, any candidate for foreign political office, or any commercial entity or person, for the purpose of influencing such person to purchase products or otherwise benefit the business of Seller.

View Table of Contents

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