



Very Heavy Duty Hydraulic Cylinders

Series VH

aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding



ENGINEERING YOUR SUCCESS.

Series "VH" very heavy-duty hydraulic cylinders are premium quality cylinders – with operating capacities of 3,000 PSI. They fully meet NFPA standards. And to make sure every cylinder is premium-quality, Parker Hannifin subjects each and every one – not just batch samples – to tough inspection and performance tests.

**OTHER SERIES "VH"
FEATURES AND SPECIFICATIONS**

Ports

Series "VH" ports are two sizes or larger than NFPA standards. Standard location is position 1 as shown in dimensional drawings. Where mountings do not interfere, ports may be located at positions 2, 3, or 4. Ports are not available at positions 2 or 4 on mounting style C, 2 1/2" thru 5" bore cylinders. SAE straight thread O-ring ports will be supplied unless otherwise specified.

**Extra-long Tapered Cushions
Oversize Ports
Meets NFPA Specifications**

Nominal Pressure - 3000 PSI
Standard Bore Sizes - 2 1/2" Through 8"
Piston Rod Diameters - 1" Through 5 1/2"
Fifteen Standard Mounting Styles

Cushions

Cushions on Series "VH" cylinders are 3" long on all sizes except 3 1/4" and 4" bore sized equipped with 2" and 2 1/2" diameter piston rods which are supplied with cushions 2 13/16" long at head end. Self-centering floating cushion sleeve at head end and cushion spear at cap is tapered for 2/3 its length to give maximum cushioning effect for 1/3 its length.

Thrust Key

An extended retainer plate, to serve as a thrust key, can be supplied on mounting styles C and F. The thrust key would be the same as used on Parker Hannifin "2H" hydraulic cylinders.

Air Bleeds

When specified, 1/8" NPTF bleed ports are available at either head or cap end.

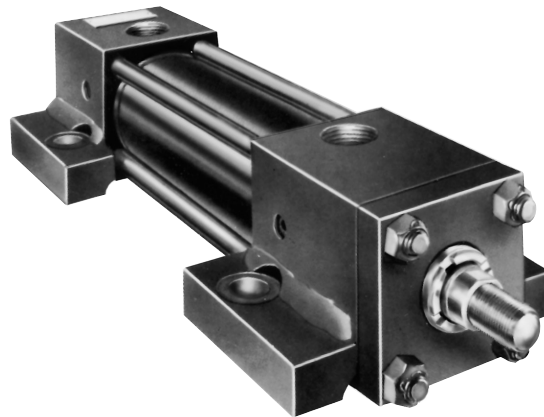


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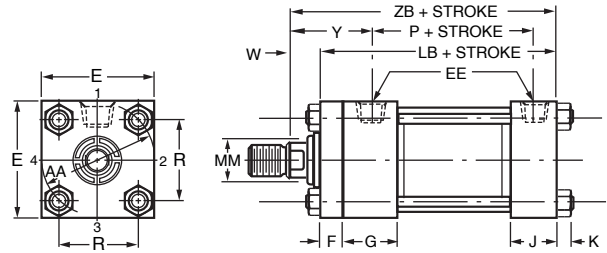
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Basic Cylinder Style T

(NFPA Style MX01)

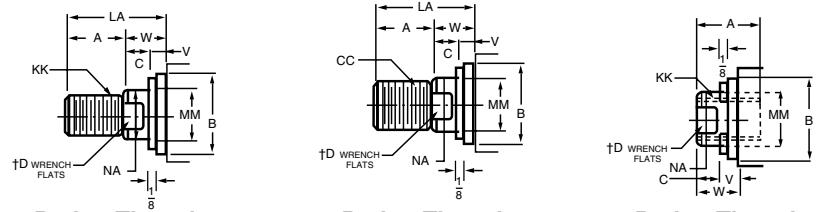


Rod End Dimensions

BORE	ROD NO.	ROD DIA.		THREAD		ROD EXTENSIONS AND PILOT DIMENSIONS										BASIC ENVELOPE AND MOUNTING DIMENSIONS							
		MM	CC	KK	A	^{+0.000} B _{-.002}	C	D	LA	NA	V	W	Y	E	EE		F	G	J	K	ADD STROKE		
															NPTF [°]	SAE [°]					LB	P	ZB
2 1/2	1(Std.)	1	7/8-14	3/4-16	1 1/8	1.499	1/2	7/8	1 7/8	15/16	1/4	3/4	4 1/8	3 1/2	1	16	5/8	3 3/4	3 1/2	7/16	9 3/8	3 1/2	10 9/16
	2	1 3/4	1 1/2-12	1 1/4-12	2	2.374	3/4	1 1/2	3 1/4	1 11/16	1/2	1 1/4	4 5/8	3 1/2	1	16	5/8	3 3/4	3 1/2	7/16	9 3/8	3 1/2	11 1/16
	3	1 3/8	1 1/4-12	1-14	1 5/8	1.999	5/8	1 1/8	2 5/8	1 5/16	3/8	1	4 3/8	3 1/2	1	16	5/8	3 3/4	3 1/2	7/16	9 3/8	3 1/2	10 13/16
3 1/4	1(Std.)	1 3/8	1 1/4-12	1-14	1 5/8	1.999	5/8	1 1/8	2 1/2	1 5/16	1/4	7/8	4 3/16	4 1/2	1 1/4	20	3/4	3 3/4	3 1/2	9/16	9 3/4	4 1/8	11 3/16
	2	2	1 3/4-12	1 1/2-12	2 1/4	2.624	7/8	1 11/16	3 1/2	1 5/16	3/8	1 1/4	4 9/16	4 1/2	1 1/4	20	3/4	3 3/4	3 1/2	9/16	9 3/4	4 1/8	11 9/16
	3	1 3/4	1 1/2-12	1 1/4-12	2	2.374	3/4	1 1/2	3 1/8	1 11/16	3/8	1 1/8	4 7/16	4 1/2	1 1/4	20	3/4	3 3/4	3 1/2	9/16	9 3/4	4 1/8	11 7/16
4	1(Std.)	1 3/4	1 1/2-12	1 1/4-12	2	2.374	3/4	1 1/2	3	1 11/16	1/4	1	4 7/16	5	1 1/4	20	7/8	3 3/4	3 1/2	9/16	10 1/8	4 3/8	11 11/16
	2	2	2 1/4-12	1 7/8-12	3	3.124	1	2 1/16	4 3/8	2 3/8	3/8	1 3/8	4 13/16	5	1 1/4	20	7/8	3 3/4	3 1/2	9/16	10 1/8	4 3/8	12 1/16
	3	2	1 3/4-12	1 1/2-12	2 1/4	2.624	7/8	1 11/16	3 3/8	1 5/16	1/4	1 1/8	4 9/16	5	1 1/4	20	7/8	3 3/4	3 1/2	9/16	10 1/8	4 3/8	11 13/16
5	1(Std.)	2	1 3/4-12	1 1/2-12	2 1/4	2.624	7/8	1 11/16	3 3/8	1 5/16	1/4	1 1/8	4 11/16	6 1/2	1 1/2	24	7/8	4	3 3/4	13/16	11 1/8	5 1/8	13 1/16
	2	3 1/2	3 1/4-12	2 1/2-12	3 1/2	4.249	1	3	4 7/8	3 3/8	3/8	1 3/8	4 15/16	6 1/2	1 1/2	24	7/8	4	3 3/4	13/16	11 1/8	5 1/8	13 5/16
	3	2 1/2	2 1/4-12	1 7/8-12	3	3.124	1	2 1/16	4 3/8	2 3/8	3/8	1 3/8	4 15/16	6 1/2	1 1/2	24	7/8	4	3 3/4	13/16	11 1/8	5 1/8	13 5/16
	4	3	2 3/4-12	2 1/4-12	3 1/2	3.749	1	2 5/8	4 7/8	2 7/8	3/8	1 3/8	4 15/16	6 1/2	1 1/2	24	7/8	4	3 3/4	13/16	11 1/8	5 1/8	13 5/16
6	1(Std.)	2 1/2	2 1/4-12	1 7/8-12	3	3.124	1	2 1/16	4 1/4	2 3/8	1/4	1 1/4	4 7/8	7 1/2	2	32	1	4 1/4	4 1/4	7/8	12 3/8	6 1/8	14 1/2
	2	4	3 3/4-12	3-12	4	4.749	1	3 3/8	5 1/4	3 7/8	1/4	1 1/4	4 7/8	7 1/2	2	32	1	4 1/4	4 1/4	7/8	12 3/8	6 1/8	14 1/2
	3	3	2 3/4-12	2 1/4-12	3 1/2	3.749	1	2 5/8	4 3/4	2 7/8	1/4	1 1/4	4 7/8	7 1/2	2	32	1	4 1/4	4 1/4	7/8	12 3/8	6 1/8	14 1/2
	4	3 1/2	3 1/4-12	2 1/2-12	3 1/2	4.249	1	3	4 3/4	3 3/8	1/4	1 1/4	4 7/8	7 1/2	2	32	1	4 1/4	4 1/4	7/8	12 3/8	6 1/8	14 1/2
7	1(Std.)	3	2 3/4-12	2 1/4-12	3 1/2	3.749	1	2 5/8	4 3/4	2 7/8	1/4	1 1/4	4 3/4	8 1/2	2	32	1	4 1/4	4 1/4	1 1/4	12 1/2	6 1/2	15
	2	5	4 3/4-12	3 1/2-12	5	5.749	1	4 1/4	6 1/4	4 7/8	1/4	1 1/4	4 3/4	8 1/2	2	32	1	4 1/4	4 1/4	1 1/4	12 1/2	6 1/2	15
	3	3 1/2	3 1/4-12	2 1/2-12	3 1/2	4.249	1	3	4 3/4	3 3/8	1/4	1 1/4	4 3/4	8 1/2	2	32	1	4 1/4	4 1/4	1 1/4	12 1/2	6 1/2	15
	4	4	3 3/4-12	3-12	4	4.749	1	3 3/8	5 1/4	3 7/8	1/4	1 1/4	4 3/4	8 1/2	2	32	1	4 1/4	4 1/4	1 1/4	12 1/2	6 1/2	15
	5	4 1/4	4 1/4-12	3 1/4-12	4 1/2	5.249	1	3 7/8	5 3/4	4 3/8	1/4	1 1/4	4 3/4	8 1/2	2	32	1	4 1/4	4 1/4	1 1/4	12 1/2	6 1/2	15
8	1(Std.)	3 1/2	3 1/4-12	2 1/2-12	3 1/2	4.249	1	3	4 3/4	3 3/8	1/4	1 1/4	4 3/4	9 1/2	2 1/2	32	1	4 1/2	4 1/2	1 1/2	13 1/2	7 1/2	16 1/4
	2	5 1/2	5 1/4-12	4-12	5 1/2	6.249	1	4 5/8	6 3/4	5 3/8	1/4	1 1/4	4 3/4	9 1/2	2 1/2	32	1	4 1/2	4 1/2	1 1/2	13 1/2	7 1/2	16 1/4
	3	4	3 3/4-12	3-12	4	4.749	1	3 3/8	5 1/4	3 7/8	1/4	1 1/4	4 3/4	9 1/2	2 1/2	32	1	4 1/2	4 1/2	1 1/2	13 1/2	7 1/2	16 1/4
	4	4 1/2	4 1/4-12	3 1/4-12	4 1/2	5.249	1	3 7/8	5 3/4	4 3/8	1/4	1 1/4	4 3/4	9 1/2	2 1/2	32	1	4 1/2	4 1/2	1 1/2	13 1/2	7 1/2	16 1/4
	5	5	4 3/4-12	3 1/2-12	5	5.749	1	4 1/4	6 1/4	4 7/8	1/4	1 1/4	4 3/4	9 1/2	2 1/2	32	1	4 1/2	4 1/2	1 1/2	13 1/2	7 1/2	16 1/4

◆ SAE straight thread ports are standard and are indicated by port number. For dimensional information see Ports page.
° NPTF ports are available at no extra charge.

Piston Rod End Threads



**Parker Thread
Style 4
(NFPA SM)**

**Parker Thread
Style 8
(NFPA IM)**

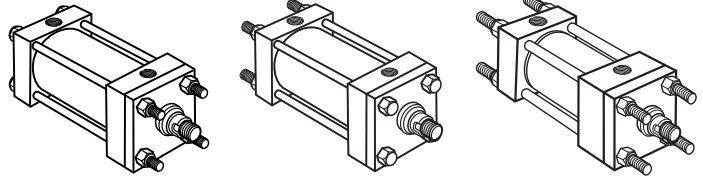
**Parker Thread
Style 9
(NFPA SF)**

Style 4 Rod Ends recommended for applications where workpiece is secured against rod shoulder. When workpiece is not shouldered, Style 4 Rod Ends are recommended through 2" rod diameter, Style 8 on larger diameters. If rod end is not specified, Style 4 will be furnished.

NOTE: Special piston rod end threads, two times length are available on 2 1/2" diameter piston rods and smaller. To order, specify thread Style 42 which has KK thread dia. or Style 82 which has CC thread dia. Other piston rod threads are available. To order, specify Style 3 and give desired dimensions for KK, A and W or WF dimension. For other specials, send dimensions or sketch.

† On 4 1/2" diameter rods and larger, 4 each .515 diameter spanner wrench holes will be provided.

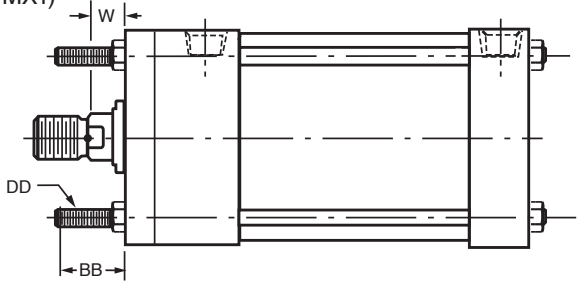
Tie Rod Mounted Styles TB, TC, TD (NFPA Styles MX3, MX2, MX1)



**Style TB
(MX3)**

**Style TC
(MX2)**

**Style TD
(MX1)**

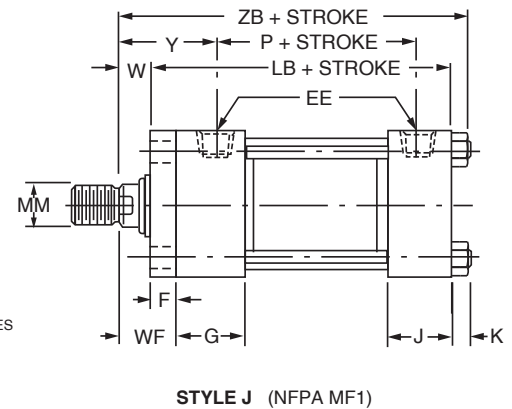
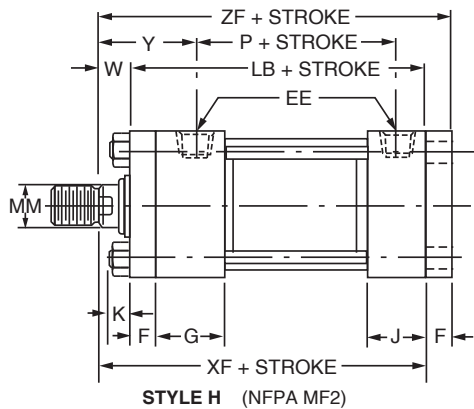


Style TB, Tie Rods Extended, is illustrated at right. Style TC, Cap Tie Rods Extended, and Style TD, Both Ends Tie Rods Extended, can be dimensioned from Style TB drawing.



Flange Mountings

Styles H, J, HB, JB



For Style "H" Mount

Bore Size	Max. PSI - Pull*				
	Rod Code				
	1	2	3	4	5
2 1/2	3000	3000	3000	-	-
3 1/4	3000	3000	3000	-	-
4	3000	3000	3000	-	-
5	2000	3000	2000	2500	-
6	1800	2500	2000	2000	-
7	2000	3000	2000	2500	2800
8	1700	2500	1700	1800	2200

* Maximum pressure rating - pull application

For Style "J" Mount

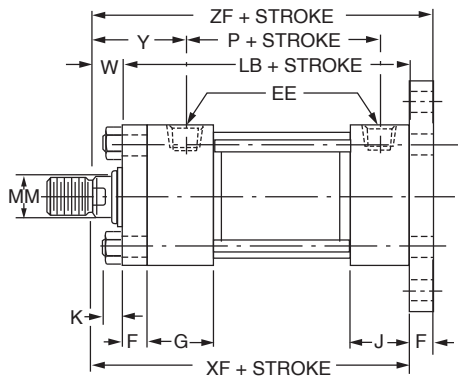
Bore Size	Max. PSI - Push*				
	Rod Code				
	1	2	3	4	5
2 1/2	2000	1100	1500	-	-
3 1/4	1800	1300	1400	-	-
4	1800	1300	1700	-	-
5	1300	800	1200	1000	-
6	1200	800	1000	900	-
7	1400	800	1200	1100	1000
8	1100	800	1000	1000	800

* Maximum pressure rating - push application

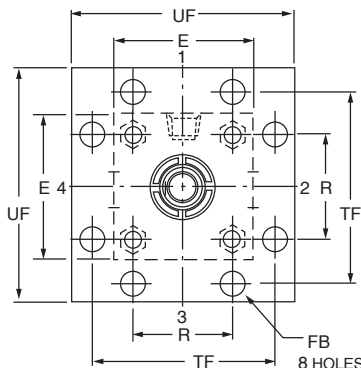
Specific Dimensions for Series VH Mounting Styles (in inches)

BORE	ROD NO.	ROD DIA. MM	AA	BB	DD	FB	L	R
2 1/2	1	1	3.6	1 13/16	1/2-20	9/16	1 1/4	2.55
	2	1 3/4						
	3	1 3/8						
3 1/4	1	1 3/8	4.6	2 5/16	5/8-18	1 1/16	1 1/2	3.25
	2	2						
	3	1 3/4						
4	1	1 3/4	5.4	2 5/16	5/8-18	1 1/16	2 1/8	3.82
	2	2 1/2						
	3	2						
5	1	2	7.0	3 3/16	7/8-14	1 5/16	2 1/4	4.95
	2	3 1/2						
	3	2 1/2						
	4	3						
6	1	2 1/2	8.1	3 5/8	1-14	1 1/16	2 1/2	5.73
	2	4						
	3	3						
	4	3 1/2						
7	1	3	9.3	4 1/8	1 1/8-12	1 3/16	3	6.58
	2	5						
	3	3 1/2						
	4	4						
	5	4 1/2						
8	1	3 1/2	10.6	4 1/2	1 1/4-12	1 5/16	3 1/4	7.50
	2	5 1/2						
	3	4						
	4	4 1/2						
	5	5						

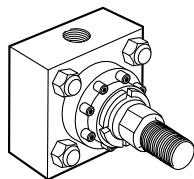
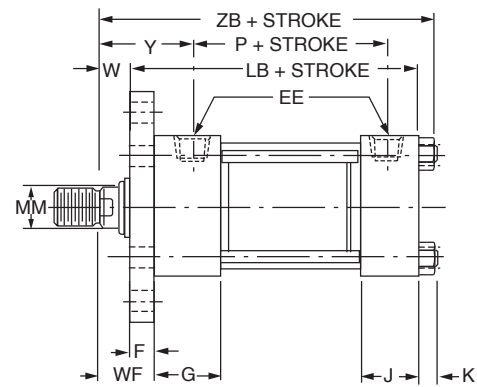
◆ Dimension CD is pin diameter. • Upper surface spotfaced for socket head screws. ◆◆ Dimension to be specified by customer.



STYLE HB (NFPA MF6)



STYLE JB (NFPA MF5)



For 7" & 8" bores, this style retainer configuration applies to all but J and JB mounts.

For Style "JB" Mount

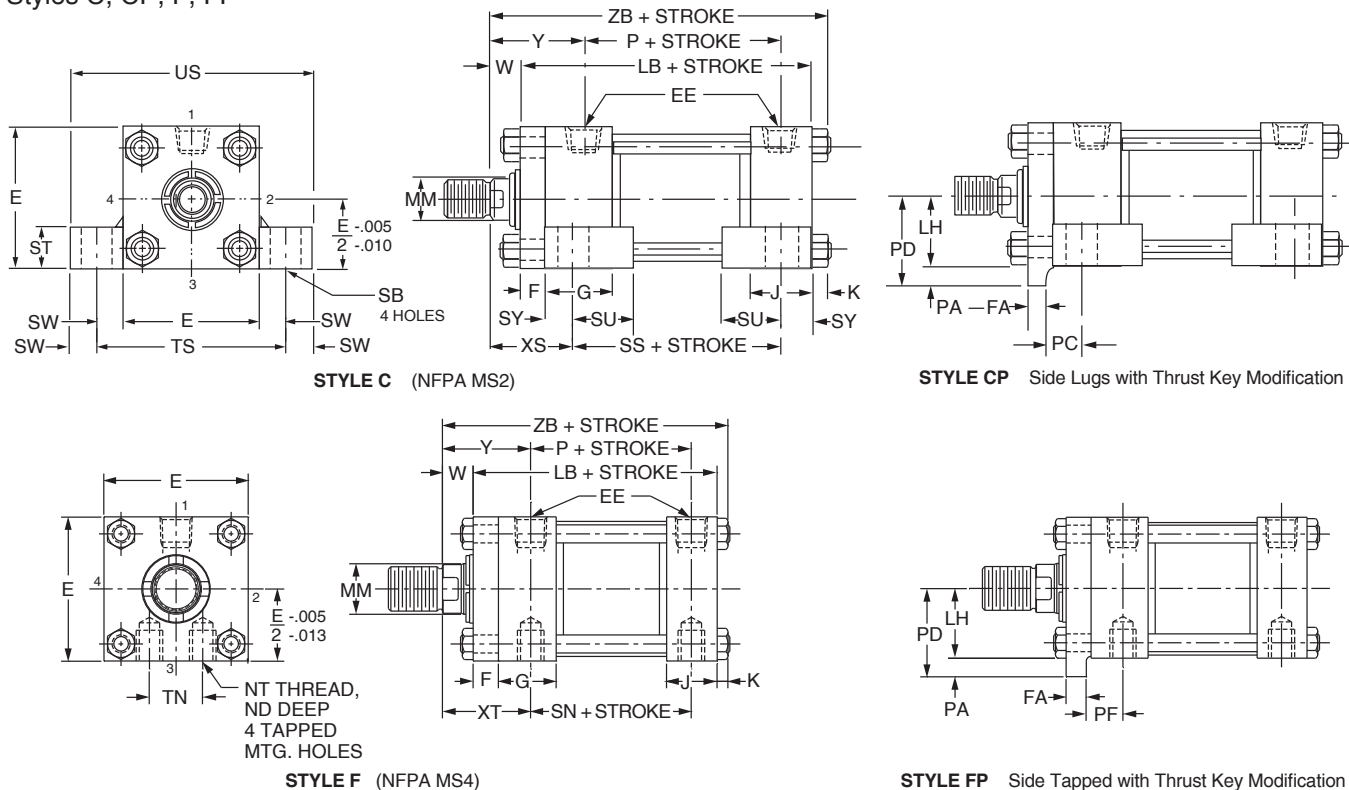
Bore Size	Max. PSI - Push*				
	Rod Code				
	1	2	3	4	5
2 1/2	3000	3000	3000	-	-
3 1/4	3000	3000	3000	-	-
4	3000	3000	3000	-	-
5	3000	3000	3000	3000	-
6	3000	2700	3000	2700	-
7	3000	2700	3000	3000	3000
8	3000	2300	2500	2500	2500

* Maximum pressure rating - push application

BORE	ROD NO.	ROD DIA. MM	TF	UF	XF	ZF
2 1/2	1	1			10 1/8	10 3/4
	2	1 3/4	4 5/8	5 3/8	10 5/8	11 1/4
	3	1 3/8			10 3/8	11
3 1/4	1	1 3/8			10 5/8	11 3/8
	2	2	5 7/8	7 1/8	11	11 3/4
	3	1 3/4			10 7/8	11 5/8
4	1	1 3/4			11 1/8	12
	2	2 1/2	6 3/8	7 5/8	11 1/2	12 3/8
	3	2			11 1/4	12 1/8
5	1	2			12 1/4	13 1/8
	2	3 1/2	8 3/16	9 3/4	12 1/2	13 3/8
	3	2 1/2			12 1/2	13 3/8
	4	3			12 1/2	13 3/8
6	1	2 1/2			13 5/8	14 5/8
	2	4	9 7/16	11 1/4	13 5/8	14 5/8
	3	3			13 5/8	14 5/8
	4	3 1/2			13 5/8	14 5/8
7	1	3			13 3/4	14 3/4
	2	5			13 3/4	14 3/4
	3	3 1/2	10 5/8	12 5/8	13 3/4	14 3/4
	4	4			13 3/4	14 3/4
	5	4 1/2			13 3/4	14 3/4
8	1	3 1/2			14 3/4	15 3/4
	2	5 1/2			14 3/4	15 3/4
	3	4	11 13/16	14	14 3/4	15 3/4
	4	4 1/2			14 3/4	15 3/4
	5	5			14 3/4	15 3/4

Side Mountings

Styles C, CP, F, FP



Specific Dimensions for Series VH Mounting Styles (in inches)

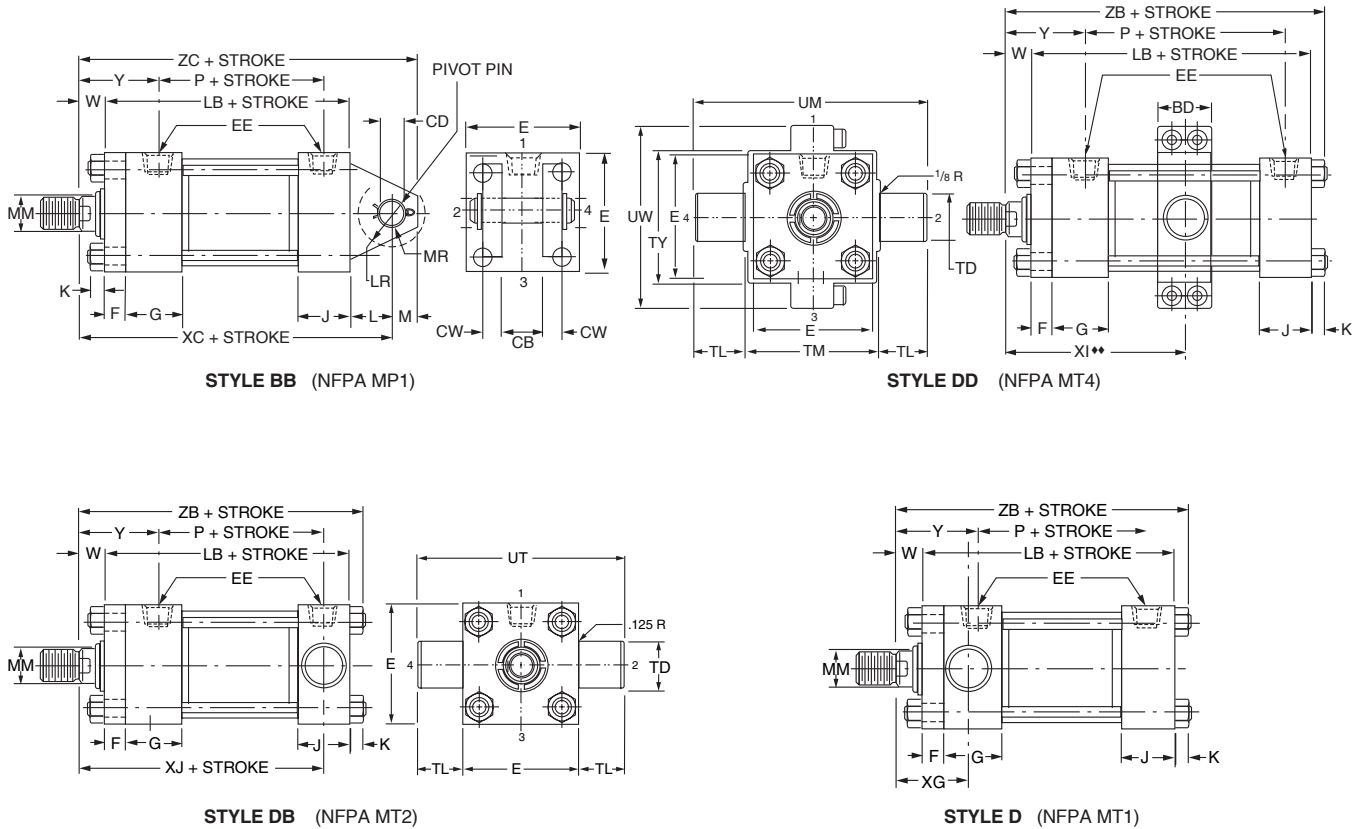
BORE	ROD NO.	ROD DIA. MM	BD	CB	CD [◆]	CW	FA ^{◆◆}	FB	L	LH ^{◆◆}	LR	M	MR	ND	NT	PA	PC	PD	PF	SB•	ST
2 1/2	1	1	1 1/2	1 1/4	.751	5/8	.562	9/16	1 1/4	1.744	15/16	3/4	15/16	9/16	5/8-11	5/16	2 3/4	2 1/16	3 1/16	13/16	1
	2	1 3/4												1 1/2							
	3	1 3/8												1 1/2							
3 1/4	1	1 3/8	2	1 1/2	1.001	3/4	.687	11/16	1 1/2	2.244	1 1/4	1	13/16	7/8	3/4-10	3/8	2 1/2	2 5/8	2 15/16	13/16	1
	2	2												1 1/2							
	3	1 3/4												1 1/2							
4	1	1 3/4	2	2	1.376	1	.812	11/16	2 1/8	2.494	1 3/4	1 3/8	1 5/8	1	1-8	7/16	2 11/16	2 15/16	2 15/16	1 1/16	1 1/4
	2	2												1 1/2							
	3	2												1 1/2							
5	1	2	2	2 1/2	1.751	1 1/4	.812	15/16	2 1/4	3.244	2 1/16	1 3/4	2 1/8	1 1/8	1-8	7/16	2 15/16	3 1/16	3 3/16	1 1/16	1 1/4
	2	3 1/2												1 1/8							
	3	2 1/2												1 1/8							
	4	3												1 1/8							
6	1	2 1/2	3	2 1/2	2.001	1 1/4	.937	1 1/16	2 1/2	3.744	2 5/16	2	2 3/8	1 3/4	1 1/4-7	1/2	3 3/16	4 1/4	3 5/16	1 5/16	1 1/2
	2	4												1 1/4							
	3	3												1 3/4							
	4	3 1/2												1 1/2							
7	1	3	3	3	2.501	1 1/2	.937	1 3/16	3	4.244	2 3/4	2 1/2	2 7/8	1 1/8	1 1/2-6	1/2	2 15/16	4 3/4	3 1/8	1 9/16	1 3/4
	2	5												1 1/8							
	3	3 1/2												1 1/8							
	4	4												1 1/8							
	5	4 1/2												1 1/8							
8	1	3 1/2	3 1/2	3	3.001	1 1/2	.937	1 5/16	3 1/4	4.744	3 1/4	2 3/4	3 1/8	1 1/2	1 1/2-6	1/2	2 15/16	5 1/4	3 1/4	1 9/16	1 3/4
	2	5 1/2												1 1/2							
	3	4												1 1/2							
	4	4 1/2												1 1/2							
	5	5												1 1/2							

◆ Dimension CD is pin diameter. • Upper surface spotfaced for socket head screws. ◆◆ Dimension to be specified by customer.



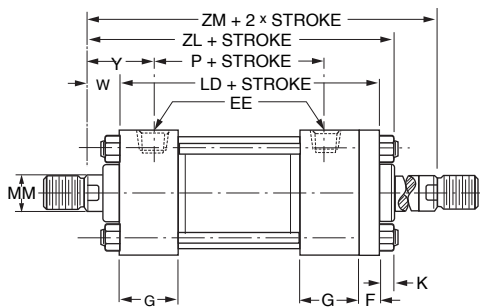
Pivot Mountings

Styles BB, DB, D, DD



BORE	ROD NO.	ROD DIA. MM	SU	SW	SY	+0.000 TD -0.001	TL	TM	TN	TS	TY	UF	UM	UT	US	UW	XG	MIN. XI ◆	DD MTG. MIN. STK.	XS	XT	ADD STROKE									
																						SN	SS	XC	XJ	ZC					
2 1/2	1	1	1 9/16	1 1/16	2 11/16	1.375	1 3/8	4	1 5/16	4 7/8	3 3/4	5 3/8	6 3/4	6 1/4	6 1/4	4 5/8	4 1/4	5 15/16	1/8	4 1/16	4 3/8	3	3 3/8	11 3/8	7 3/8	12 1/8					
	2	1 3/4																									4 9/16	4 7/8	11 7/8	7 7/8	12 5/8
	3	1 3/8																									4 5/16	4 5/8	11 5/8	7 5/8	12 3/8
3 1/4	1	1 3/8	1 9/16	1 1/16	2 7/16	1.750	1 3/4	5	1 1/2	5 7/8	4 3/4	7 1/8	8 1/2	8	7 1/4	5 13/16	4 3/8	6 3/16	3/8	4 1/16	4 1/2	3 1/2	4 1/8	12 1/8	8 3/8	13 1/2					
	2	2																									4 7/8	4 7/8	12 1/2	8 3/8	13 1/2
	3	1 3/4																									4 5/8	4 3/4	12 3/8	8 1/4	13 3/8
4	1	1 3/4	2	7/8	2 5/8	1.750	1 3/4	5 1/2	2 1/16	6 3/4	5 1/4	7 5/8	9	8 1/2	8 1/2	6 3/8	4 5/8	6 11/16	1/8	4 1/2	4 3/4	3 3/4	4	13 1/4	8 1/2	14 5/8					
	2	2 1/2																									5 7/16	7 1/16	13 3/8	8 7/8	15
	3	2																									4 3/4	4 7/8	13 3/8	8 5/8	14 3/4
5	1	2	2	7/8	2 7/8	1.750	1 3/4	7	2 15/16	8 1/4	6 3/4	9 3/4	10 1/2	10	10	7 3/4	5 7/16	7 7/16	0	4 7/8	5 1/8	4 1/4	4 1/2	14 1/2	9 3/8	16 1/4					
	2	3 1/2																									5 3/8	5 3/8	14 3/4	9 5/8	16 1/2
	3	2 1/2																									5 1/4	7 5/16	14 3/4	9 5/8	16 1/2
6	1	2 1/2	2 1/2	1 1/8	3 1/8	2.000	2	8 1/2	3 5/16	9 3/4	7 3/4	11 1/4	12 1/2	11 1/2	12	10 3/4	5 3/8	8 1/16	1/4	5 3/8	5 1/2	5 1/8	5 1/8	16 1/8	10 3/8	18 1/8					
	2	4																									5 3/8	5 1/2	16 1/8	10 3/8	18 1/8
	3	3																									5 3/8	8 1/16	16 3/8	10 3/8	18 1/8
7	1	3	2 7/8	1 3/8	2 7/8	2.500	2 1/2	9 3/4	3 3/4	11 1/4	8 3/4	12 5/8	14 3/4	13 1/2	14	11 1/2	5 1/8	8 1/16	1/8	5 1/8	5 5/16	5 7/8	5 3/4	16 3/4	10 7/8	19 1/4					
	2	5																									5 1/8	5 5/16	16 3/4	10 7/8	19 1/4
	3	3 1/2																									5 1/8	8 1/16	16 3/4	10 7/8	19 1/4
8	1	3 1/2	2 7/8	1 3/8	2 7/8	3.000	3	11	4 1/4	12 1/4	9 3/4	14	17	15 1/2	15	13 3/8	5 1/4	8 9/16	1/8	5 1/8	5 7/16	6 5/8	6 3/4	18	11 3/4	20 3/4					
	2	5 1/2																									5 1/4	8 9/16	18	11 3/4	20 3/4
	3	4																									5 1/4	8 9/16	18	11 3/4	20 3/4
8	4	4 1/2	2 7/8	1 3/8	2 7/8	3.000	3	11	4 1/4	12 1/4	9 3/4	14	17	15 1/2	15	13 3/8	5 1/4	8 9/16	1/8	5 1/8	5 7/16	6 5/8	6 3/4	18	11 3/4	20 3/4					
	5	5																									5 1/4	8 9/16	18	11 3/4	20 3/4

Double Rod Cylinders



To obtain dimensioning information on a double rod cylinder, first select the desired mounting style and refer to the corresponding single rod cylinder model shown on the preceding pages. After you have determined all necessary dimensions from that drawing, turn back to this page and supplement those dimensions with additional ones from this drawing and the table at right. These added dimensions provide the additional information needed to completely dimension a double rod cylinder model.

On a double rod cylinder where the two rod ends will be different, be sure to state which rod end is to go at which end of the cylinder.

BORE SIZE	ROD NO.	ROD DIA.	ADD STROKE				ADD 2X STROKE
			LD	ZL	SN _K	SS _K	ZM
2 1/2	1	1	10 1/4	11 7/16	3	3 5/8	11 3/4
	2	1 3/4		11 15/16			12 3/4
	3	1 3/8		11 11/16			12 1/4
3 1/4	1	1 3/8	10 3/4	12 3/16	3 1/2	4 3/8	12 1/2
	2	2		12 9/16			13 1/4
	3	1		12 7/16			13
4	1	1 3/4	11 1/4	12 13/16	3 3/4	4 1/4	13 1/4
	2	2 1/2		13 3/16			14
	3	2		12 15/16			13 1/2
5	1	2	12 1/4	14 3/16	4 1/4	4 3/4	14 1/2
	2	3 1/2		14 7/16			15
	3	2 1/2		14 7/16			15
	4	3		14 7/16			15
6	1	2 1/2	13 3/8	15 1/2	4 7/8	5 1/8	15 7/8
	2	4					
	3	3					
	4	3 1/2					
7	1	3	13 1/2	15 3/4	5 3/8	5 3/4	16
	2	5					
	3	3 1/2					
	4	4					
8	1	3 1/2	14 1/2	16 13/16	6 1/8	6 3/4	17
	2	5 1/2					
	3	4					
	4	4 1/2					
	5	5					
REPLACES			LB	ZB	SN	SS	—
ON SINGLE ROD MOUNTING STYLE			ALL MTG. STYLES		F	C	ALL MTG.

HOW TO ORDER SERIES VH CYLINDERS

Note: Parker Series VH Cylinders can be completely & accurately described by a model number consisting of coded symbols. To develop a model number select only those symbols that represent the cylinder required and place them in the sequence shown in the chart below.

SERIES VH MODEL NUMBERS — HOW TO DEVELOP THEM — HOW TO DECODE THEM.																	
	BORE SIZE	CUSHION HEAD END	DOUBLE ROD	MOUNTING STYLE	MOUNTING MOD.	COMBINATION MOUNTING STYLE	SERIES	PISTON SEAL	PORTS	SEALS	SPECIAL MODIFICATIONS	PISTON ROD NO.	ROD END THREAD STYLE NO.	ALTERNATE STANDARD ROD END THREAD LENGTH	THREAD TYPE	CUSHION CAP END	STROKE
E	6	C	K	C	P	TB	VH	K	T	V	S	1	4	2	A	C	X50
X	Specify 2 1/2" thru 8"	Specify only if Cushion Head End is required	Use only if Double Rod Cyl. is required	Specify mounting style T, TB, TC, TD, F, H, J, BB, C, D, DB, DD, HB, JB.	Specify P for Thrust Key Mtg.	Specify any practical mtg. style available	Specify Series VH	C = Ring Packed Piston L = Lip Seal Piston K = Hi Load Piston	Specify Port Type req'd. U=NPTF T=SAE P=SAE Flange Ports R=BSP B=BSPT G=Metric Y=metric ISO 6149	If required specify V=Fluoro-carbon Seals 2=Class 2 Seals X=E.P.R. Seals 4 = Class 4 Seals J=High Water Content Fluid E=Fluoro-carbon rod seal assembly only (Class 5)	Specify only if special modifications are required. Do not use symbol "S" for rod end modifications.	Specify rod code no. See Cylinder Stroke Chart for min. Piston rod diameter	Specify Style 4 Small Male Style 8 Intermediate Male Style 9 Short Female 55 = Rod End for Flange Coupling Style 3 Special. Specify KK, A, and W or WF dim. req'd	Specify only if 2 times Standard Catalog "A" dim. is required	Specify A=UNF M=Metric N=No Thread	Specify only if Cushion Cap End is required	Specify in inches. Show symbol "X" just ahead of stk. length.
A																	
M																	
P																	
L																	
E																	

Class 1 SEALS

Class 1 seals are the seals provided as standard in a cylinder assembly unless otherwise specified. For further information on fluid compatibility on operating limitations of all compounds, refer to Operating Fluids and Seals / Temperature.



Theoretical Push and Pull Forces

Push Force and Displacement

Cyl. Bore Size (Inches)	Piston Area (Sq. In.)	Cylinder Push Stroke Force In Pounds At Various Pressures										Displacement Per Inch Of Stroke (Gallons)
		25	50	65	80	100	250	500	1000	2000	3000	
2½	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	.0213
3¼	8.30	208	415	540	664	830	2075	4150	8300	16600	24900	.0359
4	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	.0544
5	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	.0850
6	28.27	707	1414	1838	2262	2827	7068	14135	28270	56540	84810	.1224
7	38.49	962	1924	2502	3079	3849	9623	19245	38490	76980	115470	.1666
8	50.27	1257	2513	3268	4022	5027	12568	25135	50270	100540	150810	.2176

Deductions for Pull Force and Displacement

Piston Rod Dia. (Inches)	Piston Area (Sq. In.)	Piston Rod Diameter Force In Pounds At Various Pressures										Displacement Per Inch Of Stroke (Gallons)
		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.										
		25	50	65	80	100	250	500	1000	2000	3000	
1	.785	20	39	51	65	79	196	392	785	1570	2355	.0034
1⅜	1.49	37	75	97	119	149	373	745	1490	2980	4470	.0065
1¾	2.41	60	121	157	193	241	603	1205	2410	4820	7230	.0104
2	3.14	79	157	204	251	314	785	1570	3140	6280	9420	.0136
2½	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	.0213
3	7.07	177	354	460	566	707	1767	3535	7070	14140	21210	.0306
3½	9.62	241	481	625	770	962	2405	4810	9620	19240	28860	.0416
4	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	.0544
4½	15.90	398	795	1033	1272	1590	3975	7950	15900	31800	47708	.0688
5	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	.0850
5½	23.76	594	1188	1544	1901	2376	5940	11880	23760	47520	71280	.1028

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.

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 (class 1)

Class 1 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 class 2 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 Class 6 seals should be used. Typical water base fluids are: Water, Water-Glycol, Water-in Emulsion, Houghto-Safe 27, 620, 5040, Mobil Pyrogard D, Shell Iruis 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)

Class 3 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)

Class 4 seals are intended for low temperature service with the same type of fluids as used with Class 1 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. **Note:** Certain fluids may react adversely with Class 4 seals compared to Class 1 seals.

Fluorocarbon Seals (class 5)

Class 5 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, class 5 seals can be used with fluids listed below under standard service. However, they are not compatible with Phosphate Ester Fluids such as Skydrols. Class 5 seals can operate with a temperature range of -10°F (-23°C) to +250°F (+121°C). Class 5 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. Class 5 Lipseals will have PTFE back-up washers when required. O-rings will have fluorocarbon back-up when required.

HWCF Seals (class 6)

Class 6 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). Class 6 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 class 6 seals, will also be modified to have lip seal piston seals and straight cushions.

Energized PTFE Seals (class 8)

Class 8 seals consist of PTFE piston lipseals, rod seal and wiperseal. 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. Minimum operating temperature is -15°F (-26°C). 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.

Warning ⚠

The piston rod stud and the piston rod to piston threaded connections are secured with an anaerobic adhesive which is temperature sensitive. Cylinders are assembled with anaerobic adhesive having a maximum temperature rating of +250°F (+121°C). Cylinders specified with all other seal compounds (built before 1997) were 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 (before 1997) with class 1 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.

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 class 6 fluids. A nitrile expander will be provided unless Class 3 or 5 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 Series 2H and 3H 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 assemblies 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 fluorocarbon 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 Series 2H 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 10in³/min. Leakage will increase as pressure and bore size increase, and viscosity of the operating hydraulic fluid decreases. For these reasons cast iron rings are not recommended when using water or (HWCF) fluids.

Water Service

Series 2H cylinders can be modified to make them more suitable for use with water as the operating medium. The modifications include chrome-plated cylinder bore; electroless nickel-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 on the next page. Series 2H and 3H hydraulic cylinders can also be modified for water operation and supplied with chrome-plated cylinder bore; electroless nickel-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

Parker Hannifin 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.

Fluids and Temperature Range

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)	Some Phosphate Ester Fluids Skydrol 500, 7000	-10°F (-23°C) to +130°F (+54°C)
Note: (EPR) seals are not compatible with Hydraulic Oil		
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)	High Temperature Houghto-Safe 1010, 1055, 1120 Fyrquel 150, 220, 300, 550 Mobil Pyrogard 42,43,53,55	See paragraph on Fluorocarbon seals for recommended temperature range.
Note: Fluorocarbon seals are not suitable for use with Skydrol fluid, but can be used with hydraulic oil if desired.		
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) Energized PTFE	See Class 5 Seals	-15°F (-26°C) to +400°F (+204°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 Series VH hydraulic cylinders.

Pressure Ratings

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

Series VH hydraulic cylinders are recommended for pressures to 3000 p.s.i. for heavy-duty service with hydraulic oil. The 4:1 design factor ratings shown are based on tensile strength of material and are for code 1 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 Diameter (Inches)	4:1* Design Factor (Tensile) (PSI)	Heavy-Duty Service (PSI)
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

*Applies to all mountings except J and H.

Ports

Parker hydraulic and pneumatic cylinders can be supplied with S.A.E. 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 except Series C and S.

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

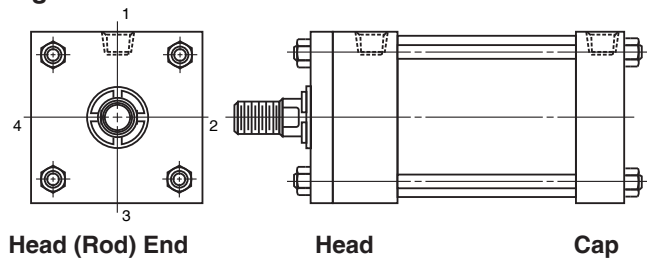


Table A

Mounting Style	Port Position Available	
	Head End	Cap End
T, TB, TC, TD, H, HB, J, JB, DD	1, 2, 3 or 4	1, 2, 3 or 4
BB, DB	1, 2, 3 or 4	1 or 3
D	1 or 3	1, 2, 3 or 4
C, F	1	1

Straight Thread Ports

The S.A.E. straight thread O-ring port is recommended for hydraulic applications. Parker will furnish this port configuration at positions shown above. This port can also be provided at positions other than those shown in Table A at an extra charge. S.A.E. port size numbers are listed next to their N.P.T.F. pipe thread counterparts for each bore size in the respective product catalogs. Size number, tube O.D. and port thread size for S.A.E. ports are listed in Table C.

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:

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

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.
Option "P"	SAE Flange Pots Code 61 (3000 psi). Recommended for hydraulic applications requiring larger port sizes.
Option "B"	BSPT (British Tapered Thread).
Option "G"	Metric Straight Thread Port similar to Option "R" with metric thread. Popular in some European applications.
Option "Y"	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.

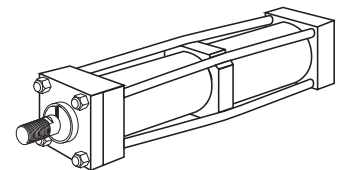
Table C

S.A.E. 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	—	—	—

Stroke Data

Parker 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.

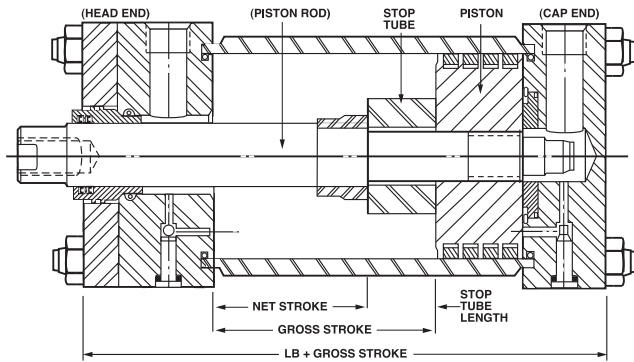


Stroke Tolerances – Stroke length tolerances are required due to build-up of tolerances of piston, head, cap and cylinder body. Standard production stroke tolerances run +1/32" to -1/64" up to 20" stroke, +1/32" to -.020" for 21" to 60" stroke and +1/32" to -1/32" for greater than 60" stroke. For closer 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 (below) may achieve the desired result.

Stop Tubing

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.

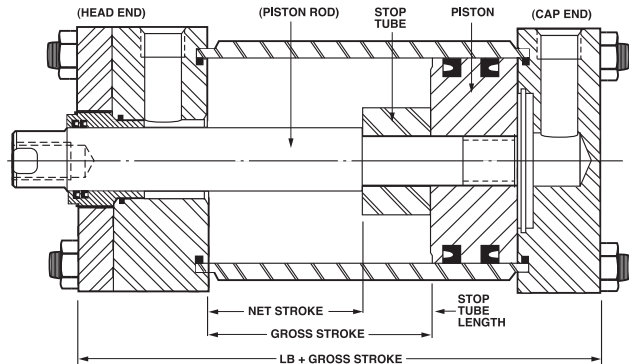
Drawing A



When specifying cylinders with long stroke and 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.

Refer to piston rod/stroke selection chart to determine stop tube length.

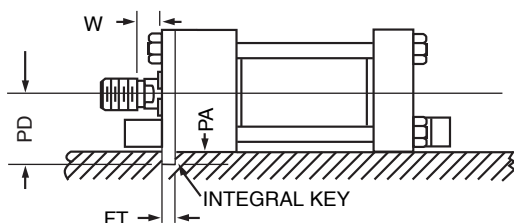
Drawing B



This design is supplied on all non cushion cylinders.

Thrust Key Mountings

Thrust key mountings eliminate the need of using fitted bolts or external keys on side mounted cylinders. Parker cylinders in mounting styles CP and FP 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. This is referred to as the "P" Modification of any side mounting style.



Mounting Classes

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.

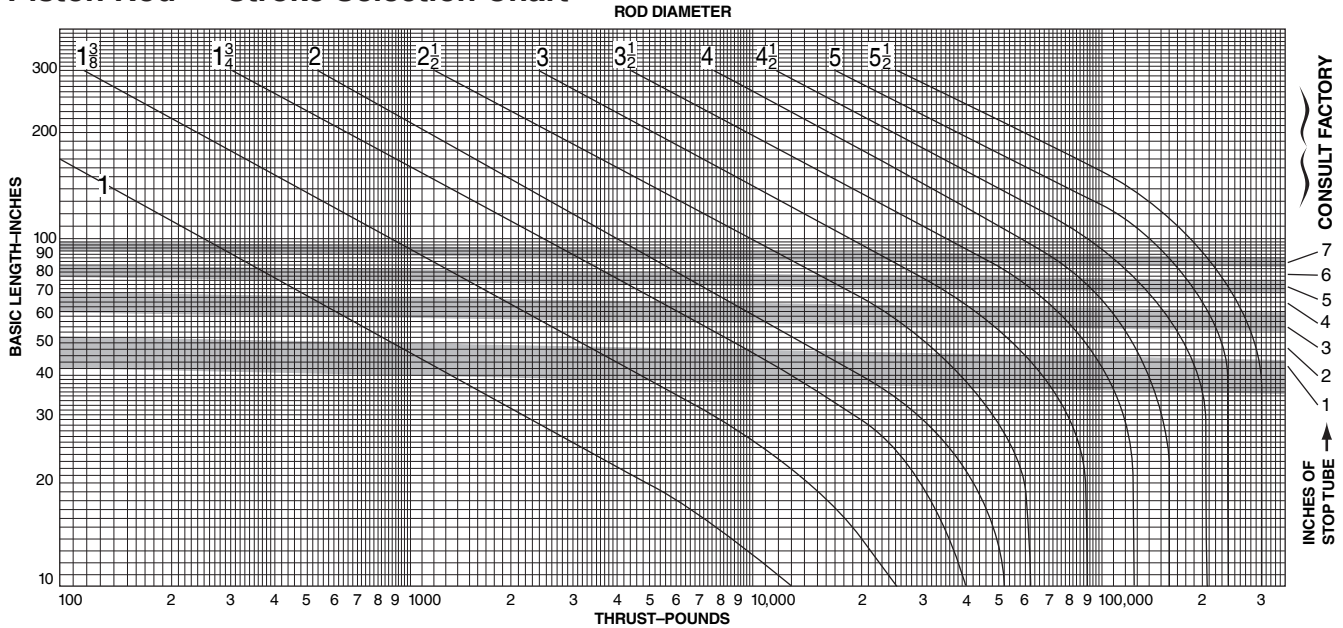
Group 2 – Pivot Force Transfer. Pivot mountings permit a cylinder to change its alignment in one plane.

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 Group 3.

Group 1 FIXED MOUNTS which absorb force on cylinder centerline.	
Heavy-Duty Service For Thrust Loads For Tension Loads	 Mounting Styles HB, TC Mounting Style TB
Medium-Duty Service For Thrust Loads For Tension Loads	Mounting Styles H, JB Mounting Styles J, HB
Light-Duty Service For Thrust Loads For Tension Loads	Mounting Style J Mounting Style H
Group 2 PIVOT MOUNTS which absorb force on cylinder centerline.	
Heavy-Duty Service For Thrust Loads For Tension Loads	 Mounting Styles DD, D Mounting Styles BB, DD, D, DB
Medium-Duty Service For Thrust Loads For Tension Loads	Mounting Style BB Mounting Style BB
Group 3 FIXED MOUNTS which do not absorb force on the centerline.	
Heavy-Duty Service For Thrust Loads For Tension Loads	 Mounting Styles C, CP Mounting Styles C, CP
Medium-Duty Service For Thrust Loads For Tension Loads	Mounting Styles F, FP Mounting Styles F, FP

Piston Rod — Stroke Selection Chart



How to Use the Chart

The selection of a piston rod for thrust (push) conditions requires the following steps:

- Determine the type of cylinder mounting style and rod end connection to be used. Then consult the chart below and find the "stroke factor" that corresponds to the conditions used.
- Using this stroke factor, determine the "basic length" from the equation:

$$\text{Basic Length} = \frac{\text{Actual Stroke}}{\text{Stroke Factor}} \times \text{Stroke}$$

The graph is prepared for standard rod extensions beyond the face of the gland retainers. For rod extensions greater than standard, add the increase to the stroke in arriving at the "basic length."

- Find the load imposed for the thrust application by multiplying the full bore area of the cylinder by the system pressure.
- Enter the graph along the values of "basic length" and "thrust" as found above and note the point of intersection:
 - The correct piston rod size is read from the diagonally curved line labeled "Rod Diameter" next above the point of intersection.
 - The required length of stop tube is read from the right of the graph by following the shaded band in which the point of intersection lies.

- If required length of stop tube is in the region labeled "consult factory," submit the following information for an individual analysis:
 - Cylinder mounting style.
 - Rod end connection and method of guiding load.
 - Bore, required stroke, length of rod extension (Dim. "W" or "WF") if greater than standard, and series of cylinder used.
 - Mounting position of cylinder. (Note: If at an angle or vertical, specify direction of piston rod.)
 - Operating pressure of cylinder if limited to less than standard pressure for cylinder selected.

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.

Recommended Mounting Styles for Maximum Stroke and Thrust Loads	Rod End Connection	Case	Stroke Factor
Groups 1 or 3 Long stroke cylinders for thrust loads should be mounted using a heavy-duty mounting style at one end, firmly fixed and aligned to take the principal force. Additional mounting should be specified at the opposite end, which should be used for alignment and support. An intermediate support may also be desirable for long stroke cylinders mounted horizontally. Machine mounting pads can be adjustable for support mountings to achieve proper alignment.	Fixed and Rigidly Guided	I	.50
	Pivoted and Rigidly Guided	II	.70
	Supported but not Rigidly Guided	III	2.00
Group 2 Style D — Trunnion on Head	Pivoted and Rigidly Guided	IV	1.00
Style DD — Intermediate Trunnion	Pivoted and Rigidly Guided	V	1.50
Style DB — Trunnion on Cap or Style BB — Clevis on Cap	Pivoted and Rigidly Guided	VI	2.00

Notes

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

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

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

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

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

1.0 General Instructions

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

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

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

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

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

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

2.0 Cylinder and Accessories Selection

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

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

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

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

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

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

- Unexpected detachment of the machine member from the piston rod.

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

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

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

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

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

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

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

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

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

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

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

The rod end pressure is approximately equal to:

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

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 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.

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 deferral 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.



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Aerospace Key Markets

Aftermarket services
Commercial transports
Engines
General & business aviation
Helicopters
Launch vehicles
Military aircraft
Missiles
Power generation
Regional transports
Unmanned aerial vehicles

Key Products

Control systems & actuation products
Engine systems & components
Fluid conveyance systems & components
Fluid metering, delivery & atomization devices
Fuel systems & components
Fuel tank inerting systems
Hydraulic systems & components
Thermal management
Wheels & brakes



Climate Control Key Markets

Agriculture
Air conditioning
Construction Machinery
Food & beverage
Industrial machinery
Life sciences
Oil & gas
Precision cooling
Process
Refrigeration
Transportation

Key Products

Accumulators
Advanced actuators
CO₂ controls
Electronic controllers
Filter driers
Hand shut-off valves
Heat exchangers
Hose & fittings
Pressure regulating valves
Refrigerant distributors
Safety relief valves
Smart pumps
Solenoid valves
Thermostatic expansion valves



Electromechanical Key Markets

Aerospace
Factory automation
Life science & medical
Machine tools
Packaging machinery
Paper machinery
Plastics machinery & converting
Primary metals
Semiconductor & electronics
Textile
Wire & cable

Key Products

AC/DC drives & systems
Electric actuators, gantry robots & slides
Electrohydraulic actuation systems
Electromechanical actuation systems
Human machine interface
Linear motors
Stepper motors, servo motors, drives & controls
Structural extrusions



Filtration Key Markets

Aerospace
Food & beverage
Industrial plant & equipment
Life sciences
Marine
Mobile equipment
Oil & gas
Power generation & renewable energy
Process
Transportation
Water Purification

Key Products

Analytical gas generators
Compressed air filters & dryers
Engine air, coolant, fuel & oil filtration systems
Fluid condition monitoring systems
Hydraulic & lubrication filters
Hydrogen, nitrogen & zero air generators
Instrumentation filters
Membrane & fiber filters
Microfiltration
Sterile air filtration
Water desalination & purification filters & systems



Fluid & Gas Handling

Key Markets

Aerial lift
Agriculture
Bulk chemical handling
Construction machinery
Food & beverage
Fuel & gas delivery
Industrial machinery
Life sciences
Marine
Mining
Mobile
Oil & gas
Renewable energy
Transportation

Key Products

Check valves
Connectors for low pressure fluid conveyance
Deep sea umbilicals
Diagnostic equipment
Hose couplings
Industrial hose
Mooring systems & power cables
PTFE hose & tubing
Quick couplings
Rubber & thermoplastic hose
Tube fittings & adapters
Tubing & plastic fittings



Hydraulics

Key Markets

Aerial lift
Agriculture
Alternative energy
Construction machinery
Forestry
Industrial machinery
Machine tools
Marine
Material handling
Mining
Oil & gas
Power generation
Refuse vehicles
Renewable energy
Truck hydraulics
Turf equipment

Key Products

Accumulators
Cartridge valves
Electrohydraulic actuators
Human machine interfaces
Hybrid drives
Hydraulic cylinders
Hydraulic motors & pumps
Hydraulic systems
Hydraulic valves & controls
Hydrostatic steering
Integrated hydraulic circuits
Power take-offs
Power units
Rotary actuators
Sensors



Pneumatics

Key Markets

Aerospace
Conveyor & material handling
Factory automation
Life science & medical
Machine tools
Packaging machinery
Transportation & automotive

Key Products

Air preparation
Brass fittings & valves
Manifolds
Pneumatic accessories
Pneumatic actuators & grippers
Pneumatic valves & controls
Quick disconnects
Rotary actuators
Rubber & thermoplastic hose & couplings
Structural extrusions
Thermoplastic tubing & fittings
Vacuum generators, cups & sensors



Process Control

Key Markets

Alternative fuels
Biopharmaceuticals
Chemical & refining
Food & beverage
Marine & shipbuilding
Medical & dental
Microelectronics
Nuclear Power
Offshore oil exploration
Oil & gas
Pharmaceuticals
Power generation
Pulp & paper
Steel
Water/wastewater

Key Products

Analytical Instruments
Analytical sample conditioning products & systems
Chemical injection fittings & valves
Fluoropolymer chemical delivery fittings, valves & pumps
High purity gas delivery fittings, valves, regulators & digital flow controllers
Industrial mass flow meters/ controllers
Permanent no-weld tube fittings
Precision industrial regulators & flow controllers
Process control double block & bleeds
Process control fittings, valves, regulators & manifold valves



Sealing & Shielding

Key Markets

Aerospace
Chemical processing
Consumer
Fluid power
General industrial
Information technology
Life sciences
Microelectronics
Military
Oil & gas
Power generation
Renewable energy
Telecommunications
Transportation

Key Products

Dynamic seals
Elastomeric o-rings
Electro-medical instrument design & assembly
EMI shielding
Extruded & precision-cut, fabricated elastomeric seals
High temperature metal seals
Homogeneous & inserted elastomeric shapes
Medical device fabrication & assembly
Metal & plastic retained composite seals
Shielded optical windows
Silicone tubing & extrusions
Thermal management
Vibration dampening

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