

Miller HV2 Series Heavy Duty Industrial Hydraulic Cylinders

Catalog HY08-M1140-4/NA

January, 2011



Heavy Duty Service – Tie Rod Construction

Nominal Pressure – 3000 PSI

Standard Bore Sizes –
1.50" through 20.00"

Piston Rod Diameters –
0.625" through 10.000"

Seventeen Standard Mounting Styles



AV Series Cylinders
 Up to 250 PSI Permanently Lubricated



AV Series air cylinders are available in bore sizes from 1.50" through 20.00" and up to 250 PSI operating pressure. Standard NFPA dimensions and proven Miller design features.

MHP Series Cylinders
 Up to 210 BAR



MHP Series *metric* hydraulic cylinders are designed to meet the requirements of ISO 6020/2 (1991), 160 Bar Compact Series and may be used for working pressures up to 210 Bar. Bore sizes from 25mm through 200mm.

CHE/CHD Series Compact Hydraulic Cylinders
 Up to 207 BAR



CHE/CHD Series compact hydraulic cylinders are available in bore sizes from 20mm through 100mm and up to 207 BAR operating pressure.

JV Series Cylinders
 400-2300 PSI
 (Pressures are bore size dependent.)



Our popularly-priced line of medium pressure hydraulic cylinders, with bore sizes from 1.00" to 8.00".

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

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Table of Contents

Table of Contents	Bore Sizes			Page
	1.50"-6.00"	7.00" & 8.00"	Large Bores	
Specifications, Mounting Styles	3	21		36-37
Cylinder Features.....	4-5	21		36
Models 51, 52, 53 Tie Rods Extended Mounts (Both Ends NFPA MX1, Cap End NFPA MX2, Head End NFPA MX3).....	6, 7	22, 23		38, 39
Model 61, Head Rectangular Flange Mount (NFPA MF1)	8, 9	24, 25		N/A
Model 65, Head Square Flange Mount (NFPA MF5).....	8, 9	24, 25		40, 41
Model 67, Head Rectangular Mount (NFPA ME5)	8, 9	24, 25		40, 41
Model 62, Cap Rectangular Flange Mount (NFPA MF2)	10, 11	26, 27		N/A
Model 66, Cap Square Flange Mount (NFPA MF6).....	10, 11	26, 27		42, 43
Model 68, Cap Rectangular Mount (NFPA ME6)	10, 11	26, 27		42, 43
Model 72, Side Lug Mount (NFPA MS2).....	12, 13	28, 29		42, 43
Model 74, Side Tap Mount (NFPA MS4).....	12, 13	28, 29		N/A
Model 84, Cap Fixed Clevis Mount (NFPA MP1).....	14, 15	32		44, 45
Model 81, Head Trunnion Mount (NFPA MT1)	16, 17	30, 31		44, 45
Model 82, Cap Trunnion Mount (NFPA MT2).....	16, 17	30, 31		44, 45
Model 89, Intermediate Trunnion Mount (NFPA MT4).....	16, 17	30, 31		44, 45
Model 87, Intermediate Trunnion Mount (NFPA MT4).....	18	33		N/A
Model 94, Spherical Bearing Mount (NFPA MPU3).....	19	N/A		N/A
Spherical Bearing Cylinder Accessories.....				20
Double Rod End Cylinders				34, 46
B & R Table – Bushing Retainer Style in 1.50" - 8.00" Bores				34
Linear Alignment Couplers				47
Cylinder Accessories				48-51
“Style 9” Piston Rod End, Split Couplers & Weld Plates.....				52, 53
Push and Pull Forces.....				54
Operating Fluids and Temperature Range.....				55
Cylinder Pressure Ratings				56
Rod End Style 4 Minimum Stroke.....				56
Cylinder Weights.....				57
Ports				58, 59
Stroke Data				60
Tie Rod Supports				60
Stroke Adjusters.....				60
Spherical Bearing Mount Application.....				61
Stop Tube, Mounting Classes.....				62
Piston Rod Selection Chart and Data.....				63, 64
Thrust Key Mountings.....				65
Rod Bushing Drain.....				65
End-of-Stroke Magnetic Principle Type Proximity Switch.....				66
Parts List, Piston and Rod Assemblies.....				67
Parts Identification, Seal Kits				68-71
How to Order HV2 Series Cylinders				72, 73
Cylinder Safety Guide				74, 75
Offer of Sale				IBC

Miller Fluid Power HV2 Series Heavy-Duty Hydraulic Cylinder

When the application demands a heavy-duty cylinder with maximum performance, specify Miller Fluid Power HV2 Series. This cylinder has standard design features to maximize machine uptime. The standard bronze rod bushing (nodular iron is a no extra cost option), case-hardened piston rod, high strength piston rod stud and tie rod material combine to make HV2 the cylinder for demanding applications up to 3000 psi.

Thorough inspection and performance testing of each cylinder before shipment assure HV2 cylinder quality. See the following pages for the inside story on all the features that make HV2 series the high performance, long lasting choice for all your heavy-duty hydraulic applications.



Standard Specifications

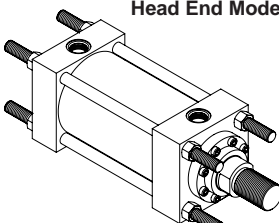
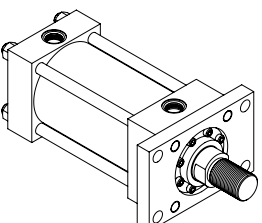
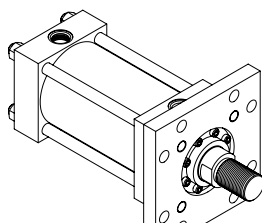
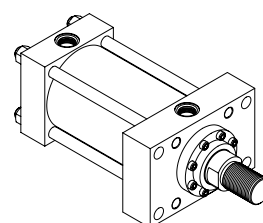
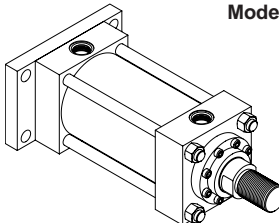
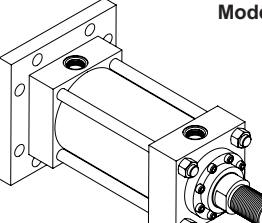
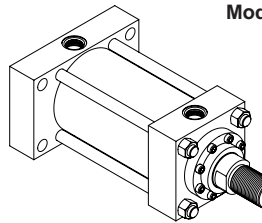
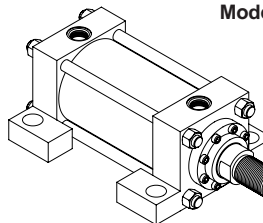
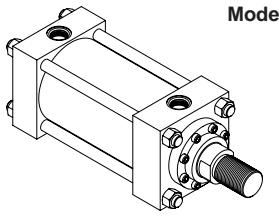
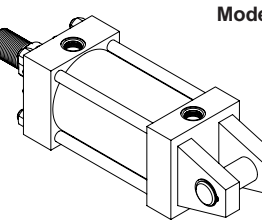
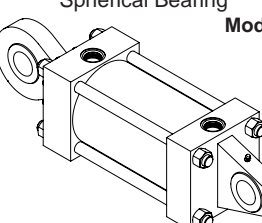
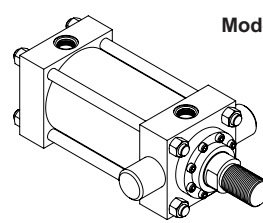
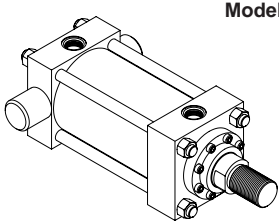
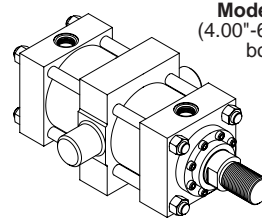
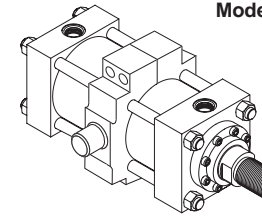
- Heavy Duty Service – ANSI/(NFPA) T3.6.7R2-1996 Mounting and Specification Dimensions
- Standard Construction – Square Head – Tie Rod Design
- Nominal Pressure – 3000 PSI¹
- Standard Fluid – Hydraulic Oil
- Standard Temperature – -10° F to +165° F
- Bore Sizes – 1.50" through 6.00"
- Piston Rod Diameter – 0.625" through 4.000"
- Mounting Styles – 17 standard styles at various application ratings

- Standard – Externally removable bolted bushing assembly
- Strokes – Available in any practical stroke length
- Cushions – Optional at either end or both ends of stroke. "Float Check" at cap end.
- Rod Ends – Three Standard Choices – Specials to Order

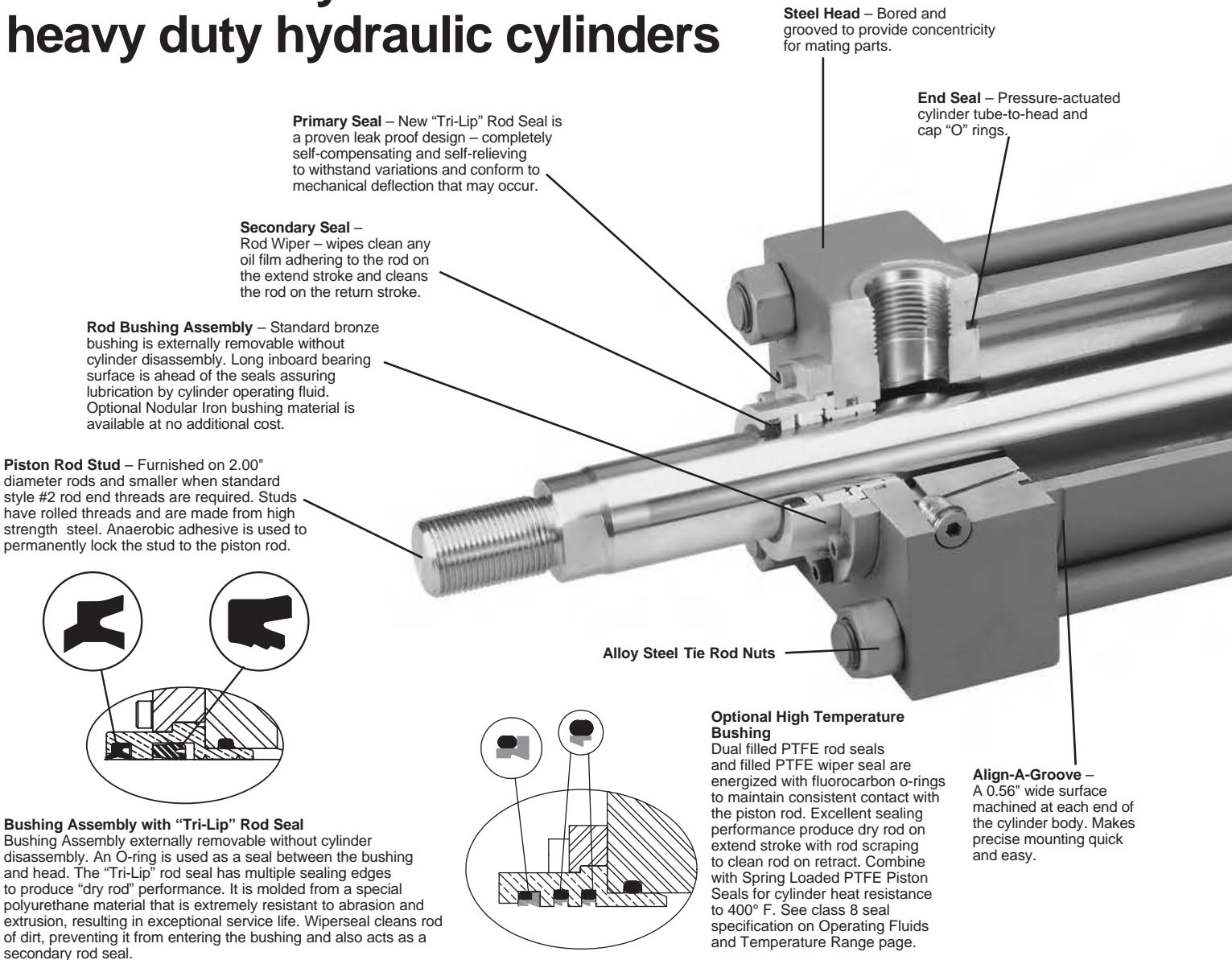
¹ If hydraulic operating pressure exceeds 3000 PSI, send application data for engineering evaluation and recommendation. See cylinder pressure ratings page for actual design factors.

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

Mounting Styles

<p>Tie Rods Extended Both Ends Model 51 Cap End Model 52 Head End Model 53</p>  <p>(BOTH ENDS NFPA MX1) (CAP END NFPA MX2) (HEAD END NFPA MX3)</p>	<p>Head Rectangular Flange Model 61</p>  <p>(NFPA MF1)</p>	<p>Head Square Flange Model 65</p>  <p>(NFPA MF5)</p>	<p>Head Rectangular Model 67</p>  <p>(NFPA ME5)</p>
<p>Cap Rectangular Flange Model 62</p>  <p>(NFPA MF2)</p>	<p>Cap Square Flange Model 66</p>  <p>(NFPA MF6)</p>	<p>Cap Rectangular Model 68</p>  <p>(NFPA ME6)</p>	<p>Side Lug Model 72</p>  <p>(NFPA MS2)</p>
<p>Side Tap Model 74</p>  <p>(NFPA MS4)</p>	<p>Cap Fixed Clevis Model 84</p>  <p>(NFPA MP1)</p>	<p>Cap Fixed Eye with Spherical Bearing Model 94</p>  <p>(NFPA MPU3)</p>	<p>Head Trunnion Model 81</p>  <p>(NFPA MT1)</p>
<p>Cap Trunnion Model 82</p>  <p>(NFPA MT2)</p>	<p>Intermediate Trunnion Model 87 (4.00"-6.00" bores)</p>  <p>(NFPA MT4)</p>	<p>Intermediate Trunnion Model 89²</p>  <p>(NFPA MT4)</p> <p>² Reduced rating 3.25"-6.00" bores</p>	

Miller . . . HV2 Series – your best choice in heavy duty hydraulic cylinders



Miller’s stepped floating cushions combine the best features of known cushion technology.

Deceleration devices or built-in “cushions” are optional and can be supplied at head end, cap end, or both ends without change in envelope or mounting dimensions. Miller cylinder cushions are a stepped design and combine the best features of known cushion technology.

Standard straight or tapered cushions have been used in industrial cylinders over a very broad range of applications, Miller research has found that both designs have their limitations.

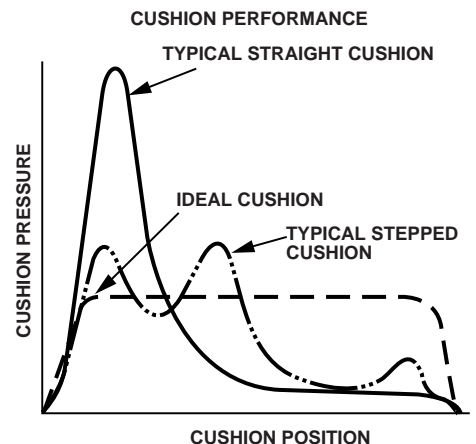
As a result, Miller has taken a new approach in cushioning of industrial hydraulic cylinders and for specific load and velocity conditions have been able to obtain deceleration curves that come very close to the ideal. The success lies in a stepped plunger concept where the steps are calculated to approximate theoretical orifice areas curves.

In the cushion performance chart, pressure traces show the results of typical orifice flow conditions. Tests of a three-step plunger show three pressure pulses coinciding with the steps. The deceleration curve shape comes very close to being theoretical, with the exception of the last 1/2 inch of travel.

This is a constant shape in order to have some flexibility in application. The stepped cushion design shows reduced pressure peaks for most load and speed conditions, with comparable reduction of objectionable stopping forces being transmitted to the load and the support structure.

All Miller HV2 cushions are adjustable.

The HV2 Series cylinder design incorporates the longest cushion plungers that can be provided in the standard envelope without decreasing the rod bearing and piston bearing lengths.

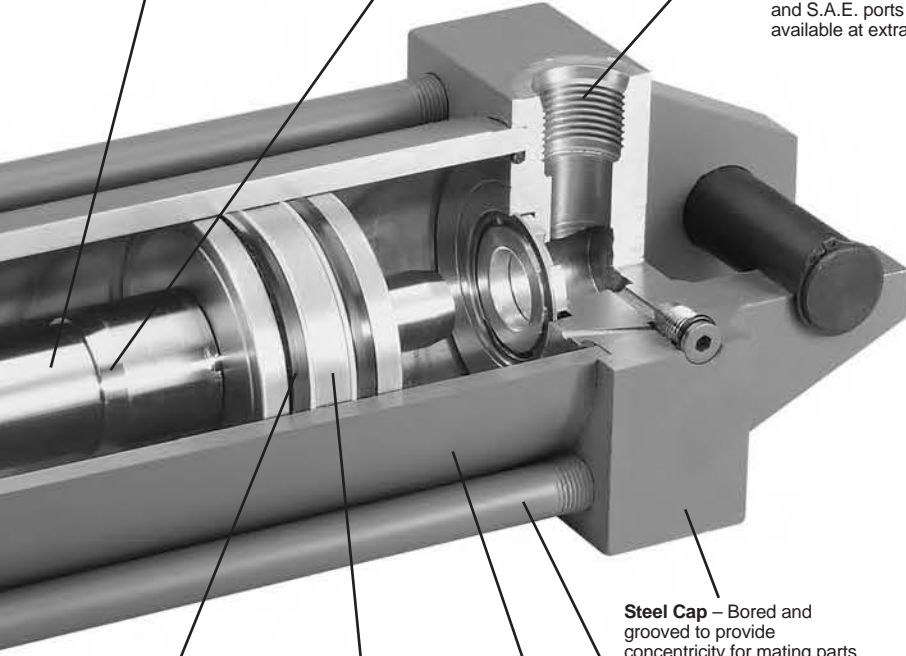


Piston Rod – Medium carbon steel, induction case-hardened, hard chrome-plated and polished to 10 RMS finish.

Adjustable Floating Stepped Cushions – For maximum performance – economical and flexible for even the most demanding applications – provides superior performance in reducing shock. Cushions are optional and can be supplied at head end, cap end, or both ends without change in envelope or mounting dimensions.

Ports – S.A. E. "O"-ring ports are standard

OPTIONAL PORTS
Ports – N.P.T.F. ports are optional at no extra charge. Oversize N.P.T.F. and S.A.E. ports are available at extra charge.



Lipseal™ Piston – Zero leakage under static conditions for hydraulic pressures up to 3000 PSI. Seals are self-compensating to conform to variations in pressure, mechanical deflection, and wear. Back-up washer prevents extrusion.

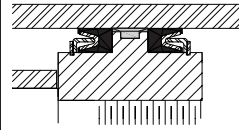
One-Piece Nodular Iron Piston – The wide piston surface contacting cylinder bore reduces bearing loads. Anaerobic adhesive is used to permanently lock and seal the piston to the rod.

Steel Cap – Bored and grooved to provide concentricity for mating parts.

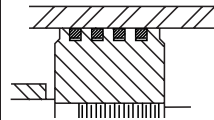
High Strength Tie Rods – Made from 100,000 PSI minimum yield steel with rolled threads for added strength.

The Cylinder Tube – Heavy-wall steel tubing, honed to a micro finish bore.

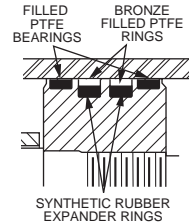
OPTIONAL PISTONS



Spring Loaded PTFE Piston Seals
Optional filled PTFE piston Lipseals utilize an internal stainless steel spring to energize both the dynamic and static sealing lips to optimize seal performance throughout the operating temperature range. Non-metallic piston wear ring in 1.50"-6.00" bores (bronze in 7.00" & 8.00" bores) reduces possibility of damaging piston which can score expensive tubing. Combine with High Temperature Bushing for cylinder heat resistance to 400° F. See class 8 seal specification on Operating Fluids and Temperature Range page.



Step cut iron piston rings are optional.



Hi Load Piston – Optional at extra charge. Includes wear rings and bronze-filled PTFE seals. Two wear rings serve as bearings which deform radially under side-loading, enabling the load to be spread over a larger area and reduce unit loading. Bronze-filled PTFE seals are designed for extrusion-free, leak-proof service and longer cylinder life than the lipseal type piston. Not available with retainer nut.

- (1) When a cushion is specified at the head end:
- A self-centering stepped plunger is furnished on the piston rod assembly.
 - A needle valve is provided that is flush with the side of the head even when wide open. It may be identified by the fact that it is socket-keyed. It is located on side number 2, in all models except 67, 68, 81, 82, 87 and 89. In these models it is located on side number 3.
 - On 6.00" bore and larger cylinders, a springless check valve is provided that is also flush with the side of the head and is mounted adjacent to the needle valve except on model 72, where it is mounted opposite the needle valve. It may be identified by the fact that it is slotted.
 - On 1.50" - 5.00" bore cylinders a slotted sleeve design is used in place of the check valve.
 - 1.50" - 2.50" bore cylinders use cartridge style needle valve (see Figure A).

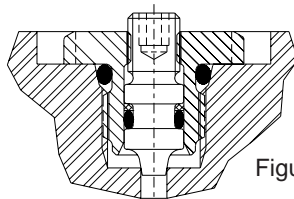
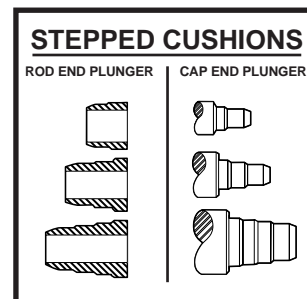


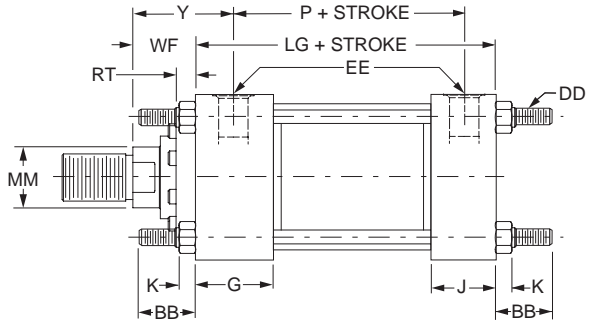
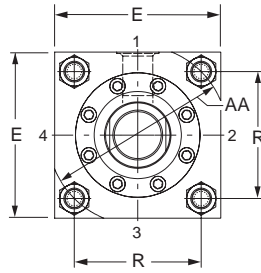
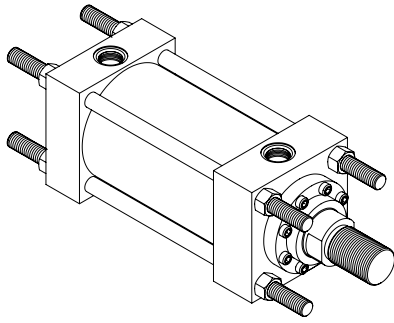
Figure A

- (2) When a cushion is specified at the cap end:
- A stepped plunger is provided on the piston rod.
 - A "float check" self-centering bushing is provided which incorporates a large flow check valve for fast "out-stroke" action.
 - A socket-keyed needle valve is provided that is flush with the side of the cap when wide open. It is located on side number 2 in all models except 67, 68, 81, 82, 87 and 89. In these models it is located on side number 3.

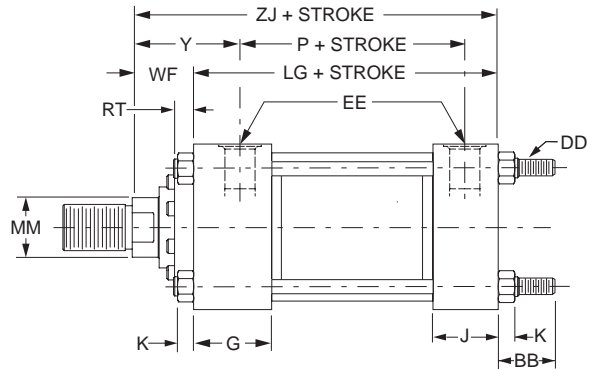
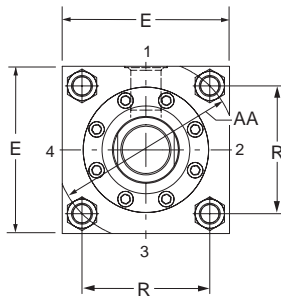
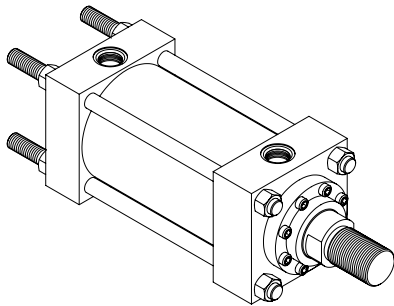


Mountings – 1.50" to 6.00" Bore Sizes

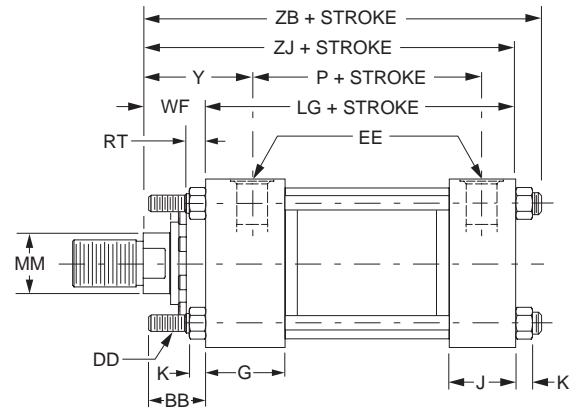
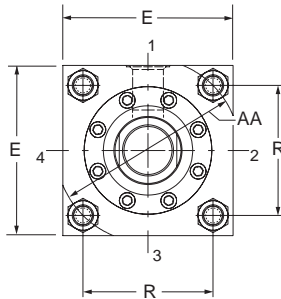
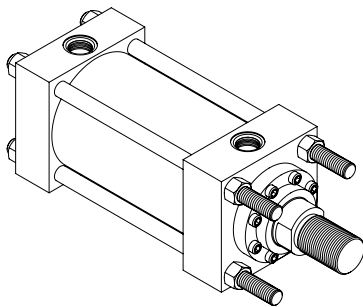
Tie Rods Extended Both Ends Mount
Model 51



Tie Rods Extended Cap End Mount
Model 52



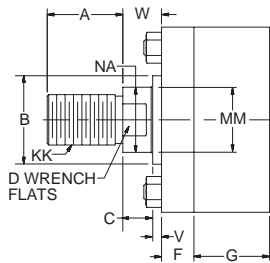
Tie Rods Extended Head End Mount
Model 53



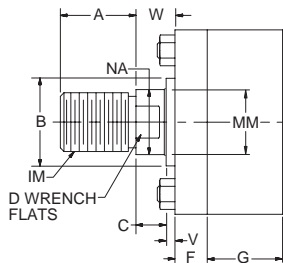
Rod End Dimensions (for Retainer Held Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

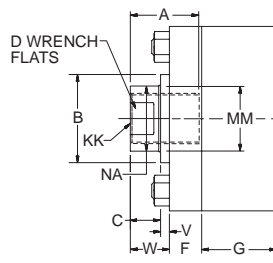
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and W. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Mountings – 1.50" to 6.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	AA	BB	DD	E	EE		F	G	J	K	R	Add Stroke	
					NPTF ²	SAE ¹						LG	P ¹
1.50	2.31	1.38 ³	3/8-24	2.50	1/2	8	0.38	1.75	1.50	0.38	1.63	4.63	2.88
2.00	2.90	1.81 ³	1/2-20	3.00	1/2	8	0.63	1.75	1.50	0.44	2.05	4.63	2.88
2.50	3.61	1.81	1/2-20	3.50	1/2	8	0.63	1.75	1.50	0.44	2.55	4.75	3.00
3.25	4.60	2.31	5/8-18	4.50	3/4	12	0.75	2.00	1.75	0.56	3.25	5.50	3.50
4.00	5.40	2.31	5/8-18	5.00	3/4	12	0.88	2.00	1.75	0.56	3.82	5.75	3.75
5.00	7.00	3.19	7/8-14	6.50	3/4	12	0.88	2.00	1.75	0.81	4.95	6.25	4.25
6.00	8.10	3.63	1-14	7.50	1	16	1.00	2.25	2.25	0.88	5.73	7.38	4.88

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06". ² NPTF ports are available at no extra charge.

³ 1.50" and 2.00" bore Models 51 and 53 are only available with retainer held bushing construction (see B&R table). Head end 'BB' dimension for these bores is referenced from the front of full square retainer that is 'F' dimension thick.

Table 2—Rod Dimensions

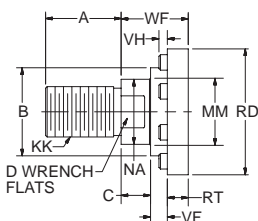
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions												Add Stroke		
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	V	VF	VH	W	WF	Y ¹	ZB (Max.)	ZJ
1.50	0.625	1/2-20	7/16-20	0.75	1.124	0.38	0.50	0.56	1.94	0.38	0.25	0.25	0.19	0.63	1.00	2.00	6.25	5.63
	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.50	0.50	0.19	1.00	1.38	2.38	6.63	6.00
2.00	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	0.75	1.38	2.38	6.69	6.00
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	2.63	6.94	6.25
2.50	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.38	6.81	6.13
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	-	1.63	2.63	7.06	6.38
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.50	0.50	0.19	-	1.88	2.88	7.31	6.63
3.25	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.25	0.63	0.19	-	1.63	2.75	7.94	7.13
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	-	1.88	3.00	8.19	7.38
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.38	0.50	0.25	-	2.00	3.13	8.31	7.50
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.25	0.50	0.19	-	1.88	3.00	8.50	7.63
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.13	8.63	7.75
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.38	8.88	8.00
5.00	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.13	9.38	8.25
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	3.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.38	9.63	8.50
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.38	0.31	-	-	2.25	3.38	9.63	8.50
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	2.38	5.94	0.94	0.38	0.31	-	-	2.25	3.38	9.63	8.50
6.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.25	0.63	0.25	-	2.25	3.50	10.81	9.63
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.25	0.31	-	-	2.25	3.50	10.81	9.63
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.25	0.31	-	-	2.25	3.50	10.81	9.63
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.25	0.31	-	-	2.25	3.50	10.81	9.63

Table 3 — Envelope and Mounting Dimensions

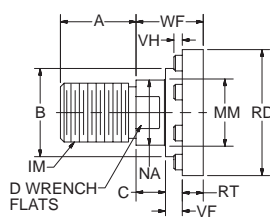
Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

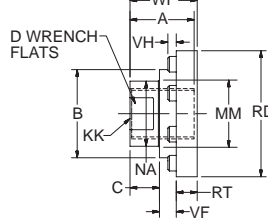
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

"Special" Thread Style X

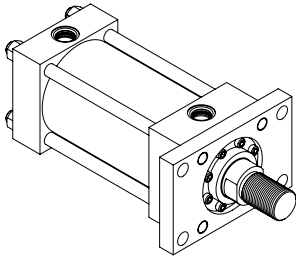
Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Mountings – 1.50" to 6.00" Bore Sizes

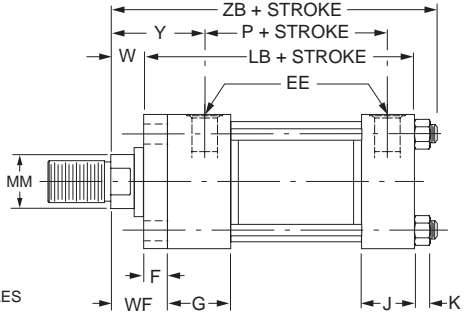
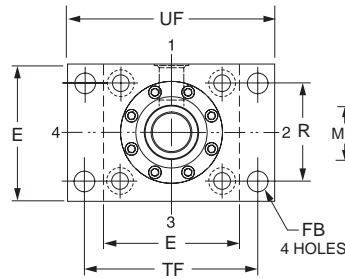
**Heavy-Duty Hydraulic Cylinders
HV2 Series**

**Head Rectangular
Flange Mount
Model 61**

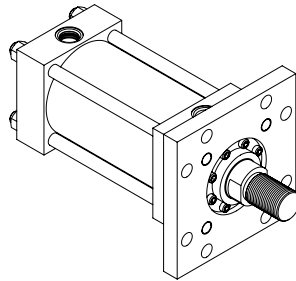


Maximum Pressure Rating - PSI
Push Application

Bore	Rod Dia				
	0.625	1.000	1.375	1.750	2.000
1.50	1400	1000	—	—	—
2.00	—	2000	1200	—	—
2.50	—	700	700	1000	—
3.25	—	—	800	800	600
4.00	—	—	—	1000	1000
5.00	—	—	—	—	850
Bore	Rod Dia				
	2.500	3.000	3.500	4.000	5.000
4.00	700	—	—	—	—
5.00	850	450	800	—	—
6.00	650	650	400	400	—

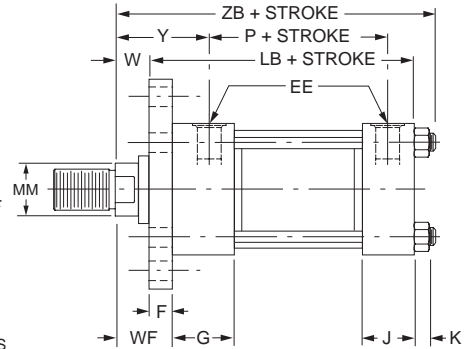
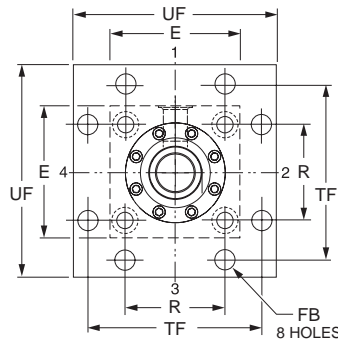


**Head Square
Flange Mount
Model 65**

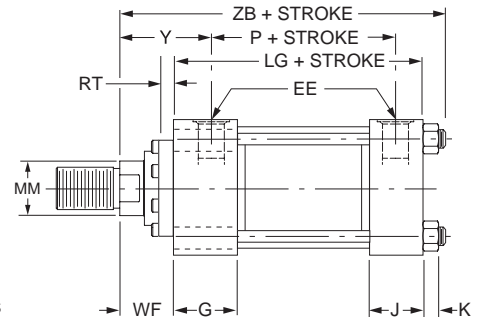
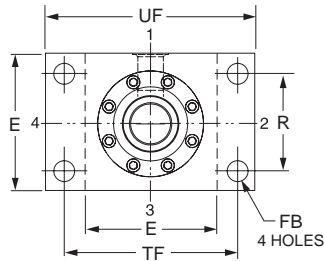
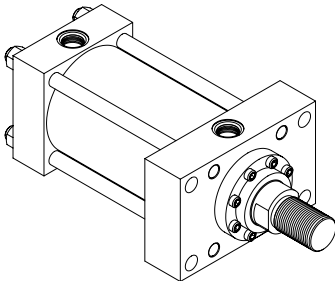


Maximum Pressure Rating - PSI
Push Application

Bore	Rod Dia				
	0.625	1.000	1.375	1.750	2.000
1.50	3000	3000	—	—	—
2.00	—	3000	3000	—	—
2.50	—	3000	3000	3000	—
3.25	—	—	3000	3000	3000
4.00	—	—	—	3000	3000
5.00	—	—	—	—	2500
Bore	Rod Dia				
	2.500	3.000	3.500	4.000	5.000
4.00	3000	—	—	—	—
5.00	2500	1800	2300	—	—
6.00	2000	2000	1600	1600	—



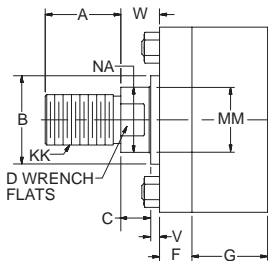
**Head Rectangular Mount
Model 67**



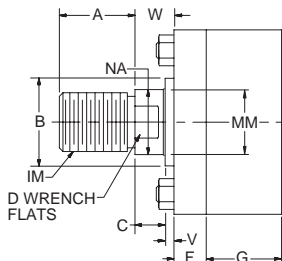
Rod End Dimensions (for Retainer Held Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

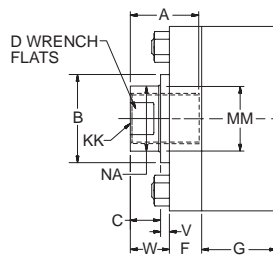
**Thread Style 2
Small Male**



**Thread Style 5
Intermediate Male**



**Thread Style 4
Short Female**



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and W. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Mountings – 1.50" to 6.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EE		F	(Bolt) FB ³	G	J	K	R	TF	UF	Add Stroke		
		NPTF ²	SAE ¹									LB	LG	P ¹
1.50	2.50	1/2	8	0.38	0.38	1.75	1.50	0.38	1.63	3.44	4.25	5.00	4.63	2.88
2.00	3.00	1/2	8	0.63	0.50	1.75	1.50	0.44	2.05	4.13	5.13	5.25	4.63	2.88
2.50	3.50	1/2	8	0.63	0.50	1.75	1.50	0.44	2.55	4.63	5.63	5.38	4.75	3.00
3.25	4.50	3/4	12	0.75	0.63	2.00	1.75	0.56	3.25	5.88	7.13	6.25	5.50	3.50
4.00	5.00	3/4	12	0.88	0.63	2.00	1.75	0.56	3.82	6.38	7.63	6.63	5.75	3.75
5.00	6.50	3/4	12	0.88	0.88	2.00	1.75	0.81	4.95	8.19	9.75	7.13	6.25	4.25
6.00	7.50	1	16	1.00	1.00	2.25	2.25	0.88	5.73	9.44	11.25	8.38	7.38	4.88

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06".

² NPTF ports are available at no extra charge. ³ Mounting holes are 0.06" larger than bolt size listed.

Table 2—Rod Dimensions

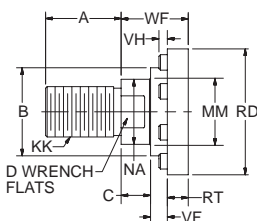
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions												Y ¹	ZB (Max.)
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	V	VF	VH	W	WF		
1.50	0.625	1/2-20	7/16-20	0.75	1.124	0.38	0.50	0.56	1.94	0.38	0.25	0.25	0.19	0.63	1.00	2.00	6.25
	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.50	0.50	0.19	1.00	1.38	2.38	6.63
2.00	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	0.75	1.38	2.38	6.69
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	2.63	6.94
2.50	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	0.75	1.38	2.38	6.81
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	2.63	7.06
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.50	0.50	0.19	1.25	1.88	2.88	7.31
3.25	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.25	0.63	0.19	0.88	1.63	2.75	7.94
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	1.13	1.88	3.00	8.19
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.38	0.50	0.25	1.25	2.00	3.13	8.31
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.25	0.50	0.19	1.00	1.88	3.00	8.50
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	1.13	2.00	3.13	8.63
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	1.38	2.25	3.38	8.88
5.00	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	1.13	2.00	3.13	9.38
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	3.38	4.25	0.63	0.38	0.63	0.25	1.38	2.25	3.38	9.63
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.38	0.31	-	1.38	2.25	3.38	9.63
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	2.38	5.94	0.94	0.38	0.31	-	1.38	2.25	3.38	9.63
6.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.25	0.63	0.25	1.25	2.25	3.50	10.81
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.25	0.31	-	1.25	2.25	3.50	10.81
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.25	0.31	-	1.25	2.25	3.50	10.81
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.25	0.31	-	1.25	2.25	3.50	10.81

Table 3 — Envelope and Mounting Dimensions

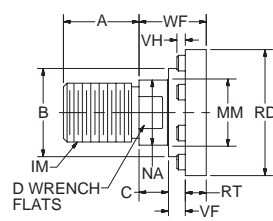
Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

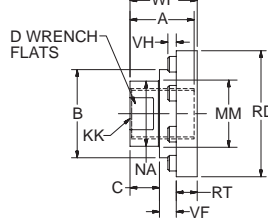
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

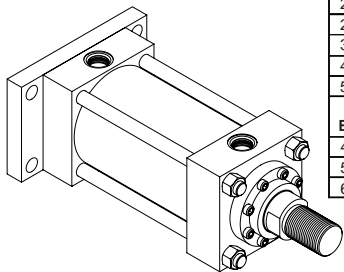
style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

"Special" Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

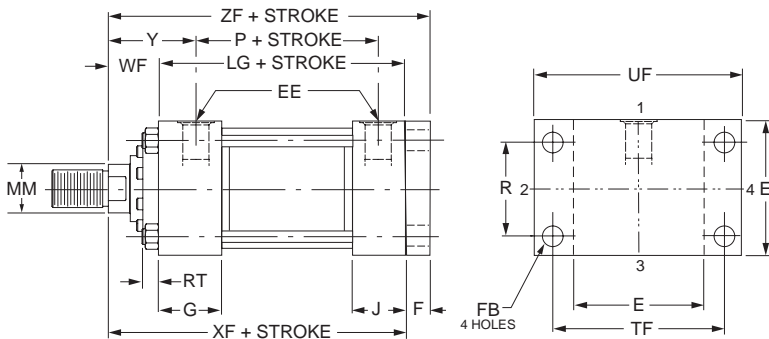
To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

**Cap Rectangular
Flange Mount
Model 62**

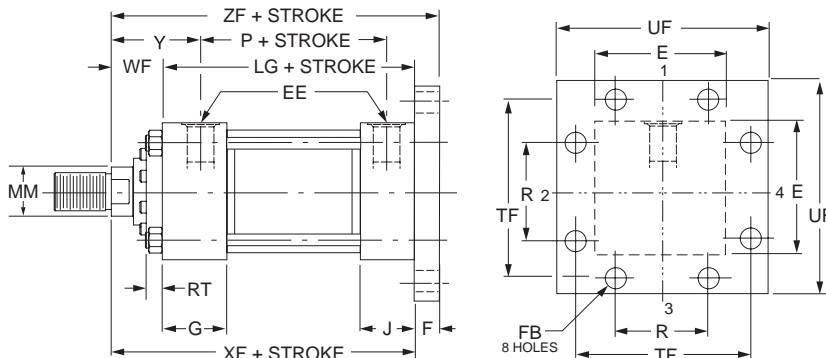
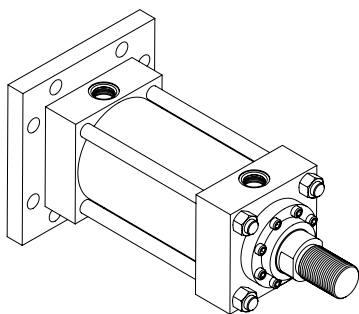


Maximum Pressure Rating - PSI
Pull Application

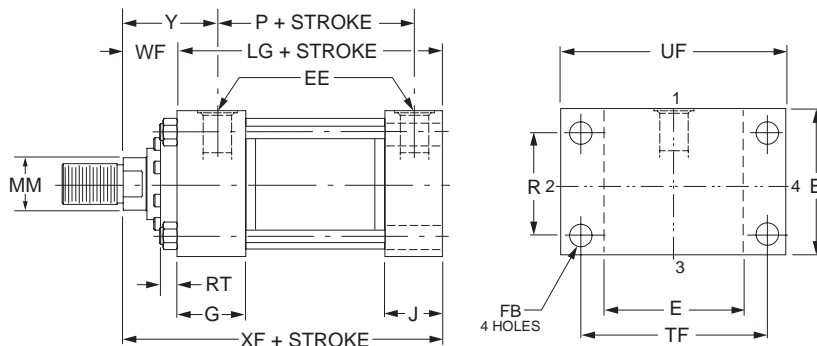
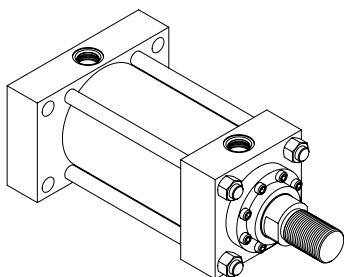
Bore	Rod Dia				
	0.625	1.000	1.375	1.750	2.000
1.50	2500	3000	-	-	-
2.00	-	3000	3000	-	-
2.50	-	3000	3000	3000	-
3.25	-	-	3000	3000	3000
4.00	-	-	-	3000	3000
5.00	-	-	-	-	2000
Bore	Rod Dia				
	2.500	3.000	3.500	4.000	5.000
4.00	3000	-	-	-	-
5.00	2000	2500	3000	-	-
6.00	1800	2000	2000	2500	-



**Cap Square Flange Mount
Model 66**



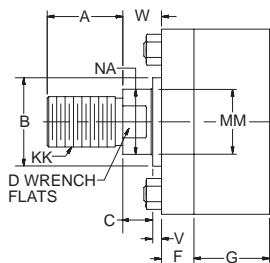
**Cap Rectangular Mount
Model 68**



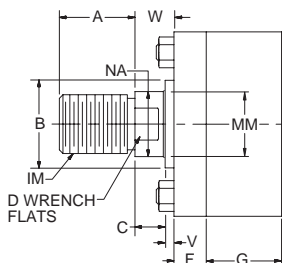
Rod End Dimensions (for Retainer Held Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

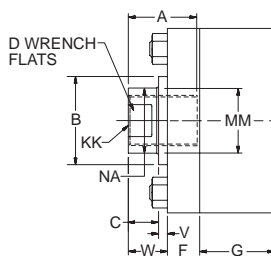
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and W. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Mountings – 1.50" to 6.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EE		F	(Bolt) FB ³	G	J	K	R	TF	UF	Add Stroke	
		NPTF ²	SAE ¹									LG	P ¹
1.50	2.50	1/2	8	0.38	0.38	1.75	1.50	0.38	1.63	3.44	4.25	4.63	2.88
2.00	3.00	1/2	8	0.63	0.50	1.75	1.50	0.44	2.05	4.13	5.13	4.63	2.88
2.50	3.50	1/2	8	0.63	0.50	1.75	1.50	0.44	2.55	4.63	5.63	4.75	3.00
3.25	4.50	3/4	12	0.75	0.63	2.00	1.75	0.56	3.25	5.88	7.13	5.50	3.50
4.00	5.00	3/4	12	0.88	0.63	2.00	1.75	0.56	3.82	6.38	7.63	5.75	3.75
5.00	6.50	3/4	12	0.88	0.88	2.00	1.75	0.81	4.95	8.19	9.75	6.25	4.25
6.00	7.50	1	16	1.00	1.00	2.25	2.25	0.88	5.73	9.44	11.25	7.38	4.88

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06".

² NPTF ports are available at no extra charge. ³ Mounting holes are 0.06" larger than bolt size listed.

Table 2—Rod Dimensions

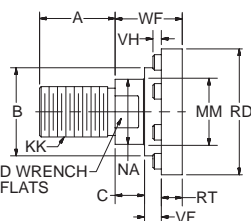
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions												Add Stroke		
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	V	VF	VH	W	WF	Y ¹	XF	ZF
1.50	0.625	1/2-20	7/16-20	0.75	1.124	0.38	0.50	0.56	1.94	0.38	0.25	0.25	0.19	-	1.00	2.00	5.63	6.00
	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.50	0.50	0.19	1.00	1.38	2.38	6.00	6.38
2.00	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.38	6.00	6.63
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	2.63	6.25	6.88
2.50	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.38	6.13	6.75
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	-	1.63	2.63	6.38	7.00
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.50	0.50	0.19	-	1.88	2.88	6.63	7.25
3.25	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.25	0.63	0.19	-	1.63	2.75	7.13	7.88
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	-	1.88	3.00	7.38	8.13
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.38	0.50	0.25	-	2.00	3.13	7.50	8.25
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.25	0.50	0.19	-	1.88	3.00	7.63	8.50
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.13	7.75	8.63
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.38	8.00	8.88
5.00	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.13	8.25	9.13
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.38	8.50	9.38
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.38	0.31	-	-	2.25	3.38	8.50	9.38
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.38	0.31	-	-	2.25	3.38	8.50	9.38
6.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.25	0.63	0.25	-	2.25	3.50	9.63	10.63
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.25	0.31	-	-	2.25	3.50	9.63	10.63
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.25	0.31	-	-	2.25	3.50	9.63	10.63
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.25	0.31	-	-	2.25	3.50	9.63	10.63

Table 3 — Envelope and Mounting Dimensions

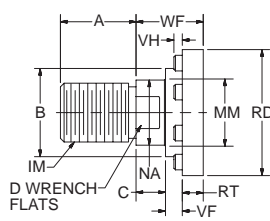
Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

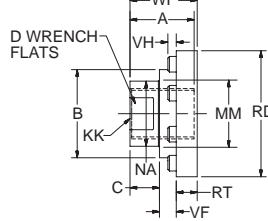
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

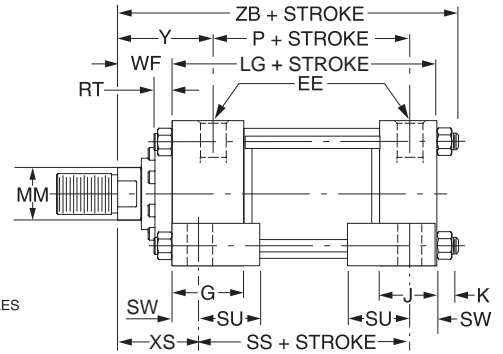
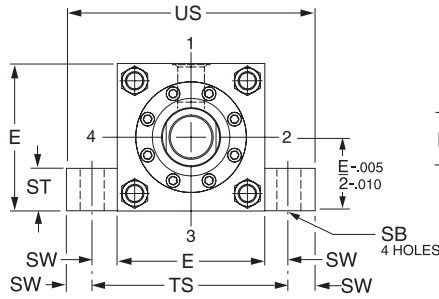
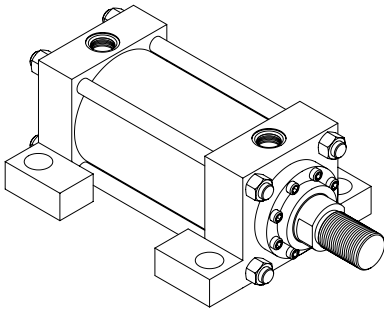
"Special" Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Mountings – 1.50" to 6.00" Bore Sizes

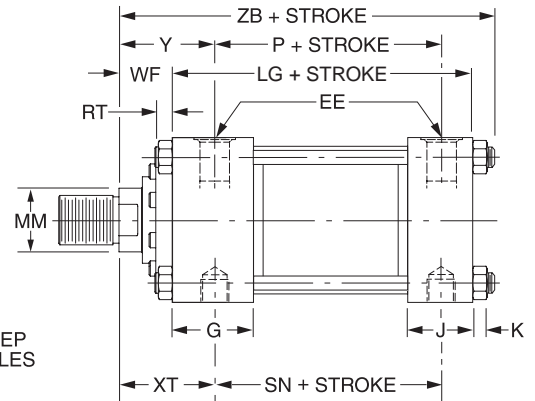
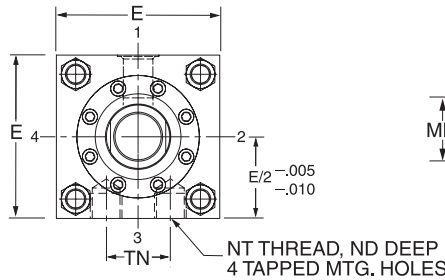
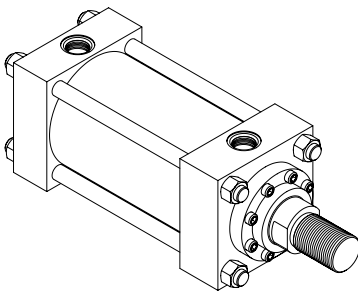
Side Lug Mount
Model 72



Model 72 cylinders have mounting lugs welded to the head and cap, and are considered to be a fixed mount that does not absorb force on its centerline. The plane of the mounting surface is not through the centerline of the cylinder, and for this reason Model 72 cylinders produce a turning moment as the cylinder applies force to the load. 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 bushing and piston bearings. **To avoid this problem, Model 72 cylinders should be specified with a stroke length at least equal to the bore size.**

Side Tap Mount
Model 74



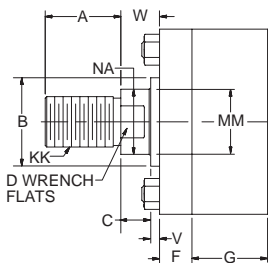
Model 74 cylinders have side tapped holes for flush mounting, and are considered to be a fixed mount that does not absorb force on its centerline. The plane of the mounting surface is not through the centerline of the cylinder, and for this reason Model 74 cylinders produce a turning moment as the cylinder applies force to the load. 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 bushing and piston bearings. **To avoid this problem, Model 74 cylinders should be specified with a stroke length at least equal to the bore size.**

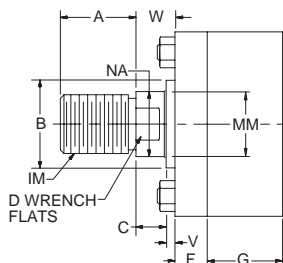
Rod End Dimensions (for Retainer Held Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

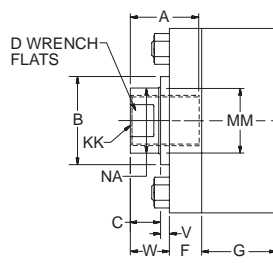
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and W. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Mountings – 1.50" to 6.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EE		F	G	J	K	NT	R	(Bolt) SB ³	ST	SU	SW	TN	TS	US	Add Stroke			
		NPTF ²	SAE ¹														LG	P ¹	SN	SS
1.50	2.50	1/2	8	0.38	1.75	1.50	0.38	3/8-16	1.63	0.38	0.50	0.94	0.38	0.75	3.25	4.00	4.63	2.88	2.88	3.88
2.00	3.00	1/2	8	0.63	1.75	1.50	0.44	1/2-13	2.05	0.50	0.75	1.25	0.50	0.94	4.00	5.00	4.63	2.88	2.88	3.63
2.50	3.50	1/2	8	0.63	1.75	1.50	0.44	5/8-11	2.55	0.75	1.00	1.56	0.69	1.31	4.88	6.25	4.75	3.00	3.00	3.38
3.25	4.50	3/4	12	0.75	2.00	1.75	0.56	3/4-10	3.25	0.75	1.00	1.56	0.69	1.50	5.88	7.25	5.50	3.50	3.50	4.13
4.00	5.00	3/4	12	0.88	2.00	1.75	0.56	1-8	3.82	1.00	1.25	2.00	0.88	2.06	6.75	8.50	5.75	3.75	3.75	4.00
5.00	6.50	3/4	12	0.88	2.00	1.75	0.81	1-8	4.95	1.00	1.25	2.00	0.88	2.94	8.25	10.00	6.25	4.25	4.25	4.50
6.00	7.50	1	16	1.00	2.25	2.25	0.88	1 1/4-7	5.73	1.25	1.50	2.50	1.13	3.31	9.75	12.00	7.38	4.88	5.13	5.13

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06".

² NPTF ports are available at no extra charge. ³ Mounting holes are 0.06" larger than bolt size listed.

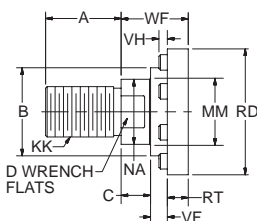
Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions													Add Stroke			
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	V	VF	VH	W	WF	ND	XS	XT	Y ¹	ZB (Max.)
1.50	0.625	1/2-20	7/16-20	0.75	1.124	0.38	0.50	0.56	1.94	0.38	0.25	0.25	0.19	-	1.00	0.38	1.38	2.00	2.00	6.25
	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.50	0.50	0.19	1.00	1.38	0.38	1.75	2.38	2.38	6.63
2.00	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	0.44	1.88	2.38	2.38	6.69
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	0.44	2.13	2.63	2.63	6.94
2.50	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	0.50	2.06	2.38	2.38	6.81
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	-	1.63	0.50	2.31	2.63	2.63	7.06
3.25	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.25	0.63	0.19	-	1.63	0.69	2.31	2.75	2.75	7.94
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	-	1.88	0.69	2.56	3.00	3.00	8.19
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	-	1.88	0.69	2.56	3.00	3.00	8.19
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.38	0.50	0.25	-	2.00	0.69	2.69	3.13	3.13	8.31
5.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.25	0.50	0.19	-	1.88	0.69	2.75	3.00	3.00	8.50
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	0.69	2.88	3.13	3.13	8.63
6.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	0.69	3.13	3.38	3.38	8.88
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	1.00	2.88	3.13	3.13	9.38
5.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	3.38	4.25	0.63	0.38	0.63	0.25	-	2.25	1.00	3.13	3.38	3.38	9.63
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.38	0.31	-	-	2.25	1.00	3.13	3.38	3.38	9.63
6.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	2.38	5.94	0.94	0.38	0.31	-	-	2.25	1.00	3.13	3.38	3.38	9.63
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.25	0.63	0.25	-	2.25	1.25	3.38	3.50	3.50	10.81
6.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.25	0.31	-	-	2.25	1.25	3.38	3.50	3.50	10.81
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.25	0.31	-	-	2.25	1.25	3.38	3.50	3.50	10.81
6.00	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.25	0.31	-	-	2.25	1.25	3.38	3.50	3.50	10.81

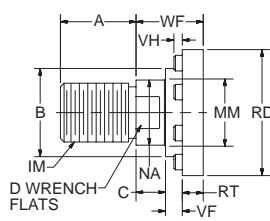
Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

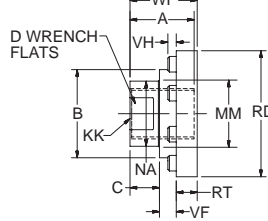
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

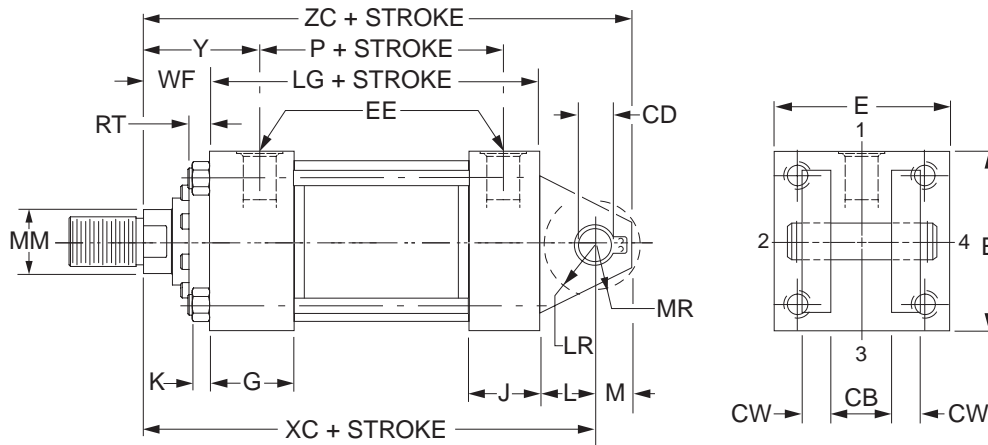
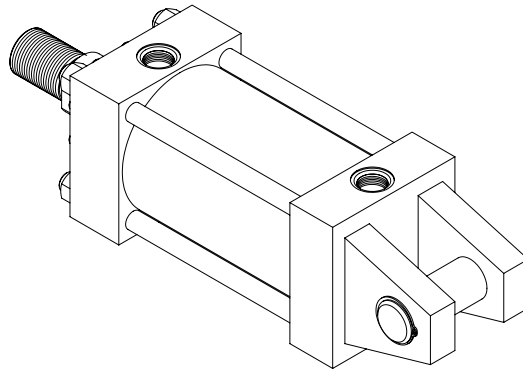
"Special" Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Mountings – 1.50" to 6.00" Bore Sizes

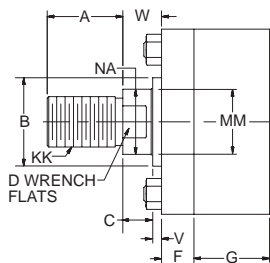
Cap Fixed Clevis Mount
Model 84



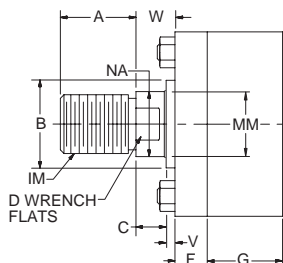
Rod End Dimensions (for Retainer Held Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

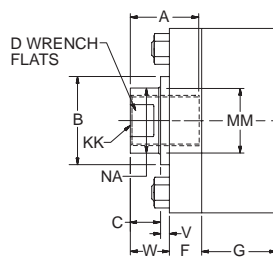
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and W. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Mountings – 1.50" to 6.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	CB	+.000 -.002 CD ³	CW	E	EE		F	G	J	K	L	LR	M	MR	Add Stroke	
					NPTF ²	SAE ¹									LG	P ¹
1.50	0.75	0.501	0.50	2.50	1/2	8	0.38	1.75	1.50	0.38	0.75	0.56	0.50	0.63	4.63	2.88
2.00	1.25	0.751	0.63	3.00	1/2	8	0.63	1.75	1.50	0.44	1.25	1.00	0.75	0.94	4.63	2.88
2.50	1.25	0.751	0.63	3.50	1/2	8	0.63	1.75	1.50	0.44	1.25	0.94	0.75	0.94	4.75	3.00
3.25	1.50	1.001	0.75	4.50	3/4	12	0.75	2.00	1.75	0.56	1.50	1.25	1.00	1.19	5.50	3.50
4.00	2.00	1.376	1.00	5.00	3/4	12	0.88	2.00	1.75	0.56	2.13	1.75	1.38	1.63	5.75	3.75
5.00	2.50	1.751	1.25	6.50	3/4	12	0.88	2.00	1.75	0.81	2.25	2.06	1.75	2.13	6.25	4.25
6.00	2.50	2.001	1.25	7.50	1	16	1.00	2.25	2.25	0.88	2.50	2.31	2.00	2.38	7.38	4.88

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06".

² NPTF ports are available at no extra charge. ³ Mounting holes are 0.06" larger than bolt size listed.

Table 2—Rod Dimensions

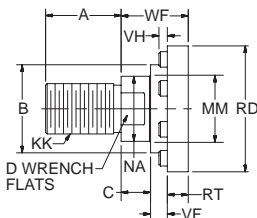
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions												Add Stroke		
		Style 5 IM	Style 2 & 4 KK	A	+.000 -.002 B	C	D	NA	RD (Max.)	RT	V	VF	VH	W	WF	Y ¹	XC	ZC
1.50	0.625	1/2-20	7/16-20	0.75	1.124	0.38	0.50	0.56	1.94	0.38	0.25	0.25	0.19	-	1.00	2.00	6.38	6.88
	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.50	0.50	0.19	1.00	1.38	2.38	6.75	7.25
2.00	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.38	7.25	8.00
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	2.63	7.50	8.25
2.50	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.38	7.38	8.13
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	-	1.63	2.63	7.63	8.38
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.50	0.50	0.19	-	1.88	2.88	7.88	8.63
3.25	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.25	0.63	0.19	-	1.63	2.75	8.63	9.63
	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	-	1.88	3.00	8.88	9.88
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.38	0.50	0.25	-	2.00	3.13	9.00	10.00
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.25	0.50	0.19	-	1.88	3.00	9.75	11.13
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.13	9.88	11.25
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.38	10.13	11.50
5.00	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.13	10.50	12.25
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	3.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.38	10.75	12.50
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.38	0.31	-	-	2.25	3.38	10.75	12.50
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	2.38	5.94	0.94	0.38	0.31	-	-	2.25	3.38	10.75	12.50
6.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.25	0.63	0.25	-	2.25	3.50	12.13	14.13
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.25	0.31	-	-	2.25	3.50	12.13	14.13
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.25	0.31	-	-	2.25	3.50	12.13	14.13
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.25	0.31	-	-	2.25	3.50	12.13	14.13

Table 3 — Envelope and Mounting Dimensions

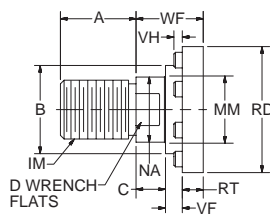
Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

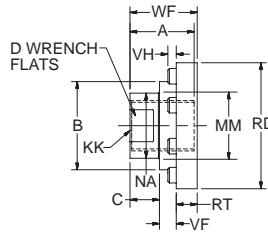
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

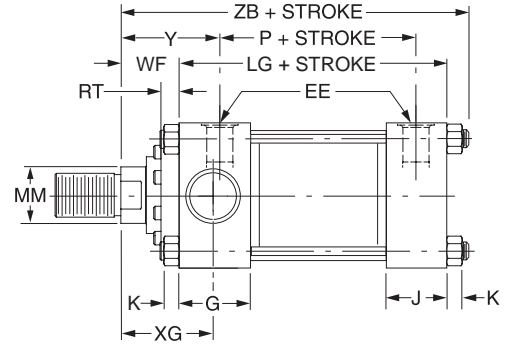
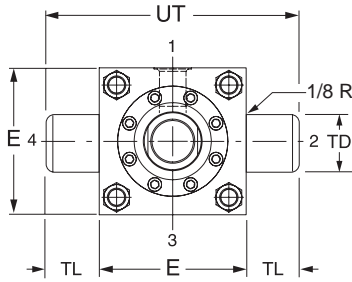
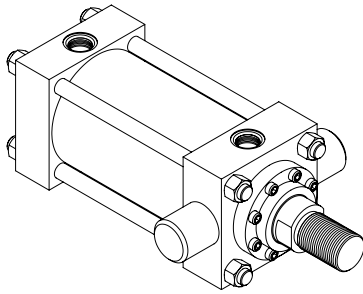
"Special" Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

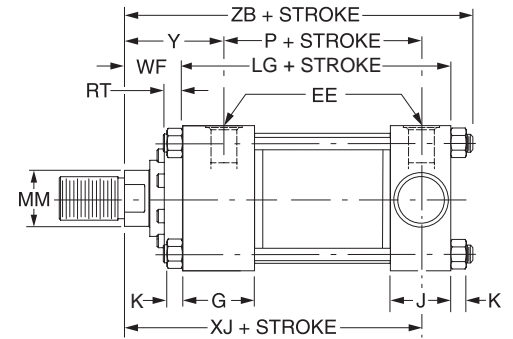
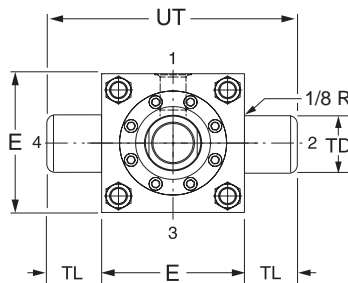
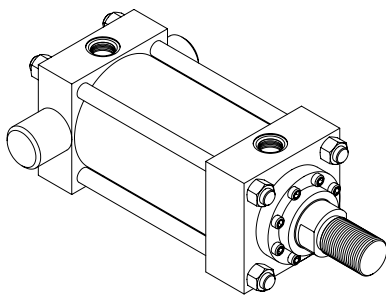
To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Mountings – 1.50" to 6.00" Bore Sizes

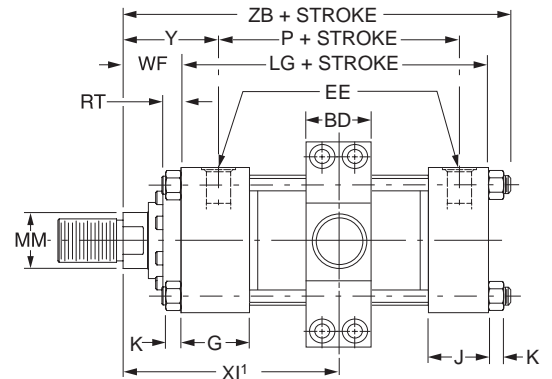
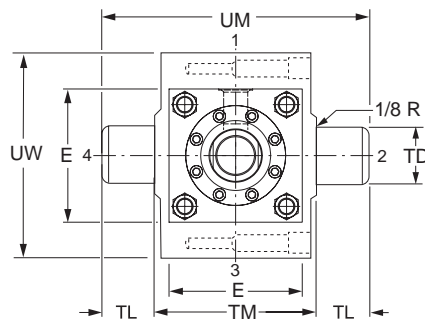
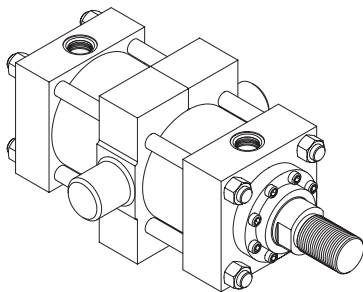
Head Trunnion Mount
Model 81



Cap Trunnion Mount
Model 82



Intermediate Trunnion Mount
Model 89

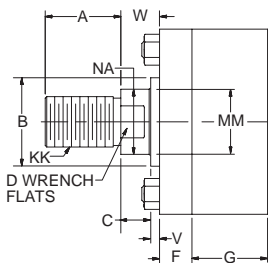


¹Dimension XI to be specified by customer.

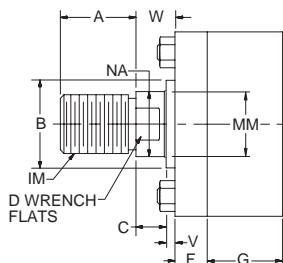
Rod End Dimensions (for Retainer Held Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

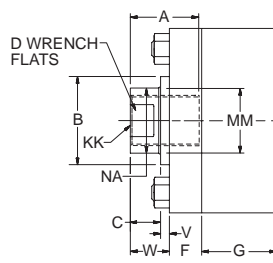
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and W. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Mountings – 1.50" to 6.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	BD	E	EE		F	G	J	K	+0.000 -0.001 TD	TL	TM	UM	UT	UW	Add Stroke		Model 89 Minimum Stroke
			NPTF ²	SAE ¹											LG	P ¹	
1.50	1.25	2.50	1/2	8	0.38	1.75	1.50	0.38	1.000	1.00	3.00	5.00	4.50	3.38	4.63	2.88	0.00
2.00	1.50	3.00	1/2	8	0.63	1.75	1.50	0.44	1.375	1.38	3.50	6.25	5.75	4.13	4.63	2.88	0.25
2.50	1.50	3.50	1/2	8	0.63	1.75	1.50	0.44	1.375	1.38	4.00	6.75	6.25	4.63	4.75	3.00	0.13
3.25	2.00	4.50	3/4	12	0.75	2.00	1.75	0.56	1.750	1.75	5.00	8.50	8.00	5.81	5.50	3.50	0.38
4.00	2.00	5.00	3/4	12	0.88	2.00	1.75	0.56	1.750	1.75	5.50	9.00	8.50	6.38	5.75	3.75	0.13
5.00	2.00	6.50	3/4	12	0.88	2.00	1.75	0.81	1.750	1.75	7.00	10.50	10.00	7.75	6.25	4.25	0.00
6.00	3.00	7.50	1	16	1.00	2.25	2.25	0.88	2.000	2.00	8.50	12.50	11.50	10.38	7.38	4.88	0.25

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06".

² NPTF ports are available at no extra charge.

Table 2—Rod Dimensions

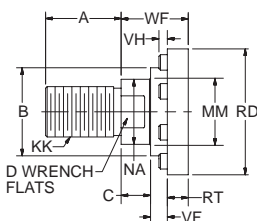
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions													Add Stroke				
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	V	VF	VH	W	WF	XG	Min. XI ³	Y ¹	Max. XI ⁴	XJ	ZB (Max.)
1.50	0.625	1/2-20	7/16-20	0.75	1.124	0.38	0.50	0.56	1.94	0.38	0.25	0.25	0.19	-	1.00	1.88	3.44	2.00	3.44	4.88	6.25
	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.50	0.50	0.19	1.00	1.38	2.25	3.81	2.38	3.81	5.25	6.63
2.00	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.25	3.94	2.38	3.69	5.25	6.69
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	1.00	1.63	2.50	4.19	2.63	3.94	5.50	6.94
2.50	1.000	7/8-14	3/4-16	1.13	1.499	0.50	0.88	0.94	2.38	0.38	0.25	0.50	0.19	-	1.38	2.25	3.94	2.38	3.81	5.38	6.81
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.38	0.63	0.19	-	1.63	2.50	4.19	2.63	4.31	5.63	7.06
2.50	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.50	0.50	0.19	-	1.88	2.75	4.44	2.88	4.06	5.88	7.31
	1.375	1 1/4-12	1-14	1.63	1.999	0.63	1.13	1.31	2.88	0.38	0.25	0.63	0.19	-	1.63	2.63	4.69	2.75	4.31	6.25	7.94
3.25	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.38	0.50	0.19	-	1.88	2.88	4.94	3.00	4.69	6.50	8.19
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.38	0.50	0.25	-	2.00	3.00	5.06	3.13	4.56	5.63	8.31
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.25	0.50	0.19	-	1.88	2.88	4.94	3.00	4.81	6.75	8.50
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.00	5.06	3.13	5.19	6.88	8.63
4.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.25	5.31	3.38	4.94	7.13	8.88
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.25	0.50	0.25	-	2.00	3.00	5.06	3.13	5.44	7.38	9.38
5.00	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.38	0.63	0.25	-	2.25	3.25	5.31	3.38	5.69	7.63	9.63
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.38	0.31	-	-	2.25	3.25	5.31	3.38	5.69	7.63	9.63
5.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.38	0.31	-	-	2.25	3.25	5.31	3.38	5.69	7.63	9.63
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.25	0.63	0.25	-	2.25	3.38	6.06	3.50	5.81	8.38	10.81
6.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.25	0.31	-	-	2.25	3.38	6.06	3.50	5.81	8.38	10.81
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.25	0.31	-	-	2.25	3.38	6.06	3.50	5.81	8.38	10.81
6.00	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.25	0.31	-	-	2.25	3.38	6.06	3.50	5.81	8.38	10.81

³ Dimension XI to be specified by customer. ⁴ Dimensions shown are valid for standard WF dimension.

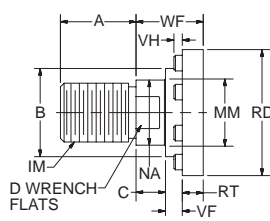
Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.

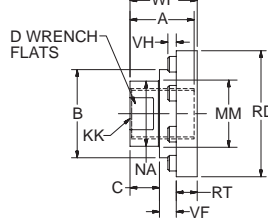
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

"Special" Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Mountings – 1.50" to 6.00" Bore Sizes

Intermediate Trunnion Mount
Model 87

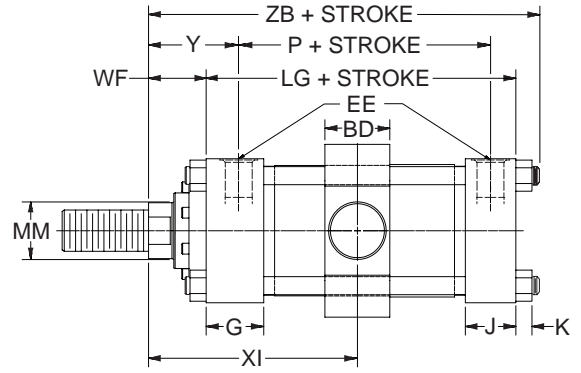
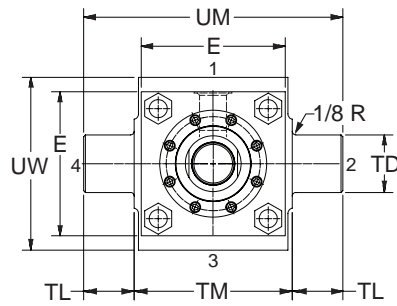
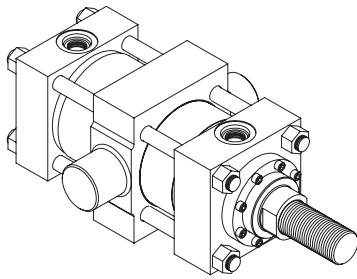


Table 1—Envelope and Mounting Dimensions

Bore	BD	E	EE		G	J	K	+.000 -.001 TD	TL	TM	UM	UW	Add Stroke		Model 87 Minimum Stroke
			NPTF ¹	SAE ²									LB	P ¹	
4.00	2.25	5.00	3/4	12	2.00	1.75	0.56	2.00	1.75	5.50	9.00	6.00	6.63	3.75	0.125
5.00	2.75	6.50	3/4	12	2.00	1.75	0.81	2.50	1.75	7.00	10.50	7.50	7.13	4.25	0.000
6.00	3.25	7.50	1	16	2.25	2.25	0.88	3.00	2.00	8.50	12.50	9.50	8.38	4.88	0.250

¹ SAE straight thread ports are standard and are indicated by port number. On 1.50", 2.00" and 2.50" bore sizes, when #10 SAE port is specified, reduce dimension "P" by 0.06" and increase dimension "Y" by 0.06".

² NPTF ports are available at no extra charge.

Table 2—Rod Dimensions

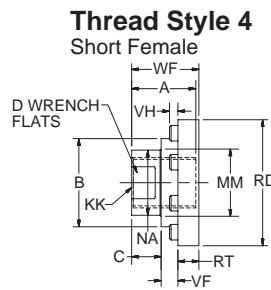
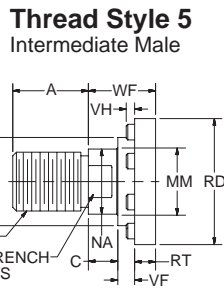
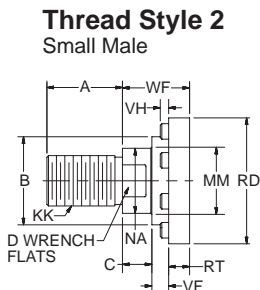
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions										Add Stroke			
		Style 5 IM	Style 2 & 4 KK	A	+.000 -.002 B	C	D	NA	RD (Max.)	RT	VF	VH	WF	Min. XI ³	Y ¹	Max. XI ⁴	ZB (Max.)
4.00	1.750	1 1/2-12	1 1/4-12	2.00	2.374	0.75	1.50	1.69	3.47	0.63	0.50	0.19	1.88	5.06	3.00	4.69	8.50
	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.50	0.25	2.00	5.19	3.13	4.81	8.63
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.63	0.25	2.25	5.44	3.38	5.06	8.88
5.00	2.000	1 3/4-12	1 1/2-12	2.25	2.624	0.88	1.69	1.94	3.72	0.63	0.50	0.25	2.00	5.44	3.13	5.06	9.38
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.63	0.25	2.25	5.69	3.38	5.06	9.63
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	-	2.25	5.69	3.38	5.31	9.63
6.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	-	2.25	5.69	3.38	5.31	9.63
	2.500	2 1/4-12	1 7/8-12	3.00	3.124	1.00	2.06	2.38	4.25	0.63	0.63	0.25	2.25	6.19	3.50	5.69	10.81
	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	-	2.25	6.19	3.50	5.69	10.81
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	-	2.25	6.19	3.50	5.69	10.81
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	-	2.25	6.19	3.50	5.69	10.81

³ Dimension XI to be specified by customer. ⁴ Dimensions shown are valid for standard WF dimension.

Table 3 —
Envelope and
Mounting Dimensions

Rod End Dimensions (for Bolted Bushings) – See Table 2

See B&R Table to determine which bore, rod and mount combinations have this feature.



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

"Special" Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

A high strength rod end stud is supplied on thread style 2 through 2.000" diameter rods. Larger sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered,

style 2 rod ends are recommended through 2.000" piston rod diameters and style 5 rod ends are recommended on larger diameters. Use style 4 for applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied.

Spherical Bearing Mount – 1.50" to 6.00" Bore HV2 Series

**Cap Fixed Eye Mount
with Spherical Bearing
Model 94**

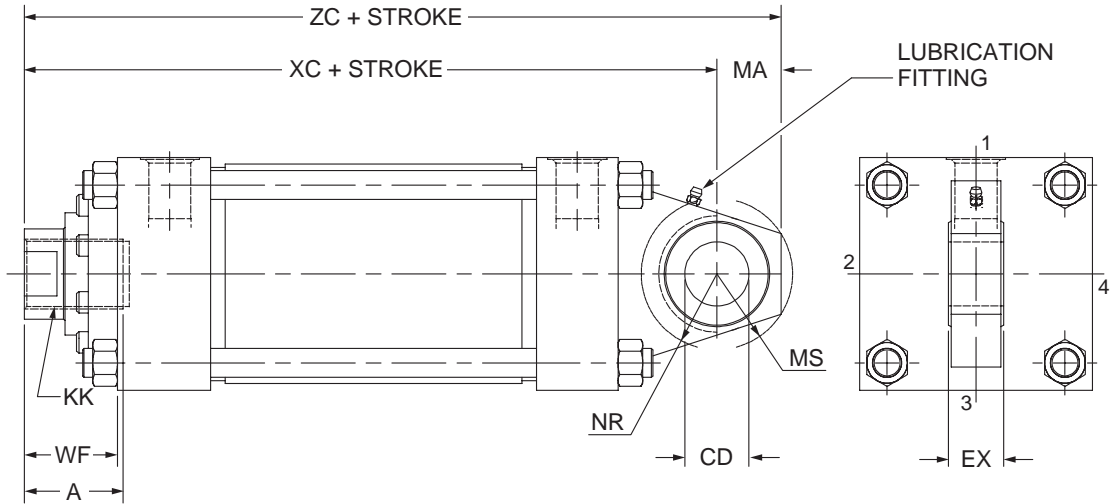


Table 1 — Dimensions

Bore	Rod Dia. MM	Thread ³ Style 4 KK	A	WF	Add Stroke		CD ²	EX	MA	MS	NR	Max. Oper. PSI ¹
					XC	ZC						
1.50	0.625	7/16-20	0.75	1.00	6.38	7.13	.5000 ^{-0.0005}	0.44	0.75	0.94	0.63	1500
	1.000	3/4-16	1.13	1.38	6.75	7.50						
2.00	1.000	3/4-16	1.13	1.38	7.25	8.25	.7500 ^{-0.0005}	0.66	1.00	1.38	1.00	2200
	1.375	1-14	1.63	1.63	7.50	8.50						
2.50	1.000	3/4-16	1.13	1.38	7.38	8.38	.7500 ^{-0.0005}	0.66	1.00	1.38	1.00	1450
	1.750	1 1/4-12	2.00	1.88	7.88	8.88						
	1.375	1-14	1.63	1.63	7.63	8.63						
3.25	1.375	1-14	1.63	1.63	8.63	9.88	1.0000 ^{-0.0005}	0.88	1.25	1.69	1.25	1500
	2.000	1 1/2-12	2.25	2.00	9.00	10.25						
	1.750	1 1/4-12	2.00	1.88	8.88	10.13						
4.00	1.750	1 1/4-12	2.00	1.88	9.75	11.63	1.3750 ^{-0.0005}	1.19	1.88	2.44	1.63	1850
	2.500	1 7/8-12	3.00	2.25	10.13	12.00						
	2.000	1 1/2-12	2.25	2.00	9.88	11.75						
5.00	2.000	1 1/2-12	2.25	2.00	10.50	13.00	1.7500 ^{-0.0005}	1.53	2.50	2.88	2.06	2000
	3.500	2 1/2-12	3.50	2.25	10.75	13.25						
	2.500	1 7/8-12	3.00	2.25	10.75	13.25						
	3.000	2 1/4-12	3.50	2.25	10.75	13.25						
6.00	2.500	1 7/8-12	3.00	2.25	12.13	14.63	2.0000 ^{-0.0005}	1.75	2.50	3.31	2.38	1800
	4.000	3-12	4.00	2.25	12.13	14.63						
	3.000	2 1/4-12	3.50	2.25	12.13	14.63						
	3.500	2 1/2-12	3.50	2.25	12.13	14.63						

¹ Maximum operating pressure at 4:1 design factor is based on tensile strength of material. Pressure ratings are based on standard commercial bearing ratings.

² Dimension "CD" is hole diameter.

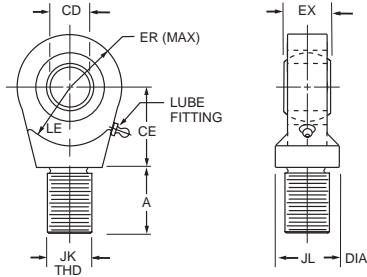
³ To match pin diameter in rod eye and cap, when an oversize rod is required, specify rod end style 'X', 'KK' thread and 'A' thread length for the standard rod diameter (first rod listed for the bore), and 'W' for the oversize rod. Order the rod eye and clevis bracket for the required bore size from the tables on the spherical bearings accessory page.

Spherical Bearing Cylinder Accessories

Miller offers a complete range of Cylinder Accessories to assure you of the greatest versatility in present or future cylinder applications. Accessories offered for the respective

cylinder include the Rod Eye, Pivot Pin and Clevis Bracket. To select the proper part number for any desired accessory refer to the charts below.

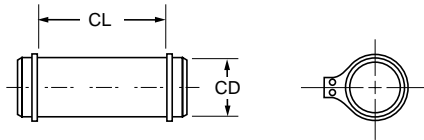
Spherical Rod Eye



Order to fit Piston Rod Thread Size.

Bore Sizes	1.50	2.00 & 2.50	3.25	4.00	5.00	6.00
Part No.	1322900000	1322910000	1322920000	1322930000	1322940000	1322950000
CD	.5000 ⁻⁰⁰⁰⁵	.7500 ⁻⁰⁰⁰⁵	1.0000 ⁻⁰⁰⁰⁵	1.3750 ⁻⁰⁰⁰⁵	1.7500 ⁻⁰⁰⁰⁵	2.0000 ⁻⁰⁰⁰⁵
A	0.69	1.00	1.50	2.00	2.13	2.88
CE	0.88	1.25	1.88	2.13	2.50	2.75
EX	0.44	0.66	7/8	1.19	1.53	1.75
ER	0.88	1.25	1.38	1.81	2.19	2.63
LE	0.75	1.06	1.44	1.88	2.13	2.50
JK	7/16-20	3/4-16	1-14	1 1/4-12	1 1/2-12	1 7/8-12
JL	0.88	1.31	1.50	2.00	2.25	2.75
LOAD CAPACITY LBS.	2644	9441	16860	28562	43005	70193

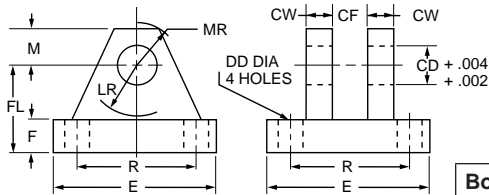
Pivot Pin



Pivot Pins are furnished with (2) Retainer Rings.

Bore Sizes	1.50	2.00 & 2.50	3.25	4.00	5.00	6.00
Part No.	0839620000	0839630000	0839640000	0839650000	0839660000	0839670000
CD	.4997 ⁻⁰⁰⁰⁴	.7497 ⁻⁰⁰⁰⁵	.9997 ⁻⁰⁰⁰⁵	1.3746 ⁻⁰⁰⁰⁶	1.7496 ⁻⁰⁰⁰⁶	1.9996 ⁻⁰⁰⁰⁷
CL	1.56	2.03	2.50	3.31	4.22	4.94
SHEAR CAPACITY LBS.	8600	19300	34300	65000	105200	137400

Clevis Bracket



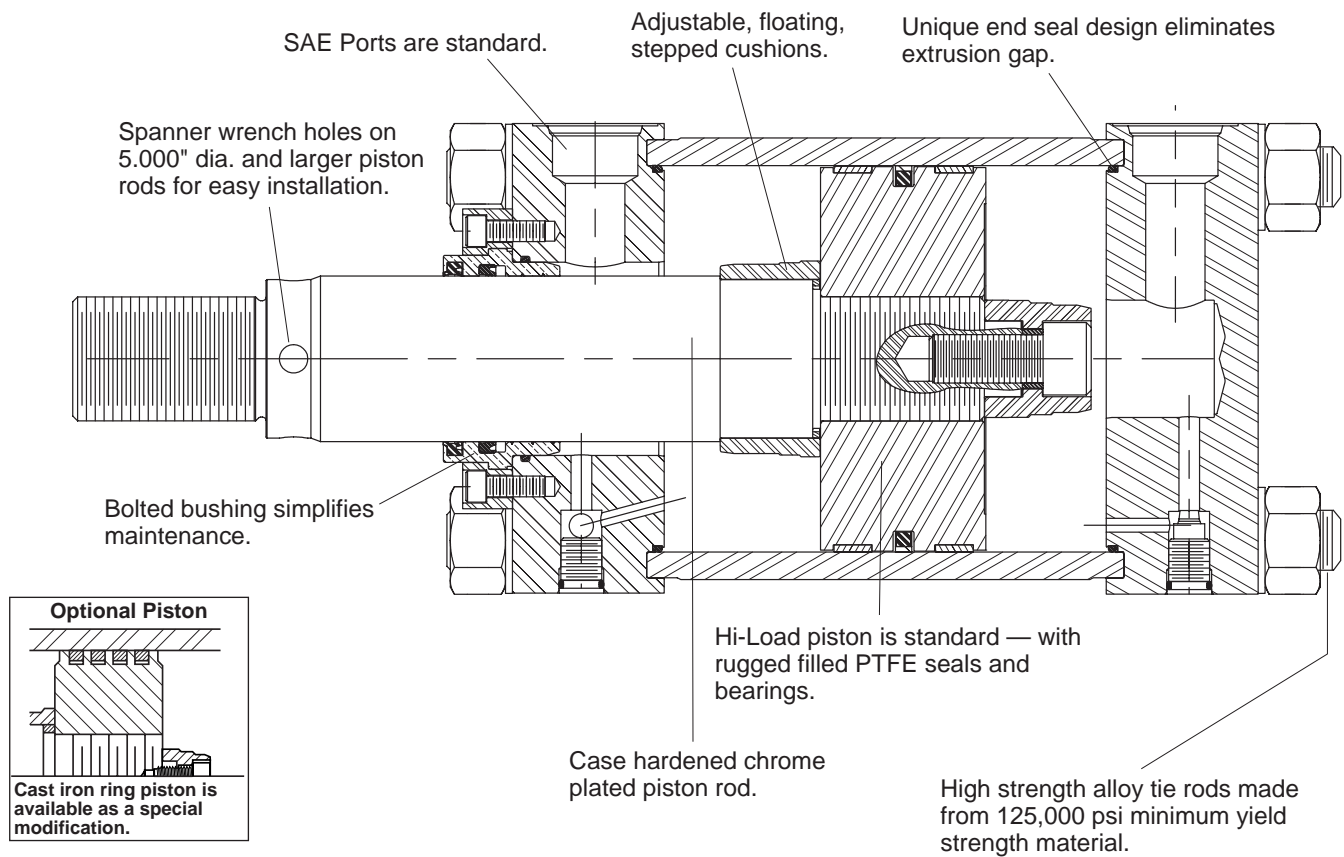
Order to fit Cap or Rod Eye.

Bore Sizes	1.50	2.00 & 2.50	3.25	4.00	5.00	6.00
Part No.	0839470000	0839480000	0839490000	0839500000	0839510000	0839520000
CD	0.500	0.750	1.000	1.375	1.750	2.000
CF	0.44	0.66	0.88	1.19	1.53	1.75
CW	0.50	0.63	0.75	1.00	1.25	1.50
DD	0.41	0.53	0.53	0.66	0.91	0.91
E	3.00	3.75	5.50	6.50	8.50	10.63
F	0.50	0.63	0.75	0.88	1.25	1.50
FL	1.50	2.00	2.50	3.50	4.50	5.00
LR	0.94	1.38	1.69	2.44	2.88	3.31
M	0.50	0.88	1.00	1.38	1.75	2.00
MR	0.63	1.00	1.19	1.63	2.06	2.38
R	2.05	2.76	4.10	4.95	6.58	7.92
LOAD CAPACITY LBS.	5770	9450	14300	20322	37800	50375

Features / Specifications

Series HV2
7.00" and 8.00" Bore
Heavy Duty High Pressure Hydraulic Cylinders

- Bolted bushing for ease of maintenance.
 - Hi-Load piston is standard.
 - Cylinder tube seal groove design and high-strength tie rods ensure trouble-free performance even in severe applications.
 - Floating cushions with float-check action and positive metal-to-metal seal.
- Every cylinder is *individually* tested before it leaves our plant.



Standard Specifications

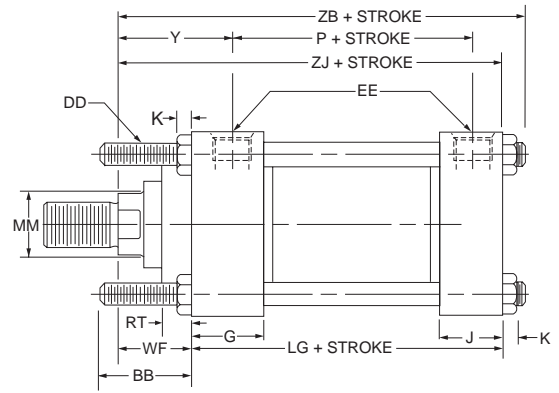
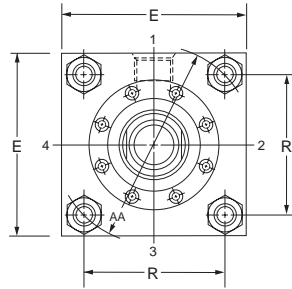
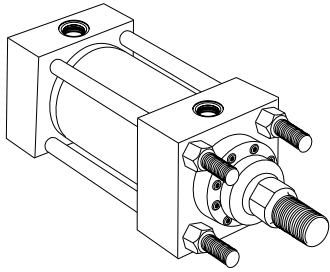
- Heavy Duty Service — ANSI/NFPA T.3.6.7R2-1996 specifications and mounting dimension standards
- Standard Construction — Square Head — Tie Rod Design
- Nominal Pressure — 3000 PSI¹
- Standard Fluid — Hydraulic Oil
- Standard Temperature — -10° F. to +165° F.
- Piston Rod Diameter — 3.000" through 5.500"
- Mounting Styles — 16 standard styles at various application ratings
- Strokes — Available in any practical stroke length
- Cushions — Optional at either end or both ends of stroke
- Rod Ends — Three Standard Choices — specials to order

¹ If hydraulic operating pressure exceeds 3000 PSI, send application data for engineering evaluation and recommendation.

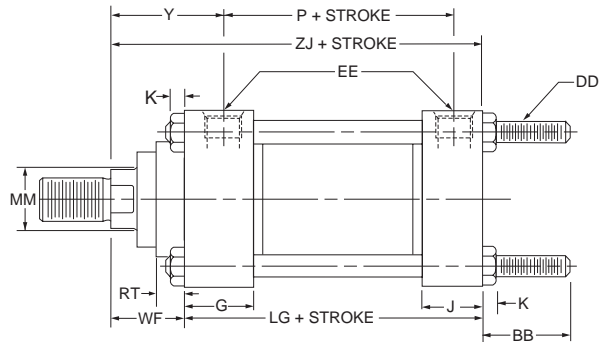
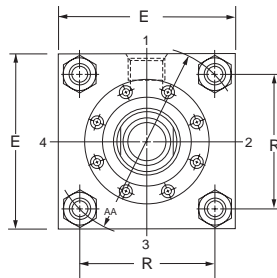
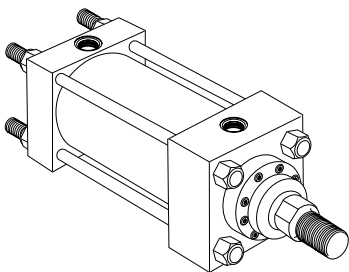
In line with our policy of continuing product improvement, specifications in this catalog are subject to change.

Mountings – 7.00" and 8.00" Bore Sizes

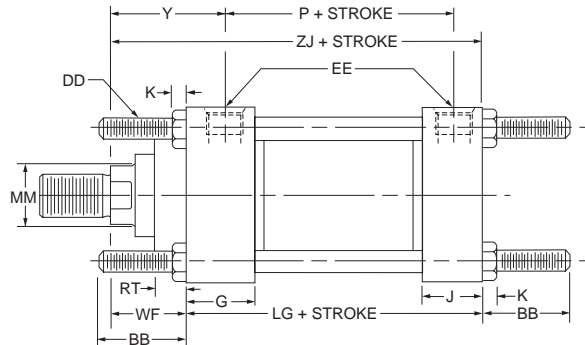
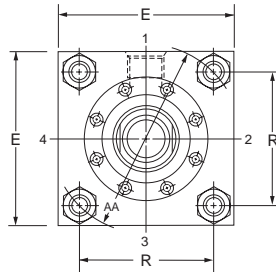
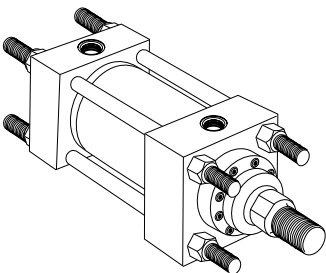
Tie Rods Extended Head End Mount
Model 53



Tie Rods Extended Cap End Mount
Model 52

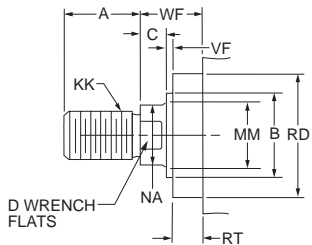


Tie Rods Extended Both Ends Mount
Model 51

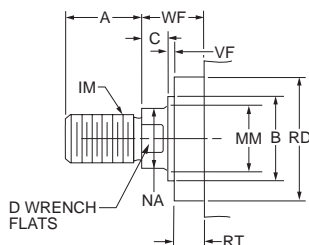


Rod End Dimensions — see Table 2

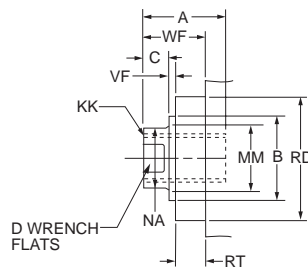
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



“Special” Thread
Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Mountings – 7.00" and 8.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	AA	BB	DD	E	EE		G	J	K	R	Add Stroke	
					NPTF ²	SAE ¹					LG	P
7.00	9.31	4.13	1 1/8-12	8.50	1 1/4	20	2.75	2.75	1.25	6.58	8.50	5.50
8.00	10.61	4.50	1 1/4-12	9.50	1 1/2	24	3.00	3.00	1.50	7.50	9.50	6.25

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Add Stroke		
		Style 5 IM	Style 2 & 4 KK	A	+0.002 -0.002 B	C	D	NA	RD (Max.)	RT	VF	WF	Y	ZB (Max.)	ZJ
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	3.75	12.31	10.75
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.75	12.31	10.75
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.75	12.31	10.75
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.75	12.31	10.75
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.88	13.56	11.75
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	–	5.38	7.94	0.94	0.31	2.25	3.88	13.56	11.75
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.88	13.56	11.75
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.88	13.56	11.75

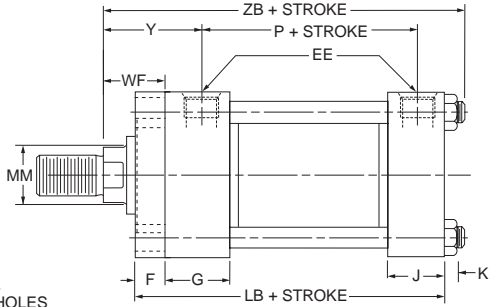
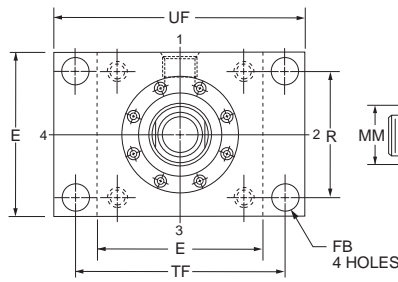
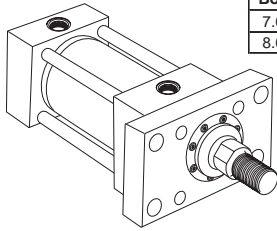
Table 3 — Envelope and Mounting Dimensions

Mountings – 7.00" and 8.00" Bore Sizes

Head Rectangular
Flange Mount
Model 61

Maximum Pressure Rating - PSI
Push Application

Bore	Rod Dia			
	3.000	3.500	4.000	5.000
7.00	1000	800	400	400
8.00	-	800	700	400

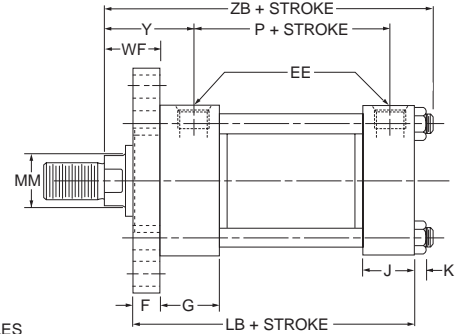
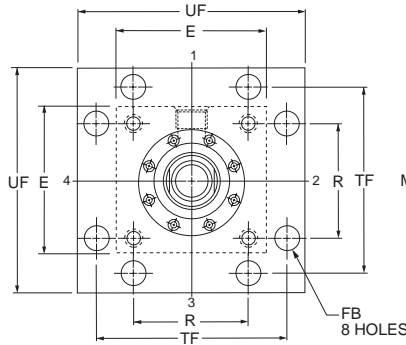
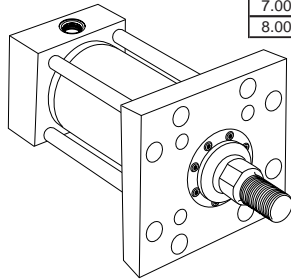


For pressures exceeding those shown use Model 65 or Model 67.

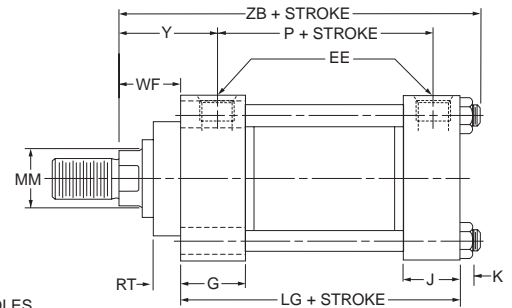
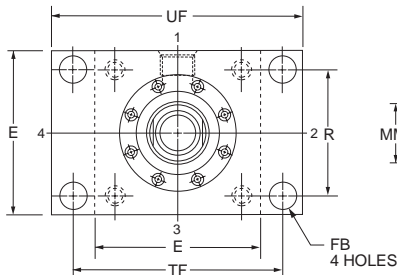
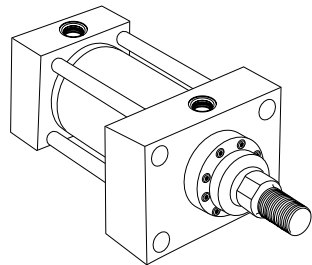
Head Square Flange Mount
Model 65

Maximum Pressure Rating - PSI
Push Application

Bore	Rod Dia			
	3.000	3.500	4.000	5.000
7.00	2500	2200	1500	1500
8.00	-	2000	2000	1400

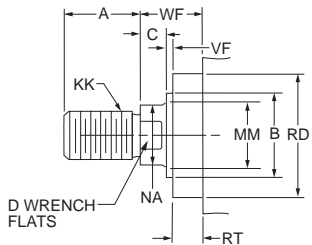


Head Rectangular Mount
Model 67

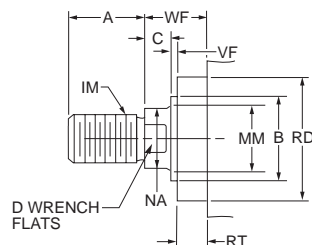


Rod End Dimensions — see Table 2

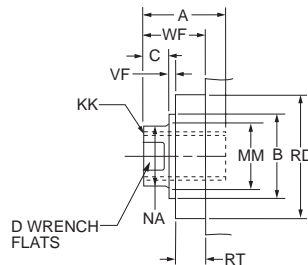
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Mountings – 7.00" and 8.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EE		F	(Bolt) FB ³	G	J	K	R	TF	UF	Add Stroke		
		NPTF ²	SAE ¹									LB	LG	P
7.00	8.50	1 1/4	20	1.00	1.13	2.75	2.75	1.25	6.58	10.63	12.63	9.50	8.50	5.50
8.00	9.50	1 1/2	24	1.00	1.25	3.00	3.00	1.50	7.50	11.81	14.00	10.50	9.50	6.25

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

³ Mounting holes are 0.06" larger than bolt size listed.

Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Add Stroke	
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	VF	WF	Y	ZB (Max.)
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	3.75	12.31
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.75	12.31
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.75	12.31
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.75	12.31
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.88	13.56
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	–	5.38	7.94	0.94	0.31	2.25	3.88	13.56
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.88	13.56
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.88	13.56

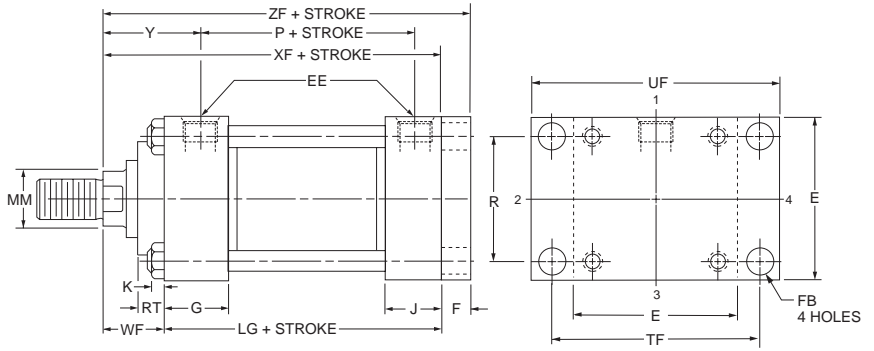
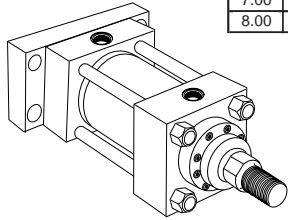
**Table 3 —
Envelope and
Mounting Dimensions**

Mountings – 7.00" and 8.00" Bore Sizes

Cap Rectangular
Flange Mount
Model 62

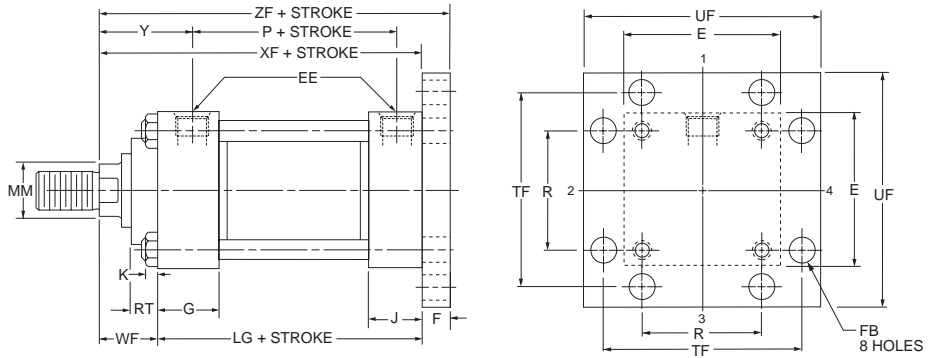
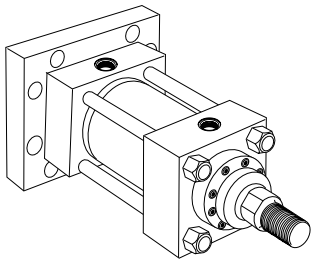
Maximum Pressure Rating - PSI
Push Application

Bore	Rod Dia				
	3.000	3.500	4.000	5.000	5.500
7.00	2000	2000	2500	3000	-
8.00	-	1700	1700	2200	2500

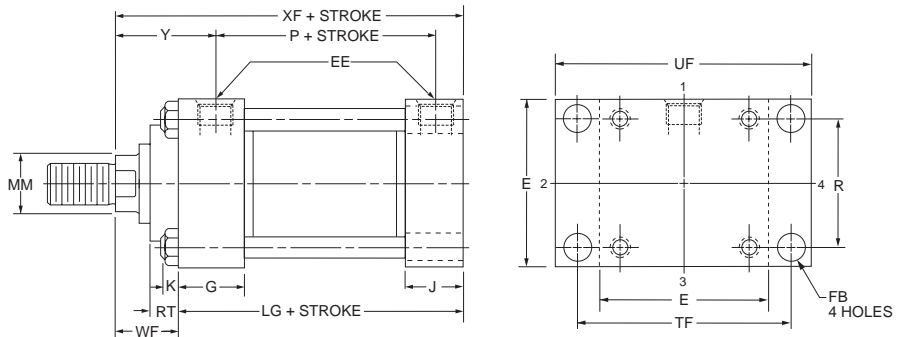
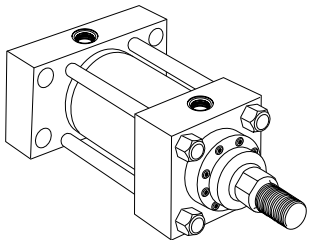


For pressures exceeding those shown use Model 66 or Model 68.

Cap Square Flange Mount
Model 66

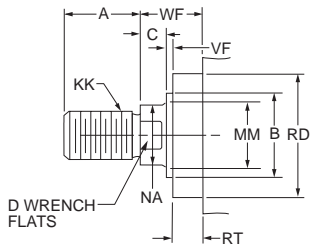


Cap Rectangular Mount
Model 68

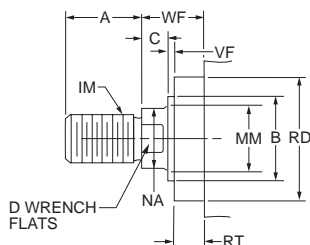


Rod End Dimensions — see Table 2

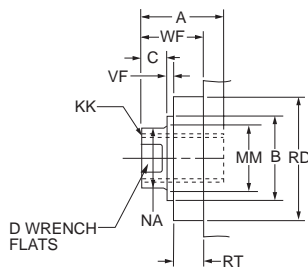
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Mountings – 7.00" and 8.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EE		F	(Bolt) FB ³	G	J	K	R	TF	UF	Add Stroke	
		NPTF ²	SAE ¹									LG	P
7.00	8.50	1 1/4	20	1.00	1.13	2.75	2.75	1.25	6.58	10.63	12.63	8.50	5.50
8.00	9.50	1 1/2	24	1.00	1.25	3.00	3.00	1.50	7.50	11.81	14.00	9.50	6.25

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

³ Mounting holes are 0.06" larger than bolt size listed.

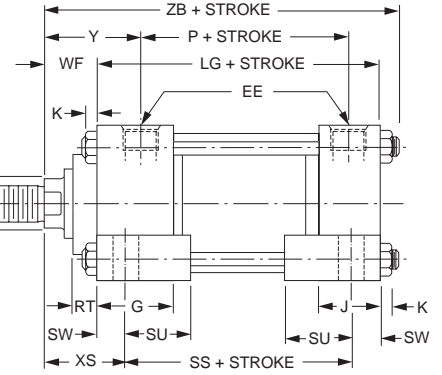
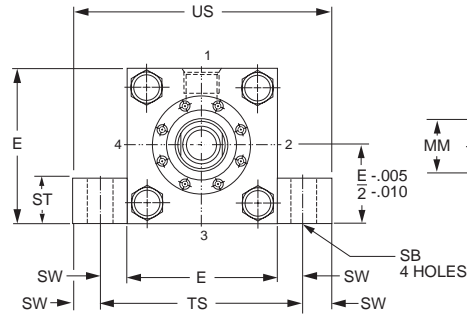
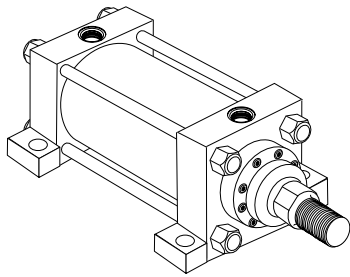
Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Add Stroke		
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -.002 B	C	D	NA	RD (Max.)	RT	VF	WF	Y	XF	ZF
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	3.75	10.75	11.75
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.75	10.75	11.75
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.75	10.75	11.75
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.75	10.75	11.75
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.88	11.75	12.75
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	–	5.38	7.94	0.94	0.31	2.25	3.88	11.75	12.75
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.88	11.75	12.75
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.88	11.75	12.75

**Table 3 —
Envelope and
Mounting Dimensions**

Mountings – 7.00" and 8.00" Bore Sizes

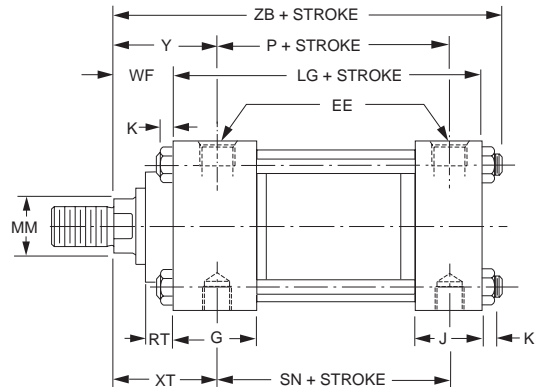
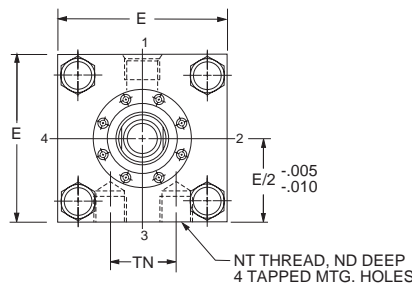
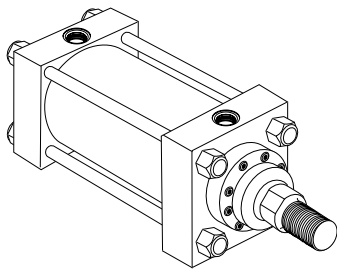
Side Lug Mount
Model 72



Model 72 cylinders have mounting lugs welded to the head and cap, and are considered to be a fixed mount that does not absorb force on its centerline. The plane of the mounting surface is not through the centerline of the cylinder, and for this reason Model 72 cylinders produce a turning moment as the cylinder applies force to the load. 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 bushing and piston bearings. **To avoid this problem, Model 72 cylinders should be specified with a stroke length at least equal to the bore size.**

Side Tap Mount
Model 74

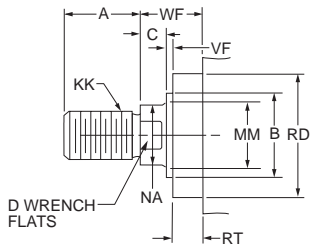


Model 74 cylinders have side tapped holes for flush mounting, and are considered to be a fixed mount that does not absorb force on its centerline. The plane of the mounting surface is not through the centerline of the cylinder, and for this reason Model 74 cylinders produce a turning moment as the cylinder applies force to the load. This turning moment tends to rotate the

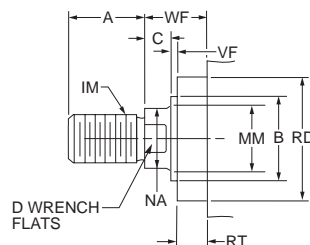
cylinder about its mounting bolts. If the cylinder is not well secured to the machine member on which it is mounted or the load is not well-guided, this turning moment results in side load applied to rod bushing and piston bearings. **To avoid this problem, Model 74 cylinders should be specified with a stroke length at least equal to the bore size.**

Rod End Dimensions — see Table 2

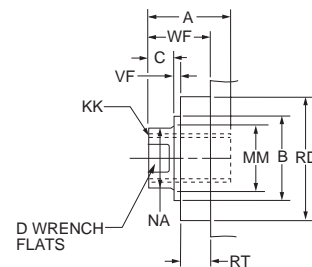
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



“Special” Thread
Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Mountings – 7.00" and 8.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EE		G	J	K	NT	(Bolt) SB ³	ST	SU	SW	TN	TS	US	Add Stroke			
		NPTF ²	SAE ¹												LG	P	SN	SS
7.00	8.50	1 1/4	20	2.75	2.75	1.25	1 1/2-6	1.50	1.75	2.88	1.38	3.75	11.25	14.00	8.50	5.50	5.88	5.75
8.00	9.50	1 1/2	24	3.00	3.00	1.50	1 1/2-6	1.50	1.75	2.88	1.38	4.25	12.25	15.00	9.50	6.25	6.63	6.75

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

³ Mounting holes are 0.06" larger than bolt size listed.

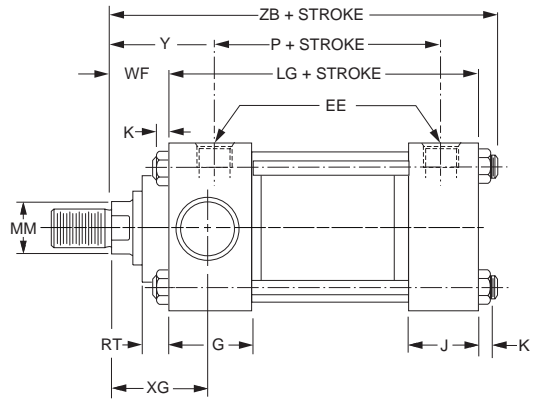
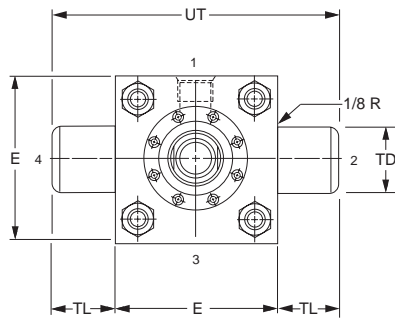
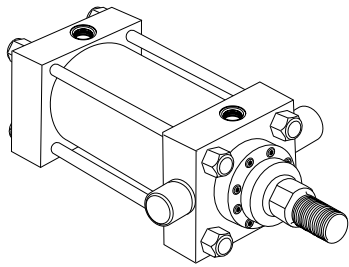
Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Add Stroke				
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -.002 B	C	D	NA	RD (Max.)	RT	VF	WF	ND	XS	XT	Y	ZB (Max.)
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	1.13	3.63	3.81	3.75	12.31
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	1.13	3.63	3.81	3.75	12.31
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	1.13	3.63	3.81	3.75	12.31
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	1.13	3.63	3.81	3.75	12.31
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	1.50	3.63	3.94	3.88	13.56
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	–	5.38	7.94	0.94	0.31	2.25	1.31	3.63	3.94	3.88	13.56
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	1.50	3.63	3.94	3.88	13.56
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	1.50	3.63	3.94	3.88	13.56

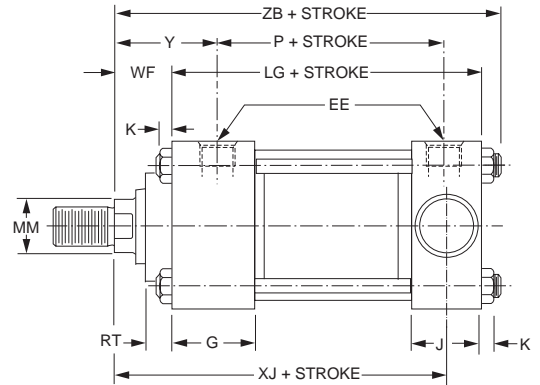
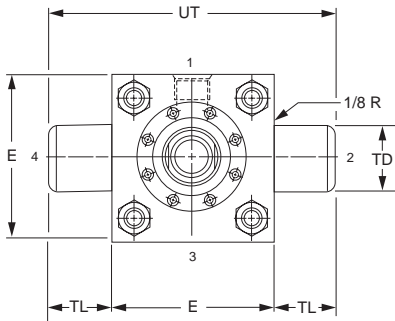
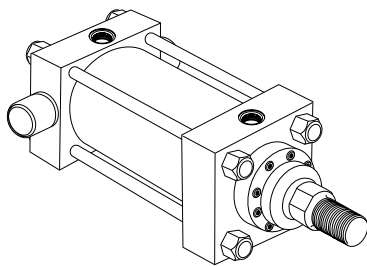
**Table 3 —
Envelope and
Mounting Dimensions**

Mountings – 7.00" and 8.00" Bore Sizes

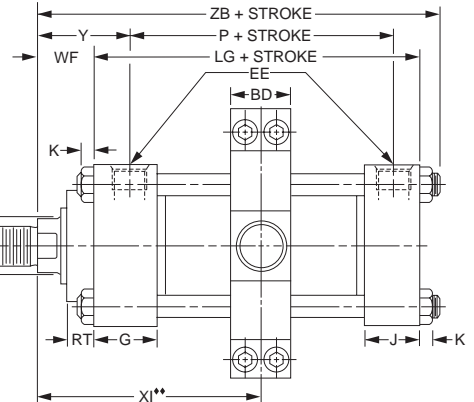
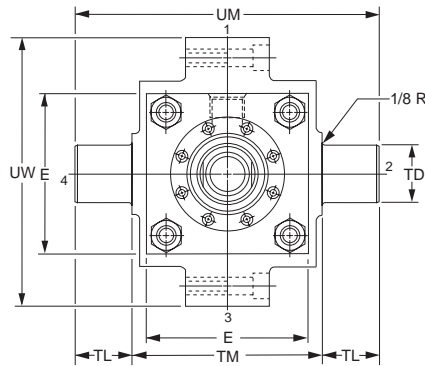
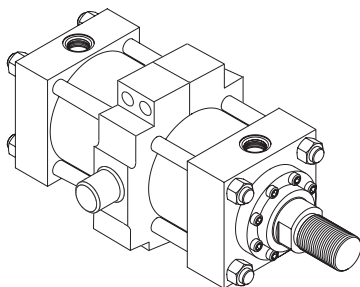
Head Trunnion Mount
Model 81



Cap Trunnion Mount
Model 82



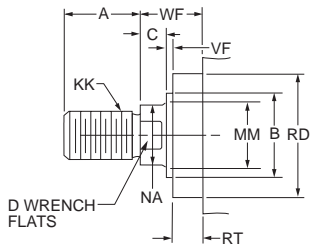
Intermediate Trunnion Mount
Model 89



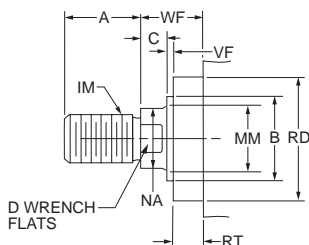
◆◆ Dimension XI to be specified by customer.

Rod End Dimensions — see Table 2

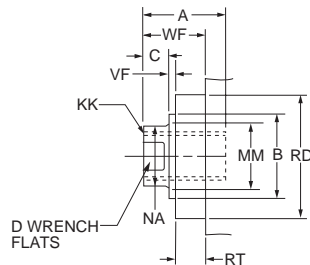
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



“Special” Thread
Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Mountings – 7.00" and 8.00" Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	BD	E	EE		G	J	K	+.000 -.002 TD	TL	TM	UM	UT	UW	Add Stroke	
			NPTF ²	SAE ¹										LG	P
7.00	3.00	8.50	1 1/4	20	2.75	2.75	1.25	2.500	2.50	9.75	14.75	13.50	11.50	8.50	5.50
8.00	3.50	9.50	1 1/2	24	3.00	3.00	1.50	3.000	3.00	11.00	17.00	15.50	13.38	9.50	6.25

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Add Stroke					
		Style 5 IM	Style 2 & 4 KK	A	+.000 -.002 B	C	D	NA	RD (Max.)	RT	VF	WF	XG	Min. XI ³	Y	XJ	ZB (Max.)	Max. XI ⁴
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	3.63	6.56	3.75	9.38	12.31	6.44
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.63	6.56	3.75	9.38	12.31	6.44
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.63	6.56	3.75	9.38	12.31	6.44
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.63	6.56	3.75	9.38	12.31	6.44
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.75	7.06	3.88	10.25	13.56	6.94
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	–	5.38	7.94	0.94	0.31	2.25	3.75	7.06	3.88	10.25	13.56	6.94
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.75	7.06	3.88	10.25	13.56	6.94
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	–	4.88	7.44	0.94	0.31	2.25	3.75	7.06	3.88	10.25	13.56	6.94

³ Dimension XI to be specified by customer.

⁴ Dimensions shown are valid for standard WF dimension.

**Table 3 —
Envelope and
Mounting Dimensions**

Mountings – 7.00" and 8.00" Bore Sizes

Cap Fixed Clevis Mount
Model 84

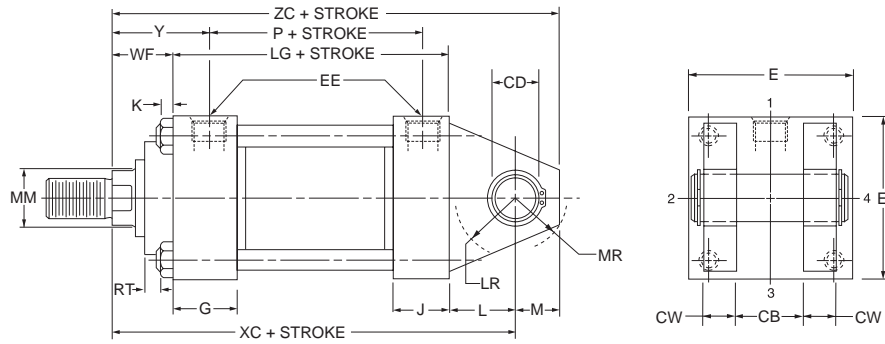
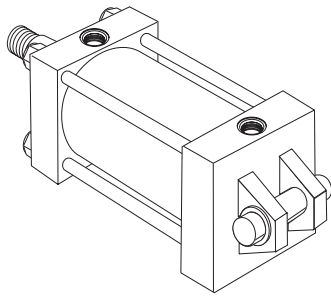


Table 1—Envelope and Mounting Dimensions

Bore	CB	+.000 -.002 CD ³	CW	E	EE		G	J	K	L	LR	M	MR	R	Add Stroke	
					NPTF ²	SAE ¹									LG	P
7.00	3.00	2.501	1.50	8.50	1 1/4	20	2.75	2.75	1.25	3.00	2.75	2.50	2.88	6.58	8.50	5.50
8.00	3.00	3.001	1.50	9.50	1 1/2	24	3.00	3.00	1.50	3.25	3.25	2.75	3.13	7.50	9.50	6.25

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

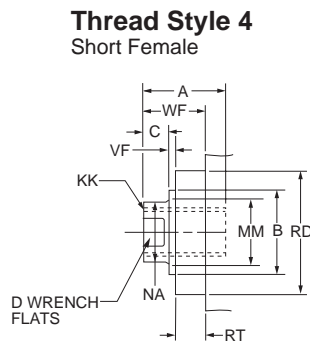
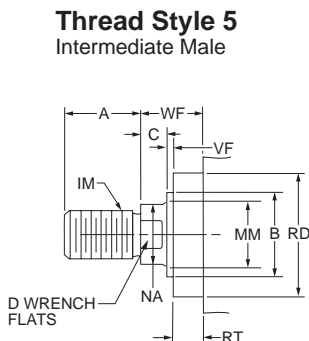
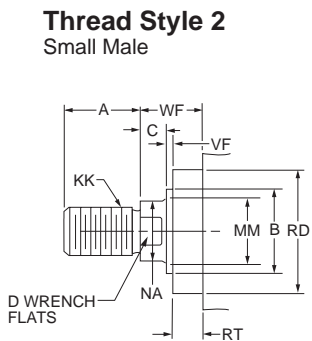
³ Dimension CD is pin diameter.

Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Add Stroke		
		Style 5 IM	Style 2 & 4 KK	A	+.000 -.002 B	C	D	NA	RD (Max.)	RT	VF	WF	Y	XC	ZC
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	3.75	13.75	16.25
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	—	4.88	7.44	0.94	0.31	2.25	3.75	13.75	16.25
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.75	13.75	16.25
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.75	13.75	16.25
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	3.88	15.00	17.75
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	—	5.38	7.94	0.94	0.31	2.25	3.88	15.00	17.75
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	3.88	15.00	17.75
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	—	4.88	7.44	0.94	0.31	2.25	3.88	15.00	17.75

Table 3 — Envelope and Mounting Dimensions

Rod End Dimensions — see Table 2



Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

“Special” Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Mountings – 7.00" and 8.00" Bore Sizes

Intermediate Trunnion Mount
Model 87

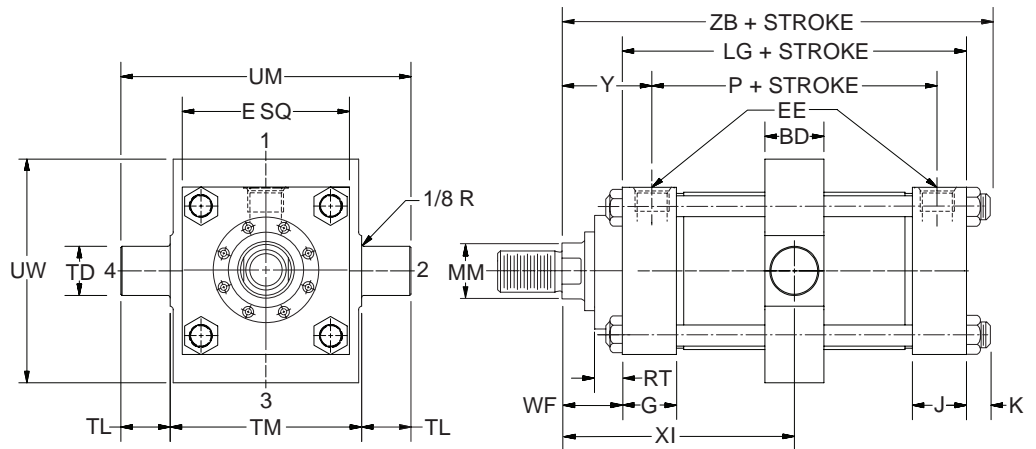
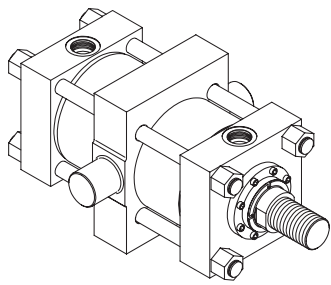


Table 1—Envelope and Mounting Dimensions

Bore	BD	E	EE		G	J	K	+0.000 -0.001 TD	TL	TM	UM	UW	Add Stroke		Model 87 Minimum Stroke
			NPTF ²	SAE ¹									LG	P	
7.00	4.000	8.50	1 1/4	20	2.75	2.75	1.25	3.500	2.50	9.75	14.75	11.38	8.50	5.50	1.13
8.00	4.500	9.50	1 1/2	24	3.00	3.00	1.50	4.000	3.00	11.00	17.00	12.00	9.50	6.25	1.13

¹ SAE straight thread ports are standard and are indicated by port number.

² NPTF ports are available at no extra charge.

Table 2—Rod Dimensions

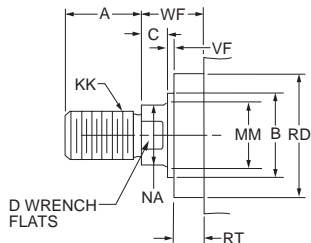
Bore	Rod Dia. MM	Thread		Rod Extensions and Bushing Dimensions									Min. XI ³	Y	Add Stroke	
		Style 5 IM	Style 2 & 4 KK	A	+0.000 -0.002 B	C	D	NA	RD (Max.)	RT	VF	WF			Max. XI ⁴	ZB (Max.)
7.00	3.000	2 3/4-12	2 1/4-12	3.50	3.749	1.00	2.63	2.88	5.44	0.88	0.31	2.25	7.06	3.75	5.94	12.31
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	—	4.88	7.44	0.94	0.31	2.25	7.06	3.75	5.94	12.31
	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	7.06	3.75	5.94	12.31
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	7.06	3.75	5.94	12.31
8.00	3.500	3 1/4-12	2 1/2-12	3.50	4.249	1.00	3.00	3.38	5.94	0.94	0.31	2.25	7.56	3.88	6.44	13.56
	5.500	5 1/4-12	4-12	5.50	6.249	1.00	—	5.38	7.94	0.94	0.31	2.25	7.56	3.88	6.44	13.56
	4.000	3 3/4-12	3-12	4.00	4.749	1.00	3.38	3.88	6.31	0.94	0.31	2.25	7.56	3.88	6.44	13.56
	5.000	4 3/4-12	3 1/2-12	5.00	5.749	1.00	—	4.88	7.44	0.94	0.31	2.25	7.56	3.88	6.44	13.56

³ Dimension XI to be specified by customer. ⁴ Dimensions shown are valid for standard WF dimension.

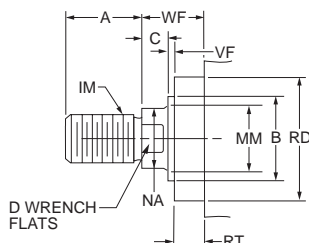
Table 3 —
Envelope and
Mounting Dimensions

Rod End Dimensions — see Table 2

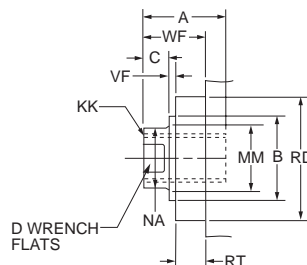
Thread Style 2
Small Male



Thread Style 5
Intermediate Male



Thread Style 4
Short Female



“Special” Thread
Style X

Special thread, extension, rod eye, blank, etc., are also available.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

To order, specify “Style X” and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensioned sketch.

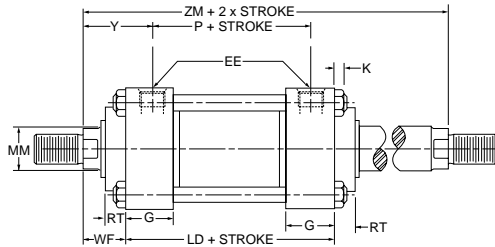
Over 2.000" rod sizes or special rod ends are cut threads. Style 2 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 5 rod ends are recommended over 2.000" piston rod diameters. Use style 4 for

applications where female rod end threads are required. If rod end is not specified, style 2 will be supplied. On 5.000" rods and above, (4) .515 dia. spanner wrench holes will be provided instead of wrench flats.

Double Rod Models / Retainer Dimensions

How to Use Double Rod Cylinder Dimension Drawings

To determine dimensions for a double rod cylinder, first refer to the desired single rod mounting style cylinder shown on preceding pages of this catalog. After selecting necessary dimensions from that drawing return to this page, supplement the single rod dimensions with those shown on drawing and dimension table. Note that double rod cylinders have a head (Dim. G) at both ends and that dimension LD replaces LG. The double rod dimensions differ from, or are in addition to, those for single rod cylinders shown on preceding pages and provide the information needed to completely dimension a double rod cylinder.



On a double rod cylinder where the two rod ends are different, be sure to clearly state which rod end is to be assembled at which end. Port position 1 is standard. If other than standard, specify pos. 2, 3 or 4 when viewed from one end only.

Bore	Rod Dia. MM	Add Stroke			Add 2X Stroke
		LD	Model D74 SN	Model D72 SS	ZM
1.50	0.625	4.88	2.88	4.13	6.88
2.00	1.000	4.88	2.88	3.88	7.63
2.50	1.000	5.00	3.00	3.63	7.75
3.25	1.375	5.75	3.50	4.38	9.00
4.00	1.750	6.00	3.75	4.25	9.75
5.00	2.000	6.50	4.25	4.75	10.50
6.00	2.500	7.38	4.88	5.13	11.88
7.00	3.000	8.50	5.38	5.75	13.00
8.00	3.500	9.50	6.13	6.75	14.00

All dimensions are in inches and apply to smallest rod sizes only. For alternate rod sizes, determine all envelope dimensions (within LD dim.) as described above and then use appropriate rod end dimensions for proper rod size from single rod cylinder.

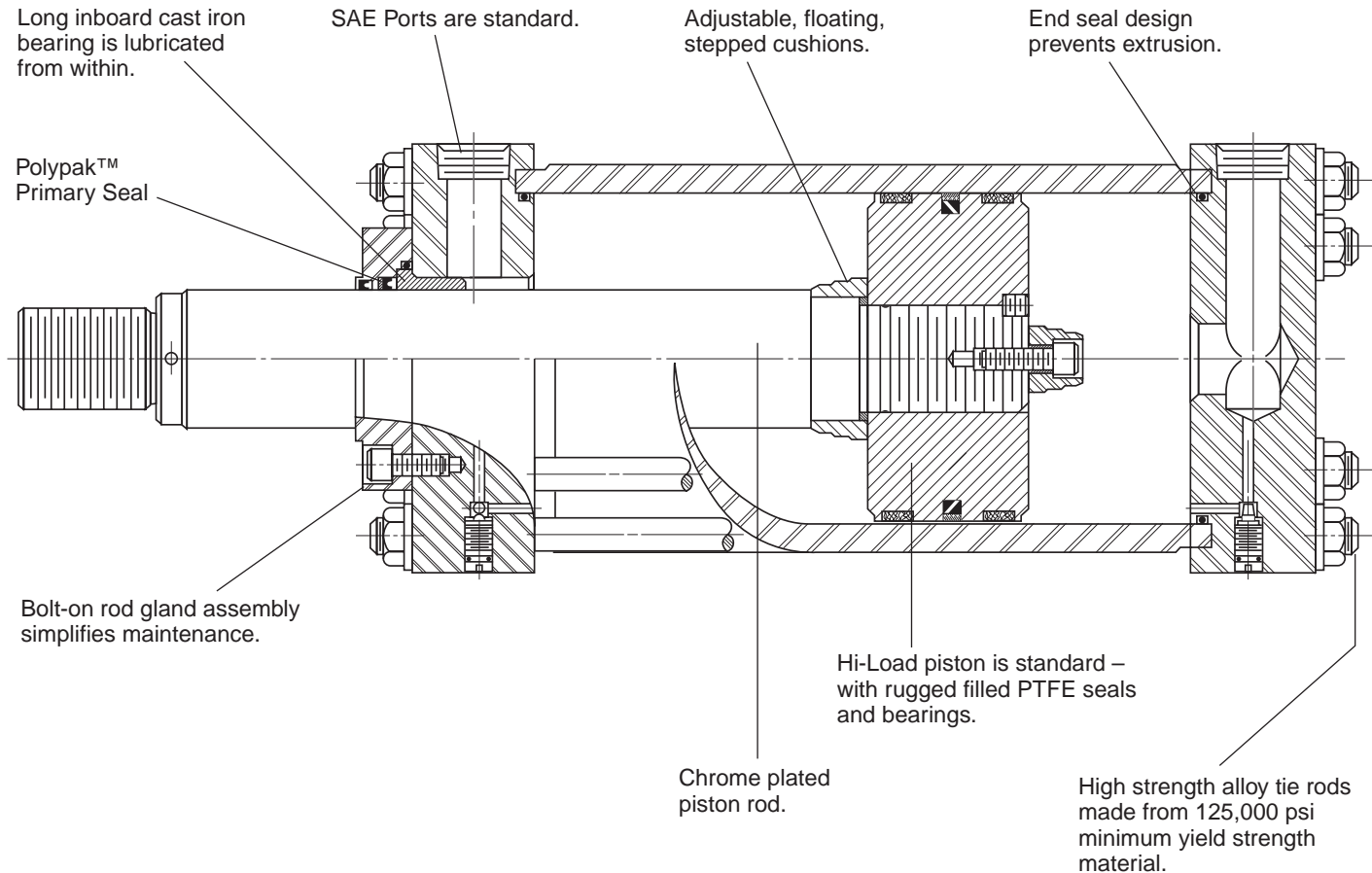
B & R Table

Bore	Rod Dia.	52, 62, 66, 68, 72, 74, 81, 82, 84, 89, 94	51, 53	61, 65	67
1.50	0.625	B	R	R	B
	1.000	R	R	R	B
2.00	1.000	B	R	R	B
	1.375	R	R	R	B
2.50	1.000	B	B	B	B
	1.375	B	B	B	B
	1.750	B	B	R	B
3.25	1.375	B	B	B	B
	1.750	B	B	B	B
	2.000	B	B	B	B
4.00	1.750	B	B	B	B
	2.000	B	B	B	B
	2.500	B	B	B	B
5.00	2.000	B	B	B	B
	2.500	B	B	B	B
	3.000	B	B	B	B
	3.500	B	B	R	B
6.00	2.500	B	B	B	B
	3.000	B	B	B	B
	3.500	B	B	B	B
	4.000	B	B	B	B
7.00	3.000	B	B	B	B
	3.500	B	B	B	B
	4.000	B	B	B	B
8.00	5.000	B	B	B	B
	4.000	B	B	B	B
	5.000	B	B	B	B
	5.500	B	B	B	B

Rod Bushing Construction
B = Bolted Bushing
R = Retainer Held Bushing

NOTES

Series HV2 Large Bore High Pressure Hydraulic Cylinders



Standard Specifications

- Heavy Duty Service
- Standard Construction – Square Head – Tie Rod Design
- Nominal Pressure – 3000 PSI¹
- Standard Fluid – Hydraulic Oil
- Standard Temperature – -10°F to +165°F²
- Bore Sizes – 10.00" through 20.00" (Larger sizes available)

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

- Piston Rod Diameter – 4.500" through 10.000"
- Mounting Styles – Twelve standard styles at various application ratings
- Strokes – Available in any practical stroke length
- Cushions – Optional at either end or both ends of stroke
- Rod Ends – Two Standard Choices – Specials to Order

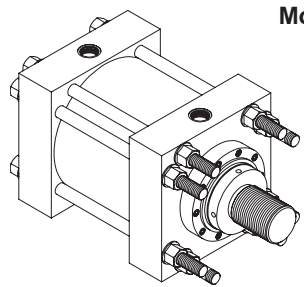
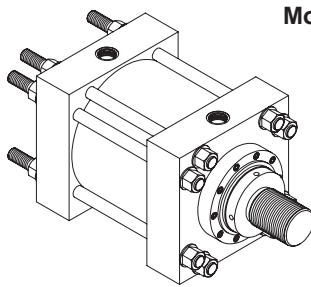
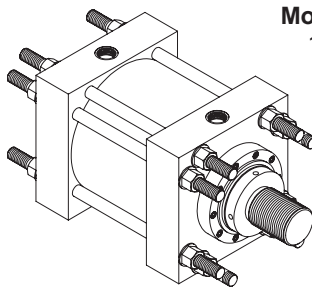
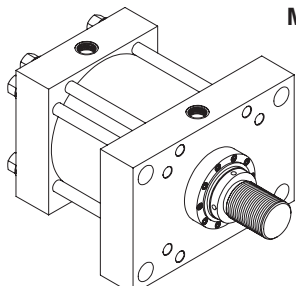
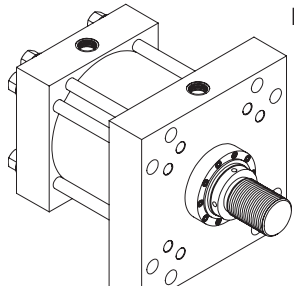
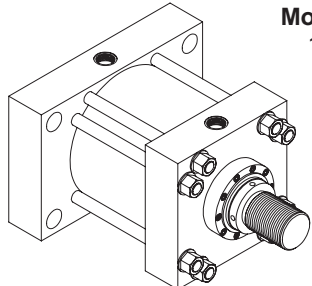
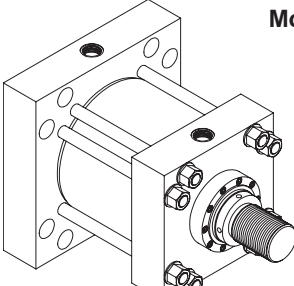
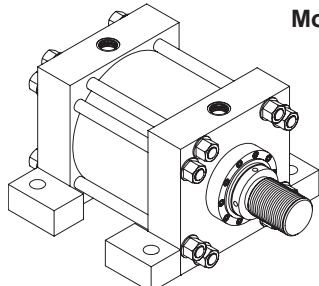
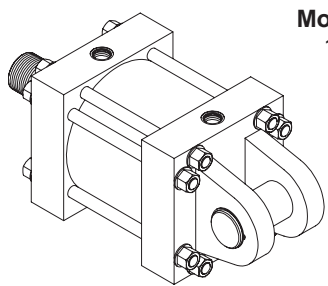
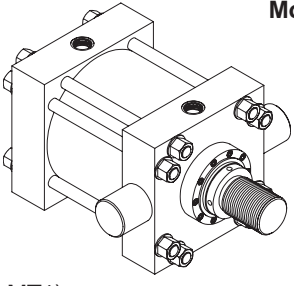
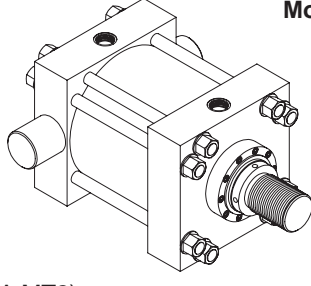
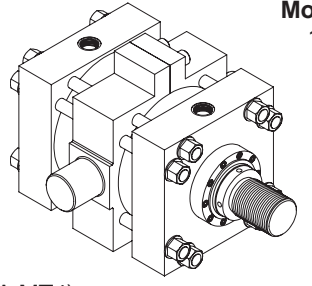
¹If hydraulic operating pressure exceeds 3000 PSI, send application data for engineering evaluation and recommendation. See pressure ratings page for actual design factors.

²See operating fluids and temperature range page for higher temperature service.

Mountings – Large Bore Sizes

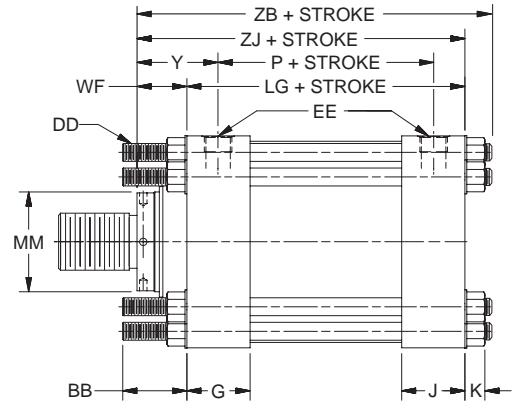
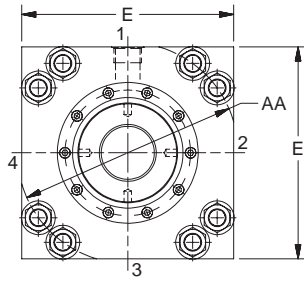
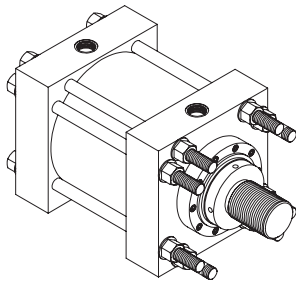
**Series HV2
Large Bore
High Pressure Hydraulic Cylinders**

Available Mounting Styles

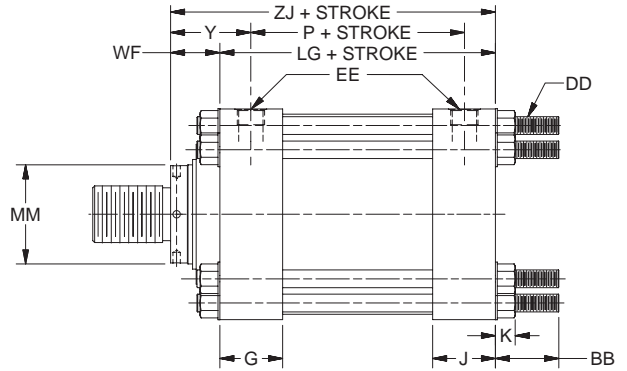
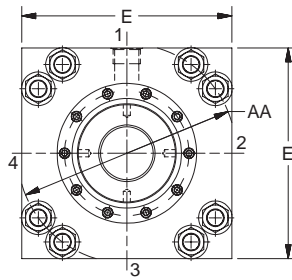
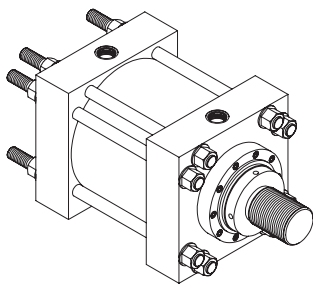
<p>Tie Rods Extended Head End</p>  <p>Model 53 10.00"- 14.00"</p> <p>(NFPA MX3)</p>	<p>Tie Rods Extended Cap End</p>  <p>Model 52 10.00"- 14.00"</p> <p>(NFPA MX2)</p>	<p>Tie Rods Extended Both Ends</p>  <p>Model 51 10.00"- 14.00"</p> <p>(NFPA MX1)</p>
<p>Head Rectangular</p>  <p>Model 67 10.00"- 20.00"</p> <p>(NFPA ME5)</p>	<p>Head Square Flange</p>  <p>Model 65 10.00"- 20.00"</p> <p>(NFPA MF5)</p>	<p>Cap Rectangular</p>  <p>Model 68 10.00"- 20.00"</p> <p>(NFPA ME6)</p>
<p>Cap Square Flange</p>  <p>Model 66 10.00"- 20.00"</p> <p>(NFPA MF6)</p>	<p>Side Lug</p>  <p>Model 72 10.00"- 14.00"</p> <p>(NFPA MS2)</p>	<p>Cap Fixed Clevis</p>  <p>Model 84 10.00"- 20.00"</p> <p>(NFPA MP1)</p>
<p>Head Trunnion</p>  <p>Model 81 10.00"- 14.00"</p> <p>(NFPA MT1)</p>	<p>Cap Trunnion</p>  <p>Model 82 10.00"- 14.00"</p> <p>(NFPA MT2)</p>	<p>Intermediate Fixed Trunnion</p>  <p>Model 89 10.00"- 14.00"</p> <p>(NFPA MT4)</p>

Tie Rod Mountings – Large Bore Sizes

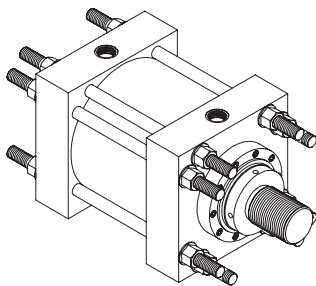
**Tie Rods Extended Head End
Model 53**



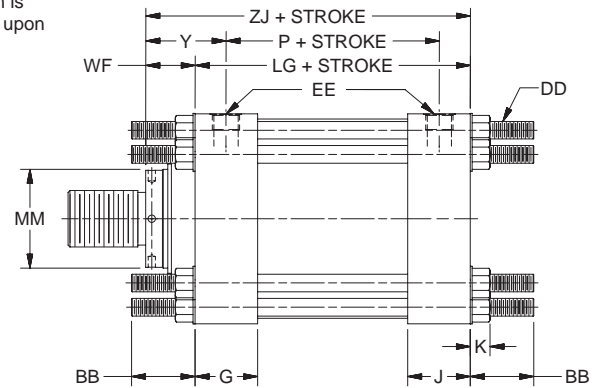
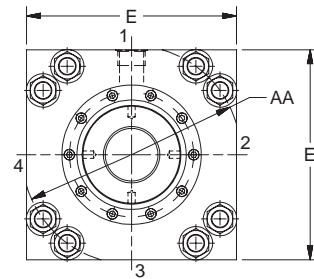
**Tie Rods Extended Cap End
Model 52**



**Tie Rods Extended Both Ends
Model 51**

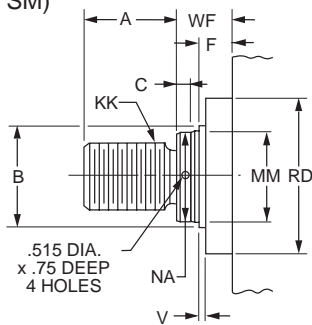


Basic Mounting (Model 50) — Not shown is no tie rod extended and can be supplied upon request.

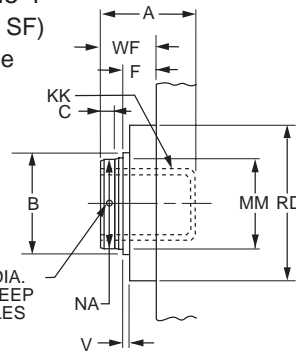


Rod End Dimensions — see Table 2

**Thread Style 2
(NFPA Style SM)
Small Male**



**Thread Style 4
(NFPA Style SF)
Small Female**



**Special Thread
Style X**

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensional sketch.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

If rod end is not specified, Style 2 will be furnished.

Use Style 4 for applications where female rod ends are required.

Tie Rod Mounting – Large Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	AA	BB	DD	E	EE ¹ NPTF	EE ² SAE FLANGE PORT	EE ³ SAE STRAIGHT THREAD	G	J	K	RA	RB	RC	RR	Add Stroke	
															LG	P
10.00	13.00	4.13	1 1/8-12	12.63	2	2	24	3.69	3.69	1.28	5.291	3.775	–	2.13	12.13	8.50
12.00	15.50	4.50	1 1/4-12	14.88	2 1/2	2 1/2	24	4.44	4.44	1.41	6.270	4.555	–	2.38	14.50	10.13
14.00	17.38	4.50	1 1/4-12	17.13	2 1/2	2 1/2	24	4.88	4.88	1.41	7.485	6.143	4.409	2.25	15.63	10.88

¹ NPTF ports are available at no extra charge.

² Optional SAE flange ports may be specified – flange to be supplied by customer. See Table 4 for flange port pattern dimensions.

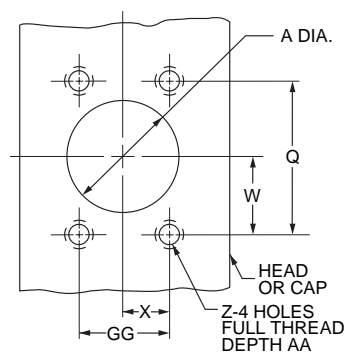
³ SAE straight thread ports are standard and are indicated by port number.

Table 2—Rod Dimensions

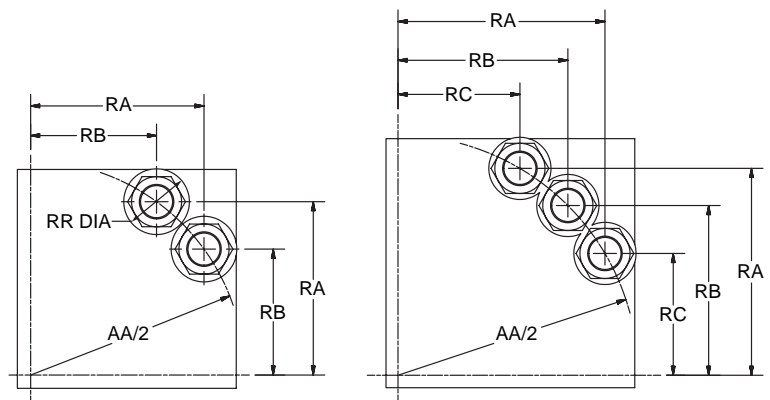
Bore	Rod Dia. MM	Thread KK	Rod Extensions and Pilot Dimensions								Add Stroke		
			A	+0.000 -0.005 B	C	F	NA	RD	V	WF	Y	ZB (Max.)	ZJ
10.00	4.500	3 1/4-12	4.50	5.249	1.00	1.94	4.38	8.25	0.25	2.94	4.75	16.69	15.06
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.31	17.25	15.63
	5.000	3 1/2-12	5.00	5.749	1.00	1.94	4.88	8.88	0.25	3.19	5.00	16.94	15.31
	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.00	16.94	15.31
12.00	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.38	19.44	17.69
	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	6.19	20.25	18.50
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.69	19.75	18.00
14.00	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.88	20.88	19.13
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	6.88	21.88	20.13
	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	6.38	21.38	19.63

**Table 3 —
Envelope and
Mounting Dimensions**

Table 4—Optional SAE Flange Port Pattern



Tie Rod Information—see Table 1 for dimensions



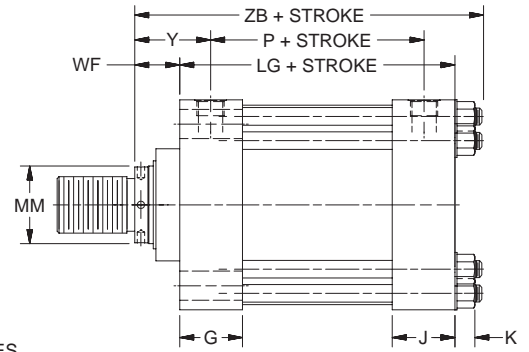
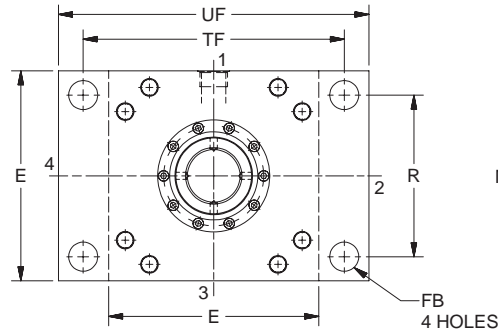
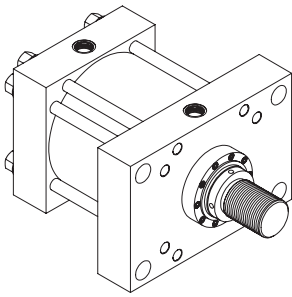
10", 12" Bores, 8 Tie Rods

14" Bores, 12 Tie Rods

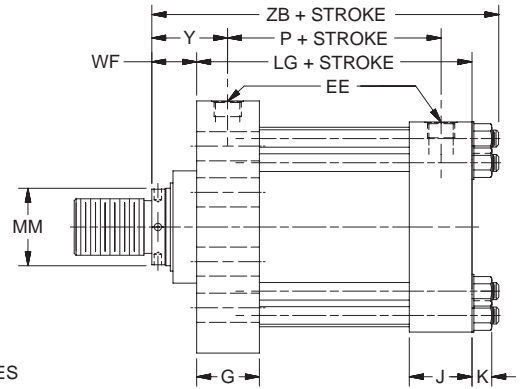
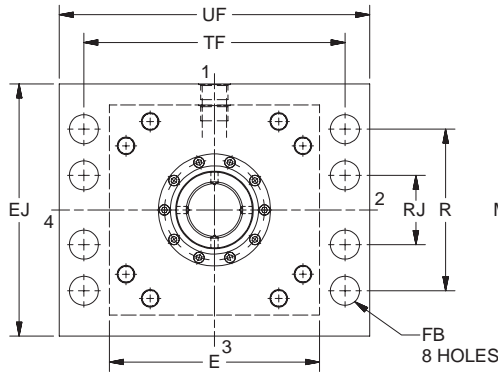
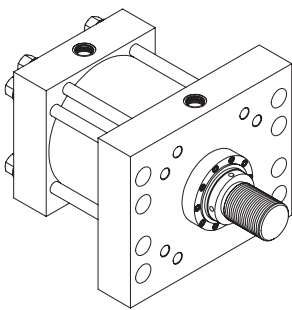
Nom. Flange Size	S.A.E. Flange Dash Size	A	Q	GG	W	X	Z-THD UNC-2B	AA Min.
1 1/2	-24	1.50	2.750	1.406	1.38	0.70	1/2-13	1.06
2	-32	2.00	3.062	1.688	1.53	0.84	1/2-13	1.06
2 1/2	-40	2.50	3.500	2.000	1.75	1.00	1/2-13	1.19
3	-48	3.00	4.188	2.438	2.09	1.22	5/8-11	1.19

Mounting Information – Large Bore Sizes

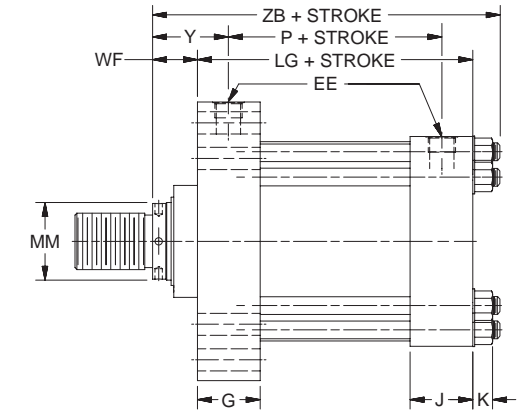
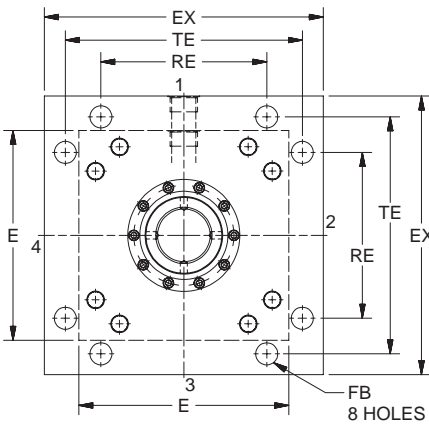
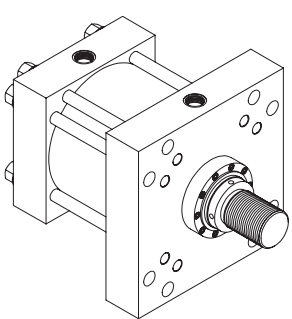
Head Rectangular Mounting
Model 67
(10.00"-14.00" Bore)



Head Rectangular Mounting
Model 67
(16.00"-20.00" Bore)

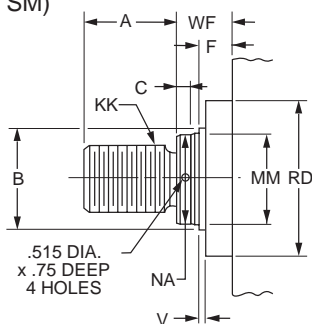


Head Square Flange Mounting
Model 65

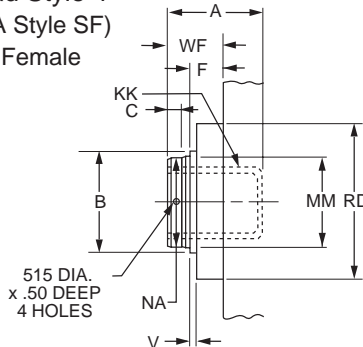


Rod End Dimensions — see Table 2

Thread Style 2
(NFA Style SM)
Small Male



Thread Style 4
(NFA Style SF)
Small Female



Special Thread
Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensional sketch.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

If rod end is not specified, Style 2 will be furnished.

Use Style 4 for applications where female rod ends are required.

Mounting Information – Large Bore Sizes

Table 1—Envelope and Mounting Dimensions

Bore	E	EB	EE ¹ NPTF	EE ² SAE FLANGE PORT	EE ³ SAE STRAIGHT THREAD	EX	(Bolt) FB ⁴	G	J	K	R	RE	TE	TF	UF	Add Stroke	
																LG	P
10.00	12.63	1.31	2	2	24	16.63	1.75	3.69	3.69	1.28	9.62	9.89	14.13	15.88	19.00	12.13	8.50
12.00	14.88	1.56	2 1/2	2 1/2	24	19.75	2.00	4.44	4.44	1.41	11.45	11.75	16.79	18.50	22.00	14.50	10.13
14.00	17.13	1.81	2 1/2	2 1/2	24	21.75	2.25	4.88	4.88	1.41	13.26	12.90	18.43	21.00	25.00	15.63	10.88

Table 1A—Envelope and Mounting Dimensions

Bore	E	EB	EE (SAE)	EE (FLANGE)	EJ	EX	(Bolt) FB	G	J	K	R	RJ	RE	TE	TF	UF	Add Stroke	
																	LG	P
16.00	19.00	1.81	24	3	20.00	24.50	1.75	5.88	5.88	1.91	15.50	8.00	15.28	21.03	21.00	24.50	18.13	12.13
18.00	22.00	2.06	24	3	23.00	26.50	2.00	6.88	6.88	1.91	18.00	7.25	16.45	22.65	24.25	28.25	21.13	15.13
20.00	24.00	2.06	24	3	25.00	29.00	2.00	7.88	7.88	1.91	20.00	8.00	18.07	24.87	26.50	30.50	23.63	17.63

¹ NPTF ports are available at no extra charge.

² Optional SAE flange ports may be specified – flange to be supplied by customer. See Table 4 for flange port pattern dimensions.

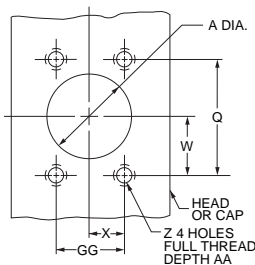
³ SAE straight thread ports are standard and are indicated by port number. ⁴ Mounting holes are 0.06" larger than bolt size listed.

Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread KK	Rod Extensions and Pilot Dimensions								Y	Add Stroke ZB (Max.)
			A	+0.000 -0.005 B	C	F	NA	RD	V	WF		
10.00	4.500	3 1/4-12	4.50	5.249	1.00	1.94	4.38	8.25	0.25	2.94	4.75	16.69
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.31	17.25
	5.000	3 1/2-12	5.00	5.749	1.00	1.94	4.88	8.88	0.25	3.19	5.00	16.94
	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.00	16.94
12.00	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.38	19.44
	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	6.19	20.25
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.69	19.75
14.00	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.88	20.88
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	6.88	21.88
	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	6.38	21.38
16.00	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	7.00	24.38
	9.000	6 1/2-12	9.00	9.999	1.00	1.94	8.88	13.50	0.38	4.25	7.25	24.63
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	7.50	24.88
18.00	9.000	6 1/2-12	9.00	9.999	1.00	1.94	8.88	13.50	0.38	4.25	7.25	27.63
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	7.50	27.88
20.00	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	7.50	30.38

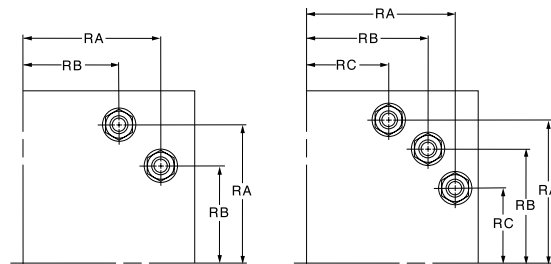
Table 3—Envelope and Mounting Dimensions

Table 4—Optional SAE Flange Port Pattern



Nom. Flange Size	S.A.E. Flange Dash Size	A	Q	GG	W	X	Z-THD UNC-2B	AA Min.
1 1/2	-24	1.50	2.750	1.406	1.38	0.70	1/2-13	1.06
2	-32	2.00	3.062	1.688	1.53	0.84	1/2-13	1.06
2 1/2	-40	2.50	3.500	2.000	1.75	1.00	1/2-13	1.19
3	-48	3.00	4.188	2.438	2.09	1.22	5/8-11	1.19

Table 5—Tie Rod Information



10.00", 12.00" Bores

14.00" Bore

Bore	10.00	12.00	14.00	16.00	18.00	20.00
Tie Rod Thread	1 1/8-12	1 1/4-12	1 1/4-12	4	4	4
RA	5.291	6.270	7.485	4	4	4
RB	3.775	4.555	6.143	4	4	4
RC	—	—	4.409	4	4	4

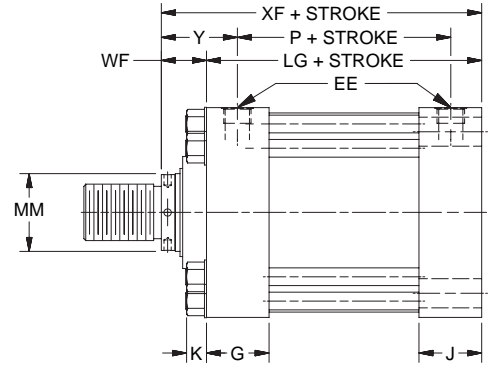
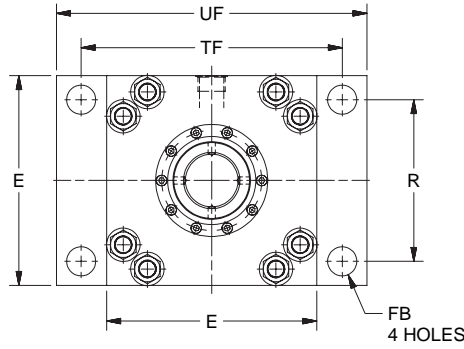
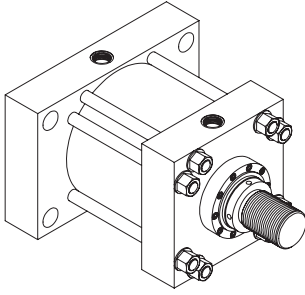
⁴ Consult factory for dimensions

Mounting Information – Large Bore Sizes

Cap Rectangular Mountings

Model 68

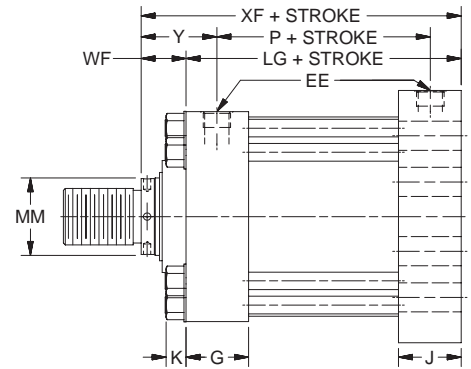
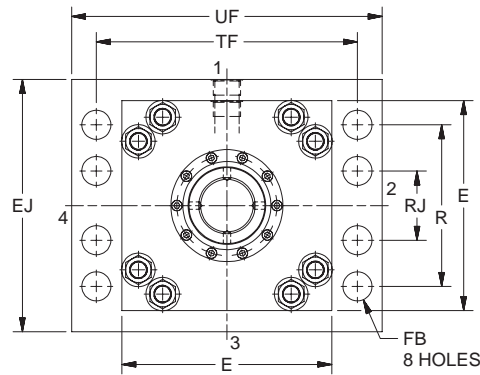
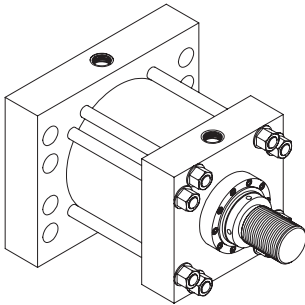
(10.00"-14.00" Bore)



Cap Rectangular Mountings

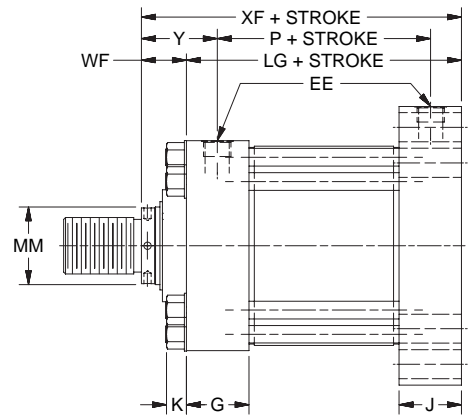
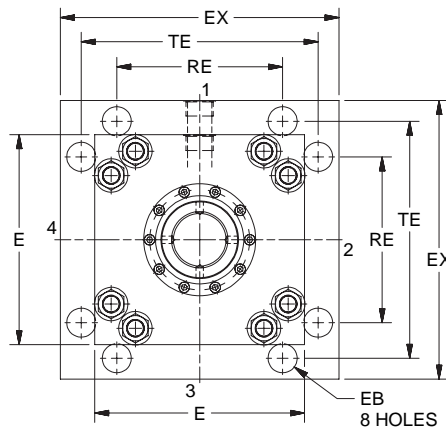
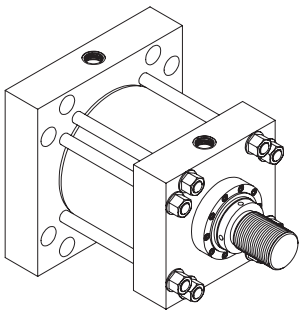
Model 68

(16.00"-20.00" Bore)



Cap Square Flange Mounting

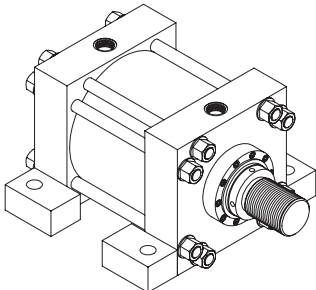
Model 66



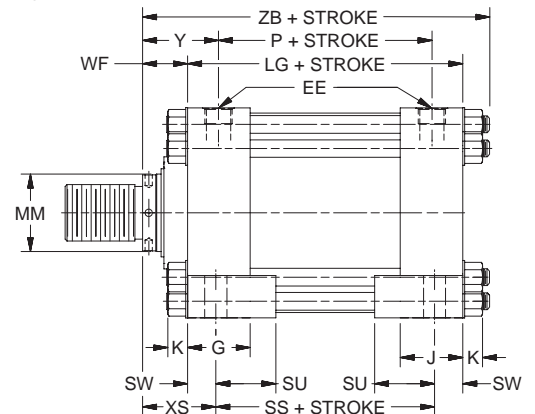
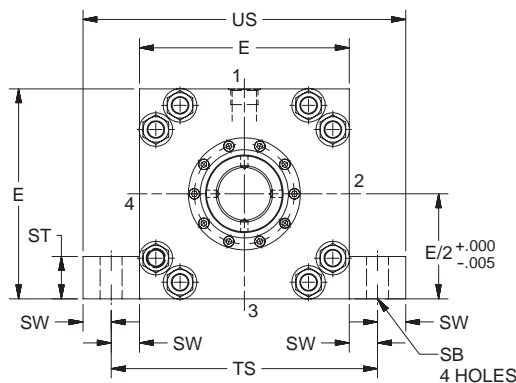
Side Lugs Mounting

Model 72

(10.00"-14.00" Bore only)



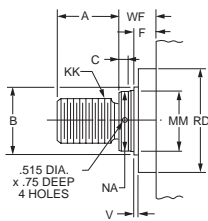
Note: Stroke lengths on lug mounted cylinders should not be shorter than the cylinder bore diameter. Consult factory for recommendations on shorter stroke lengths.



Mounting Information – Large Bore Sizes

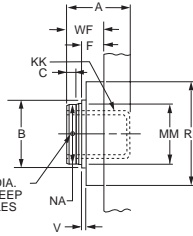
Rod End Dimensions — see Table 2

Thread Style 2
(NPTA Style SM)
Small Male



If rod end is not specified, Style 2 will be furnished.

Thread Style 4
(NPTA Style SF)
Small Female



Use Style 4 for applications where female rod ends are required.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

Special Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensional sketch.

Table 1—Envelope and Mounting Dimensions

Bore	E	EB	EE ¹ NPTF	EE ² SAE FLANGE PORT	EE ³ SAE STRAIGHT THREAD	EX	(Bolt) FB ⁵	G	J	K	R	RE	(Bolt) SB ⁵	ST	SU	SW	TE	TF	TS	UF	US	Add Stroke		
																						LG	P	SS
10.00	12.63	1.31	2	2	24	16.63	1.75	3.69	3.69	1.28	9.62	9.89	1.56	2.25	3.50	1.63	14.13	15.88	15.88	19.00	19.13	12.13	8.50	8.88
12.00	14.88	1.56	2 1/2	2 1/2	24	19.75	2.00	4.44	4.44	1.41	11.45	11.75	1.56	3.00	4.25	2.00	16.79	18.50	18.88	22.00	22.88	14.50	10.13	10.50
14.00	17.13	1.81	2 1/2	2 1/2	24	21.75	2.25	4.88	4.88	1.41	13.26	12.90	2.31	4.00	4.75	2.25	18.43	21.00	21.63	25.00	26.13	15.63	10.88	11.13

Table 1A—Envelope and Mounting Dimensions

Bore	E	EB	EE (SAE)	EE (FLANGE)	EJ	EX	(Bolt) FB ⁵	G	J	K	R	RA	RE	TE	TF	UF	Add Stroke	
																	LG	P
16.00	19.00	1.81	24	3	20.00	24.50	1.75	5.88	5.88	1.91	15.50	8.00	15.28	21.03	21.00	24.50	18.13	12.13
18.00	22.00	2.06	24	3	23.00	26.50	2.00	6.88	6.88	1.91	18.00	7.25	16.45	22.65	24.25	28.25	21.13	15.13
20.00	24.00	2.06	24	3	25.00	29.00	2.00	7.88	7.88	1.91	20.00	8.00	18.07	24.87	26.50	30.50	23.63	17.63

¹NPTF ports are available at no extra charge.

²Optional SAE flange ports may be specified – flange to be supplied by customer. See Table 4 for flange port pattern dimensions.

³SAE straight thread ports are standard and are indicated by port number.

⁵Mounting Holes are 0.06" larger than bolt size listed.

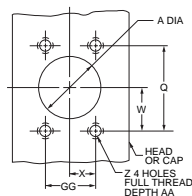
Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread KK	Rod Extensions and Pilot Dimensions								Add Stroke			
			A	+0.000 -0.005 B	C	F	NA	RD	V	WF	Y	XS	XF	ZB (Max.)
10.00	4.500	3 1/4-12	4.50	5.249	1.00	1.94	4.38	8.25	0.25	2.94	4.75	4.56	15.06	16.69
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.31	5.13	15.63	17.25
	5.000	3 1/2-12	5.00	5.749	1.00	1.94	4.88	8.88	0.25	3.19	5.00	4.81	15.31	16.94
	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.00	4.81	15.31	16.94
12.00	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.38	5.19	17.69	19.44
	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	6.19	6.00	18.50	20.25
14.00	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.69	5.50	18.00	19.75
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.88	5.75	19.13	20.88
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	6.88	6.75	20.13	21.88
16.00	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	7.00	⁴	22.13	24.38
	9.000	6 1/2-12	9.00	9.999	1.00	1.94	8.88	13.50	0.38	4.25	7.25	⁴	22.38	24.63
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	7.50	⁴	22.63	24.88
18.00	9.000	6 1/2-12	9.00	9.999	1.00	1.94	8.88	13.50	0.38	4.25	7.25	⁴	25.38	27.63
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	7.50	⁴	25.63	27.88
20.00	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	7.50	⁴	28.13	30.38

⁴Consult Factory

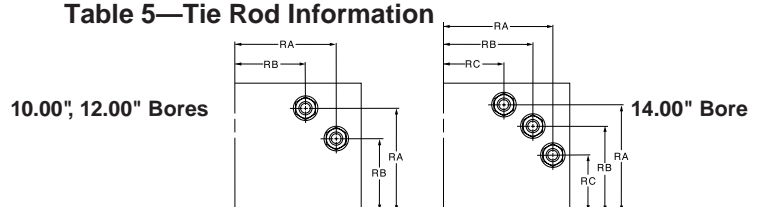
Table 3—Envelope and Mounting Dimensions

Table 4—Optional SAE Flange Port Pattern



Nom. Flange Size	S.A.E. Flange Dash Size	A	Q	GG	W	X	Z-THD UNC-2B	AA Min.
1 1/2	-24	1.50	2.750	1.406	1.38	0.70	1/2-13	1.06
2	-32	2.00	3.062	1.688	1.53	0.84	1/2-13	1.06
2 1/2	-40	2.50	3.500	2.000	1.75	1.00	1/2-13	1.19
3	-48	3.00	4.188	2.438	2.09	1.22	5/8-11	1.19

Table 5—Tie Rod Information

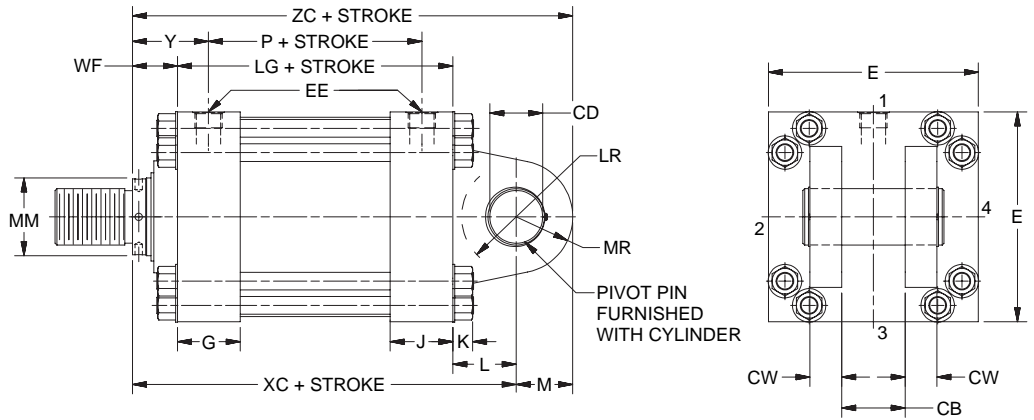
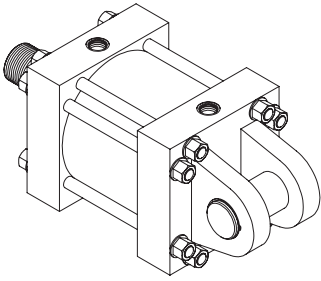


Bore	10.00	12.00	14.00	16.00	18.00	20.00
Tie Rod Thread	1 1/8-12	1 1/4-12	1 1/4-12	6	6	6
RA	5.291	6.270	7.485	6	6	6
RB	3.775	4.555	6.143	6	6	6
RC	—	—	4.409	6	6	6

⁶Consult factory for dimensions

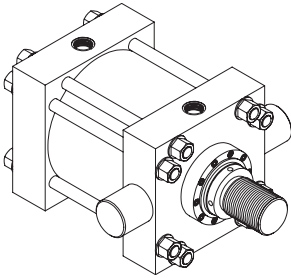
Mounting Information – Large Bore Sizes

Cap Fixed Clevis Mountings
Model 84



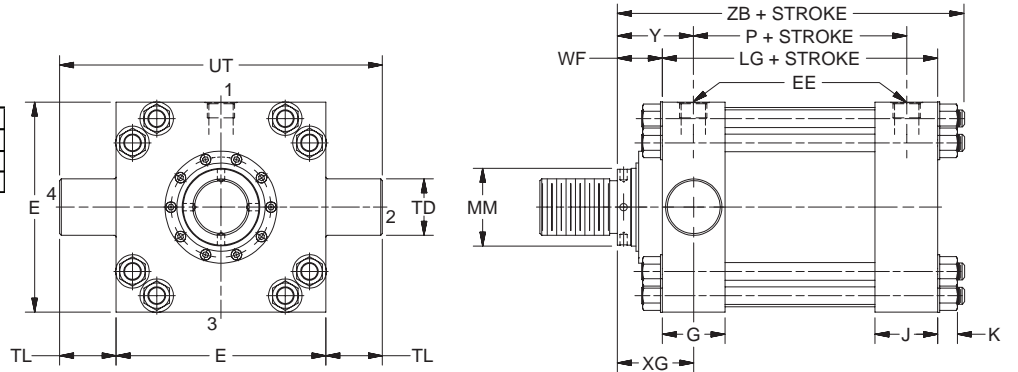
Head Trunnion Mounting
Model 81

(10.00"-14.00"
Bore only)



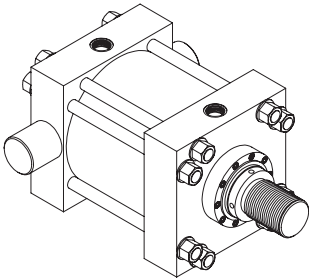
For Model 81
Maximum
Pressure
Rating - PSI

Bore	PSI
10.00	2800
12.00	2350
14.00	2200



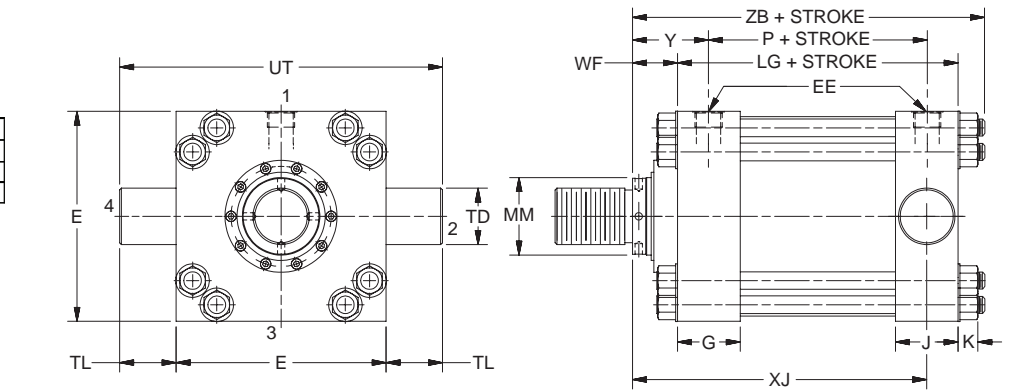
Cap Trunnion Mounting
Model 82

(10.00"-14.00"
Bore only)



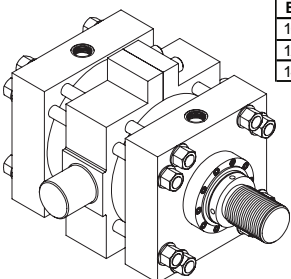
For Model 82
Maximum
Pressure
Rating - PSI

Bore	PSI
10.00	2800
12.00	2350
14.00	2200



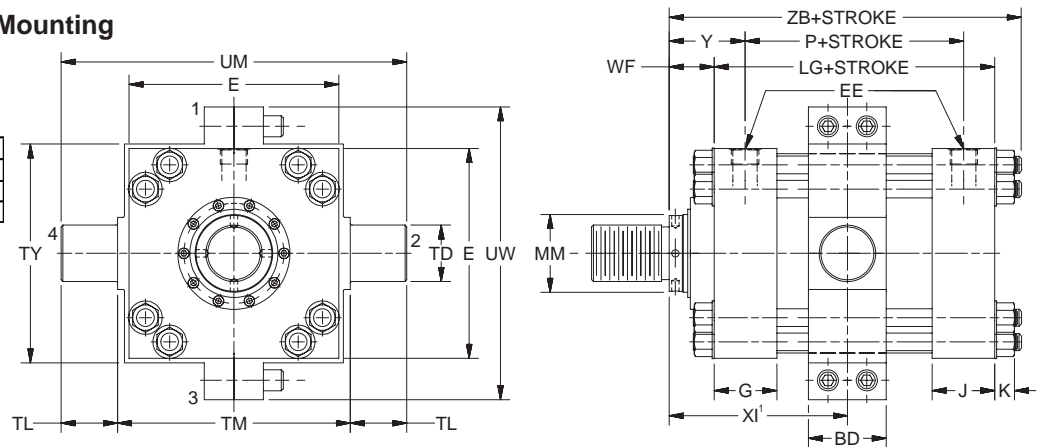
Intermediate Fixed Trunnion Mounting
Model 89

(10.00"-14.00"
Bore only)



For Model 89
Maximum
Pressure
Rating - PSI

Bore	PSI
10.00	2800
12.00	2350
14.00	2200

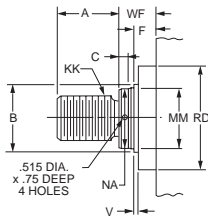


¹Dimension XI to be specified by customer.

Mounting Information – Large Bore Sizes

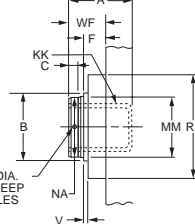
Rod End Dimensions — see Table 2

Thread Style 2
(NFPA Style SM)
Small Male



If rod end is not specified, Style 2 will be furnished.

Thread Style 4
(NFPA Style SF)
Small Female



Use Style 4 for applications where female rod ends are required.

Style 4 stroke restrictions may apply. See Style 4 Minimum Stroke page for details.

Special Thread Style X

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style X" and give desired dimensions for KK, A and WF. If otherwise special, furnish dimensional sketch.

Table 1—Envelope and Mounting Dimensions

Bore	BD	CB	+.001 -.003 CD ⁴	CW	E	EE ¹ NPTF	EE ² SAE FLANGE PORT	EE ³ SAE STR. THD.	G	J	K	L	LR	M	MR	+.000 -.001 TD	TL	TM	TY	UM	UT	UW	Add Stroke	
																							LG	P
10.00	4.50	4.00	3.500	2.00	12.63	2	2	24	3.69	3.69	1.28	4.00	3.38	3.50	3.50	3.500	3.50	14.00	13.00	21.00	19.63	17.50	12.13	8.50
12.00	5.50	4.50	4.000	2.25	14.88	2 1/2	2 1/2	24	4.44	4.44	1.41	4.50	3.88	4.00	4.000	4.00	16.50	15.50	24.50	22.88	20.75	14.50	10.13	
14.00	5.50	6.00	5.000	3.00	17.13	2 1/2	2 1/2	24	4.88	4.88	1.41	5.75	4.19	5.00	5.000	4.500	4.50	19.50	19.25	28.50	26.13	24.75	15.63	10.88

Table 1A—Envelope and Mounting Dimensions

Bore	E	EE (SAE)	EE (FLANGE)	CB	CD ⁴	CW	G	J	K	L	LR	M	MD	MR	Add Stroke	
															LG	P
16.00	19.00	24	3	7.00	6.00	3.50	5.88	5.88	1.91	7.00	6.25	6.00	16.00	6.00	18.13	12.13
18.00	22.00	24	3	8.00	6.50	4.00	6.88	6.88	1.91	7.63	6.75	6.50	18.00	6.50	21.13	15.13
20.00	24.00	24	3	9.00	7.50	4.50	7.88	7.88	1.91	8.75	7.75	7.50	20.00	7.50	23.63	17.63

¹ NPTF ports are available at no extra charge.

² Optional SAE flange ports may be specified – flange to be supplied by customer. See Table 4 for flange port pattern dimensions.

³ SAE straight thread ports are standard and are indicated by port number.

⁴ Dimension CD is pin diameter.

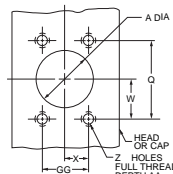
Table 2—Rod Dimensions

Bore	Rod Dia. MM	Thread KK	Rod Extensions and Pilot Dimensions								XG	Min. XI ⁵	Y	Add Stroke			
			A	+.000 -.005 B	C	F	NA	RD	V	WF				XC	XJ	ZB (Max.)	ZC
10.00	4.500	3 1/4-12	4.50	5.249	1.00	1.94	4.38	8.25	0.25	2.94	4.75	9.06	4.75	19.06	13.38	16.69	22.56
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.31	9.63	5.31	19.63	13.94	17.25	23.13
	5.000	3 1/2-12	5.00	5.749	1.00	1.94	4.88	8.88	0.25	3.19	5.00	9.31	5.00	19.31	13.63	16.94	22.81
	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.00	9.31	5.00	19.31	13.63	16.94	22.81
12.00	5.500	4-12	5.50	6.249	1.00	1.94	5.38	9.38	0.25	3.19	5.38	10.63	5.38	22.19	15.50	19.44	26.19
	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	6.19	11.50	6.19	23.00	16.31	20.25	27.00
14.00	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.69	10.94	5.69	22.50	15.81	19.75	26.50
	7.000	5-12	7.00	7.999	1.00	1.94	6.88	10.50	0.38	3.50	5.94	11.44	5.88	24.88	16.69	20.88	29.88
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	6.94	12.44	6.88	25.88	17.69	21.88	30.88
16.00	8.000	5 3/4-12	8.00	8.999	1.00	1.94	7.88	12.50	0.38	4.00	⁶	⁶	7.00	29.13	⁶	24.38	35.13
	9.000	6 1/2-12	9.00	9.999	1.00	1.94	8.88	13.50	0.38	4.25	⁶	⁶	7.25	29.38	⁶	24.63	35.38
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	⁶	⁶	7.50	29.63	⁶	24.88	35.63
18.00	9.000	6 1/2-12	9.00	9.999	1.00	1.94	8.88	13.50	0.38	4.25	⁶	⁶	7.25	33.00	⁶	27.63	39.50
	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	⁶	⁶	7.50	33.25	⁶	27.88	39.75
20.00	10.000	7 1/4-12	10.00	10.999	1.00	1.94	9.88	14.50	0.38	4.50	⁶	⁶	7.50	36.88	⁶	30.38	44.38

⁵ Dimension XI to be specified by customer.

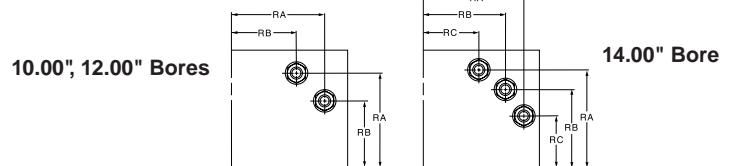
⁶ Consult Factory

Table 4—Optional SAE Flange Port Pattern



Nom. Flange Size	S.A.E. Flange Dash Size	A	Q	GG	W	X	Z-THD UNC-2B	AA Min.
1 1/2	-24	1.50	2.750	1.406	1.38	0.70	1/2-13	1.06
2	-32	2.00	3.062	1.688	1.53	0.84	1/2-13	1.06
2 1/2	-40	2.50	3.500	2.000	1.75	1.00	1/2-13	1.19
3	-48	3.00	4.188	2.438	2.09	1.22	5/8-11	1.19

Table 5—Tie Rod Information

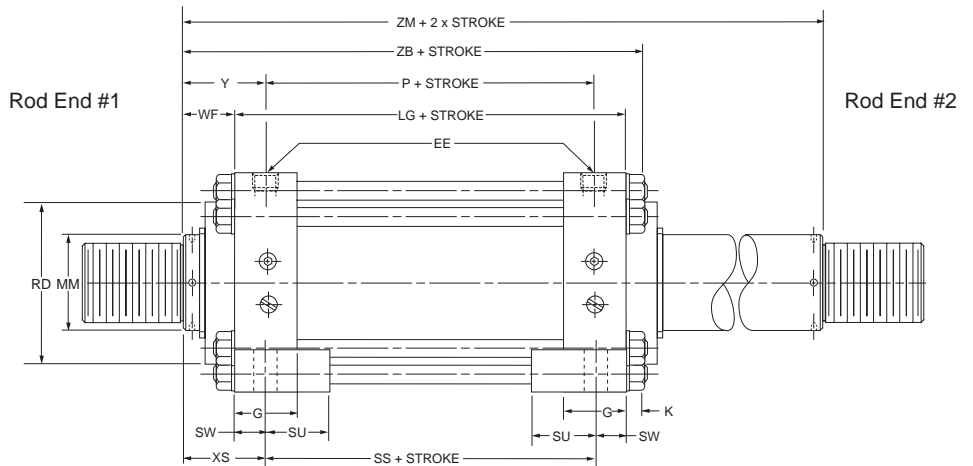
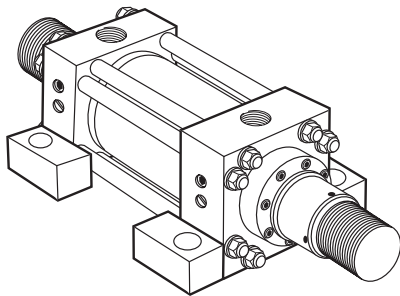


Bore	10.00	12.00	14.00	16.00	18.00	20.00
Tie Rod Thread	1 1/8-12	1 1/4-12	1 1/4-12	7	7	7
RA	5.291	6.270	7.485	7	7	7
RB	3.775	4.555	6.143	7	7	7
RC	—	—	4.409	7	7	7

⁷ Consult factory for dimensions

Double Rod Models – Large Bore Sizes

How to Use Double Rod Cylinder Dimensioned Drawings



Mounting Styles for Single Rod Models	Dimension Shown on This Page Supplement Dimensions on Pages Listed Below
53	36, 37
52	36, 37
51	36, 37
67	38, 39
65	38, 39
72	40, 41
81	42, 43
89 ¹	42, 43

If only one end of these Double Rod Cylinders is to be cushioned, be sure to specify clearly which end this will be.

¹Specify XI dimension from rod end #1.

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. (See table at left.) After you have determined all necessary dimensions from that drawing, turn back to this page and supplement those dimensions with additional ones from the drawing above and table at right. These added dimensions differ from, or are in addition to, those shown on the preceding pages and provide the additional information needed to completely dimension a double rod cylinder model.

On a double rod cylinder where the two rod ends are different, be sure to clearly state which rod end is to be assembled at which end. Port position 1 is standard. If other than standard, specify pos. 2, 3 or 4 when viewed from rod end #1 only. See port position information on ports page.

Bore	Rod Dia.	Add 2X Stroke
		ZM
10.00	4.500	18.00
	7.000	19.13
	5.000	18.50
12.00	5.500	18.50
	8.000	20.88
	7.000	22.50
14.00	7.000	21.50
	10.000	22.63
	8.000	24.63
16.00	8.000	23.63
	9.000	26.13
	10.000	27.13
18.00	9.000	26.63
	10.000	29.63
20.00	10.000	30.13
		32.63

Mounting Recommendations and Other Mountings

In addition to the standard mountings dimensioned on the preceding pages, the following information covers mounting ideas that may prove helpful in your applications. When needed, special heads, caps, and flanges can be provided. Sketches of your requirements, together with specifications relative to the application and forces involved should be submitted.

Mounting Bolts — High tensile socket head screws are recommended for all mounting styles.

Flange Mountings — Cylinders can be properly centered by measuring from piston rod diameter. After mounting, the flange may be drilled for pins or dowels to prevent shifting.

Side Lug Mountings — Caution, cylinders which do not absorb force on their centerline (Group 3) tend to sway when under load. Short stroke, non-centerline mounted cylinders can subject mounting bolts to large tension forces which when combined with shear forces can overstress standard mounting bolts. Side lug mounted cylinders should always be prevented from shifting through use of shear keys so located as to resist the major load, whether push or pull.

Trunnion Mountings — Cylinders require lubricated pillow blocks with minimum bearing clearances. Pillow blocks should be carefully aligned and rigidly mounted so the trunnions will not be subjected to bending moments. The rod end connection should also be pivoted, with the customer's pin in the piston rod eye parallel to the trunnions.

Clevis Mountings — Cylinders should be pivoted at both ends, with the customer's pin in the piston rod eye parallel to the pivot pin supplied with the clevis.

Metallic Rod Wiper

When specified, metallic rod wipers can be supplied at extra cost, instead of the standard synthetic rubber wiperseal. Recommended in applications where atmospheric particles or splashing tend to cling to the extended piston rod and otherwise damage the synthetic rubber wiperseal. Installation of metallic rod wiper does not affect cylinder dimensions.

Linear Alignment Couplers

Linear Alignment Couplers are available in 19 standard thread sizes...

Cost Saving Features and Benefits Include...

- Maximum reliability for trouble-free operation, long life and lower operating costs
- Increased cylinder life by reducing wear on piston and rod bearings
- Simplifying cylinder installation and reducing assembly costs
- Increase rod bearing and rod seal life for lower maintenance costs

Alignment Coupler

See Table 1 for Part Numbers and Dimensions

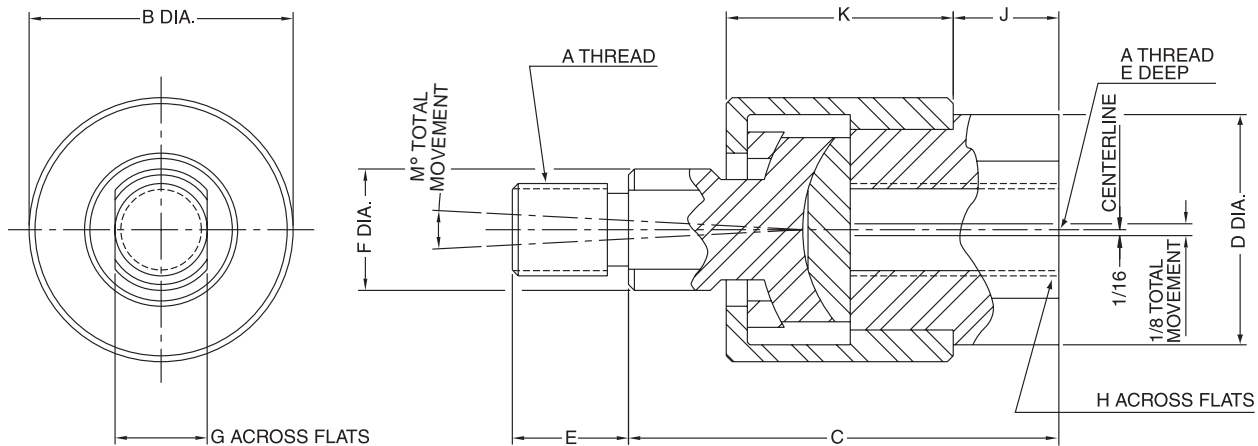


Table 1 — Part Numbers and Dimensions

Part No.	A	B	C	D	E	F	G	H	J	K	M	Max. Pull Load (lbs.)	Approx. Weight (lbs.)
1347570031	5/16-24	1.13	1.75	0.94	0.50	0.50	0.38	0.75	0.38	0.94	6°	1200	.35
1347570038	3/8-24	1.13	1.75	0.94	0.50	0.50	0.38	0.75	0.38	0.94	6°	2425	.35
1347570044	7/16-20	1.38	2.00	1.13	0.75	0.63	0.50	0.88	0.38	1.09	6°	3250	.55
1347570050	1/2-20	1.38	2.00	1.13	0.75	0.63	0.50	0.88	0.38	1.09	6°	4450	.55
1347570063	5/8-18	1.38	2.00	1.13	0.75	0.63	0.50	0.88	0.38	1.09	6°	6800	.55
1347570075	3/4-16	2.00	2.31	1.63	1.13	0.94	0.75	1.31	0.44	1.28	6°	9050	1.4
1347570088	7/8-14	2.00	2.31	1.63	1.13	0.94	0.75	1.31	0.44	1.28	6°	14450	1.4
1347570100	1-14	3.13	3.00	2.38	1.63	1.44	1.25	1.88	0.75	1.78	6°	19425	4.8
1347570125	1 1/4-12	3.13	3.00	2.38	1.63	1.44	1.25	1.88	0.75	1.78	6°	30500	4.8
1337390125	1 1/4-12	3.50	4.00	2.00	2.00	1.50	1.25	1.69	0.75	2.50	6°	30500	6.9
1337390150	1 1/2-12	4.00	4.38	2.25	2.25	1.75	1.50	1.94	0.88	2.75	10°	45750	9.8
1337390175	1 3/4-12	4.00	4.38	2.25	2.25	1.75	1.50	1.94	0.88	2.75	10°	58350	9.8
1337390188	1 7/8-12	5.00	5.63	3.00	3.00	2.25	1.94	2.63	1.38	3.38	10°	67550	19.8
1337390200	2-12	5.00	5.63	3.00	3.00	2.25	1.94	2.63	1.38	3.38	10°	77450	19.8
1337390225	2 1/4-12	6.75	6.38	3.25	3.50	2.75	2.38	2.88	1.63	3.75	10°	99250	35.3
1337390250	2 1/2-12	7.00	6.50	4.00	3.50	3.25	2.88	3.38	1.63	3.88	10°	123750	45.3
1337390275	2 3/4-12	7.00	6.50	4.00	3.50	3.25	2.88	3.38	1.63	3.88	10°	150950	45.3
1337390300	3-12	7.00	6.50	4.00	3.50	3.25	2.88	3.38	1.63	3.88	10°	180850	45.3
1337390325	3 1/4-12	9.25	8.50	5.25	4.50	4.00	3.38	4.50	2.00	5.50	10°	213450	—
1337390425	4 1/4-12	12.88	11.25	7.75	4.50	5.50	4.88	7.00	1.50	8.75	10°	370850	—

How to Order Linear Alignment Couplers — When ordering a cylinder with a threaded male rod end, specify the coupler of equal thread size by part number as listed in Table 1, i.e.; Piston Rod “KK” dimension is 3/4-16, specify coupler part number 1347570075.

Cylinder Accessories

Miller offers a complete range of cylinder accessories to assure you of the greatest versatility in present and future cylinder applications.

Rod End Accessories

Accessories offered for the rod end of the cylinder include Rod Clevis, Eye Bracket, Rod Eye, Clevis Bracket, and Pivot Pin. To select the proper part number for any desired accessory, refer to the table below or on the opposite page and look in the row to the right of the rod thread in the first column. For economical accessory selection, it is recommended that rod end style 2 be specified on your cylinder order.

Accessory Load Capacity

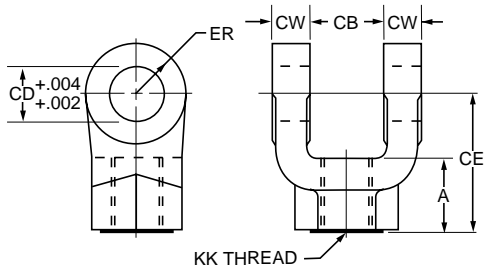
The various accessories have been load rated for your convenience. The load capacity in lbs. is the recommended maximum load for that accessory based on a 4:1 design factor in tension. (Pivot Pin is rated in shear.) Before specifying, compare the actual load or the tension (pull) force at maximum operating pressure of the cylinder with the load capacity of the accessory you plan to use. If load or pull force of cylinder exceeds load capacity of accessory, consult factory.

Thread Size	Rod Clevis		Eye Bracket		Pivot Pin	
	Part Number	Load Capacity (Lbs.)	Part Number	Load Capacity (Lbs.)	Part Number	Shear Capacity (Lbs.)
5/16-24	0512210000 ¹	2600	0740770000	1700	–	–
7/16-20	0509400000	4250	0691950000	4100	0683680000	8600
1/2-20	0509410000	4900	0691950000	4100	0683680000	8600
3/4-16	0509420000	11200	0691960000	10500	0683690000	19300
3/4-16	1332840000	11200	0691960000	10500	0683690000	19300
7/8-14	0509430000	18800	0853610000 ²	20400	0683700000	34300
1-14	0509440000	19500	0853610000 ²	20400	0683700000	34300
1-14	1332850000	19500	0853610000 ²	20400	0683700000	34300
1 1/4-12	0509450000	33500	0691980000	21200	0683710000	65000
1 1/4-12	1332860000	33500	0691980000	21200	0683710000	65000
1 1/2-12	0509460000	45600	0853620000 ²	49480	0683720000	105200
1 3/4-12	0509470000	65600	0853630000 ²	70000	0683730000	137400
1 7/8-12	0509480000	65600	0853630000 ²	70000	0683730000	137400
2 1/4-12	0509490000	98200	0853640000 ²	94200	0683740000	214700
2 1/2-12	0509500000	98200	0853650000 ²	121900	0683750000	309200
2 3/4-12	0509510000	98200	0853650000 ²	121900	0683750000	309200
3 1/4-12	0509520000	156700	0735380000	57400	0735450000	420900
3 1/2-12	0509530000	193200	0735390000	75000	0735470000	565800
4-12	0509540000	221200	0735390000	75000	0735470000	565800

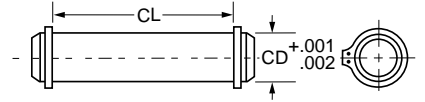
¹Includes pivot pin.

²Cylinder accessory dimensions conform to NFPA recommended standard NFPA/T3.6.8 R1-1984, NFPA recommended standard fluid power systems – cylinder – dimensions for accessories for cataloged square head industrial cylinders.

Rod Clevis Dimensions



Pivot Pin Dimensions



Part Number	A	CB	CD	CE	CW	ER	KK
0512210000 ¹	0.81	0.34	0.313	2.25	0.20	0.30	5/16-24
0509400000	0.75	0.75	0.500	1.50	0.50	0.50	7/16-20
0509410000	0.75	0.75	0.500	1.50	0.50	0.50	1/2-20
0509420000	1.13	1.25	0.750	2.13	0.63	0.75	3/4-16
1332840000	1.13	1.25	0.750	2.38	0.63	0.75	3/4-16
0509430000	1.63	1.50	1.000	2.94	0.75	1.00	7/8-14
0509440000	1.63	1.50	1.000	2.94	0.75	1.00	1-14
1332850000	1.63	1.50	1.000	3.13	0.75	1.00	1-14
0509450000	1.88	2.00	1.375	3.75	1.00	1.38	1 1/4-12
1332860000	2.00	2.00	1.375	4.13	1.00	1.38	1 1/4-12
0509460000	2.25	2.50	1.750	4.50	1.25	1.75	1 1/2-12
0509470000	3.00	2.50	2.000	5.50	1.25	2.00	1 3/4-12
0509480000	3.00	2.50	2.000	5.50	1.25	2.00	1 7/8-12
0509490000	3.50	3.00	2.500	6.50	1.50	2.50	2 1/4-12
0509500000	3.50	3.00	3.000	6.75	1.50	2.75	2 1/2-12
0509510000	3.50	3.00	3.000	6.75	1.50	2.75	2 3/4-12
0509520000	3.50	4.00	3.500	7.75	2.00	3.50	3 1/4-12
0509530000	4.00 ²	4.50	4.000	8.81	2.25	4.00	3 1/2-12
0509540000	4.00 ²	4.50	4.000	8.81	2.25	4.00	4-12

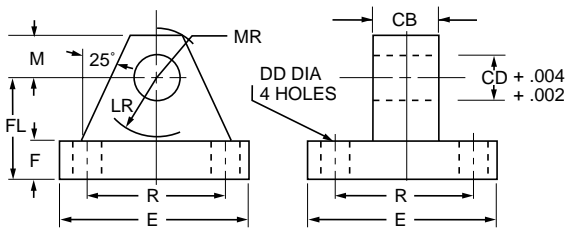
Part Number	CD	CL
0683680000	0.500	1.88
0683690000	0.750	2.63
0683700000	1.000	3.13
0683710000	1.375	4.13
0683720000	1.750	5.19
0683730000	2.000	5.19
0683740000	2.500	6.19
0683750000	3.000	6.25
0735450000	3.500	8.25
0735470000	4.000	9.00

1. Pivot Pins are furnished with Clevis Mounted Cylinders as standard.
2. Pivot Pins are furnished with (2) Retainer Rings.
3. Pivot Pins must be ordered as a separate item if to be used with Rod Eyes, Rod Clevises, or Clevis Brackets.

¹ Includes Pivot Pin

² Consult appropriate cylinder rod end dimensions for compatibility.

Eye Bracket Dimensions



1. When used to mate with the Rod Clevis, select by thread size in table on opposite page.
2. When used to mount the Model 84 Cylinders, select by bore size below.

Part Number	CB	CD	DD	E	F	FL	LR	M	MR	R	Bore
0740770000	0.31	0.313	0.27	2.25	0.38	1.00	0.63	0.38	0.50	1.75	-
0691950000	0.75	0.500	0.41	2.50	0.38	1.13	0.75	0.50	0.56	1.63	1.50"
0691960000	1.25	0.750	0.53	3.50	0.63	1.88	1.25	0.75	0.88	2.55	2.00", 2.50"
0853610000 ³	1.50	1.000	0.66	4.50	0.88	2.38	1.50	1.00	1.25	3.25	3.25"
0691980000	2.00	1.625	0.66	5.00	0.88	3.00	2.13	1.38	1.63	3.82	4.00"
0853620000 ³	2.50	1.750	0.91	6.50	1.13	3.38	2.25	1.75	2.13	4.95	5.00"
0853630000 ³	2.50	2.000	1.06	7.50	1.50	4.00	2.50	2.00	2.44	5.73	6.00"
0853640000 ³	3.00	2.500	1.19	8.50	1.75	4.75	3.00	2.50	3.00	6.58	7.00"
0853650000 ³	3.00	3.000	1.31	9.50	2.00	5.25	3.25	2.75	3.25	7.50	8.00"
0735380000	4.00	3.500	1.81	12.63	1.69	5.69	4.00	3.50	4.13	9.62	-
0735390000	4.50	4.000	2.06	14.88	1.94	6.44	4.50	4.00	5.25	11.45	-

³ Cylinder accessory dimensions conform to NFPA recommended standard NFPA/T3.6.8 R1-1984, NFPA recommended standard fluid power systems – cylinder – dimensions for accessories for cataloged square head industrial cylinders.

Rod End Accessories

Accessories offered for the rod end of the cylinder include Rod Clevis, Eye Bracket, Rod Eye, Clevis Bracket, and Pivot Pin. To select the proper part number for any desired accessory, refer to the table below or on the opposite page and look in the row to the right of the rod thread in the first column. For economical accessory selection, it is recommended that rod end style 2 be specified on your cylinder order.

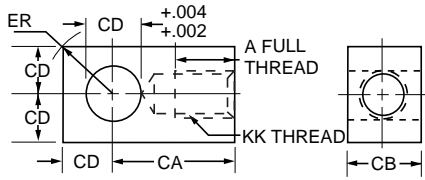
Accessory Load Capacity

The various accessories have been load rated for your convenience. The load capacity in lbs. is the recommended maximum load for that accessory based on a 4:1 design factor in tension. (Pivot Pin is rated in shear.) Before specifying, compare the actual load or the tension (pull) force at the maximum operating pressure of the cylinder with the load capacity of the accessory you plan to use. If load or pull force of cylinder exceeds load capacity of accessory, consult factory.

Thread Size	Rod Eye		Clevis Bracket		Pivot Pin	
	Part Number	Load Capacity (Lbs.)	Part Number	Load Capacity (Lbs.)	Part Number	Shear Capacity (Lbs.)
5/16-24	0740750000	3300	0740760000	3600	0740780000	6600
7/16-20	0690890000	5000	0692050000	7300	0683680000	8600
1/2-20	0690900000	5700	0692050000	7300	0683680000	8600
3/4-16	0690910000	12100	0692060000	14000	0683690000	19300
3/4-16	0690910000	12100	0692060000	14000	0683690000	19300
7/8-14	0690920000	13000	0692070000	19200	0683700000	34300
1-14	0690930000	21700	0692070000	19200	0683700000	34300
1-14	0690930000	21700	0692070000	19200	0683700000	34300
1 1/4-12	0690940000	33500	0692080000	36900	0683710000	65000
1 1/4-12	0690940000	33500	0692080000	36900	0683710000	65000
1 1/2-12	0690950000	45000	0692090000	34000	0683720000	105200
1 3/4-12	0690960000	53500	0692100000	33000	0692150000	137400
1 7/8-12	0690970000	75000	0692100000	33000	0692150000	137400
2 1/4-12	0690980000	98700	0692110000	34900	0683740000	214700
2 1/2-12	0690990000	110000	0692120000	33800	0683750000	309200
2 3/4-12	0691000000	123300	0692130000	36900	0692160000	309200
3 1/4-12	0735360000	161300	0735420000	83500	0735450000	420900
3 1/2-12	0734370000	217300	0735420000	83500	0735450000	420900
4-12	0734380000	273800	0735430000	102600	0821810000	565800
4 1/2-12	0734390000	308500	0735440000	108400	0735470000 ¹	565800

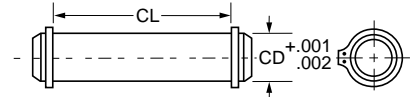
¹This size supplied with cotter pins.

Rod Eye Dimensions



Part Number	A	CA	CB	CD	ER	KK
0740750000	0.75	1.50	0.44	0.438	0.59	5/16-24
0690890000	0.75	1.50	0.75	0.500	0.72	7/16-20
0690900000	0.75	1.50	0.75	0.500	0.72	1/2-20
0690910000	1.13	2.06	1.25	0.750	1.06	3/4-16
0690920000	1.13	2.38	1.50	1.000	1.44	7/8-14
0690930000	1.63	2.81	1.50	1.000	1.44	1-14
0690940000	2.00	3.44	2.00	1.375	1.97	1 1/4-12
0690950000	2.25	4.00	2.50	1.750	2.50	1 1/2-12
0690960000	2.25	4.38	2.50	2.000	2.84	1 3/4-12
0690970000	3.00	5.00	2.50	2.000	2.84	1 7/8-12
0690980000	3.50	5.81	3.00	2.500	3.56	2 1/4-12
0690990000	3.50	6.13	3.00	3.000	4.25	2 1/2-12
0691000000	3.63	6.50	3.50	3.000	4.25	2 3/4-12
0735360000	4.50	7.63	4.00	3.500	4.97	3 1/4-12
0734370000	5.00	7.63	4.00	3.500	4.97	3 1/2-12
0734380000	5.50	9.13	4.50	4.000	5.69	4-12
0734390000	5.50	9.13	5.00	4.000	5.69	4 1/2-12

Pivot Pin Dimensions

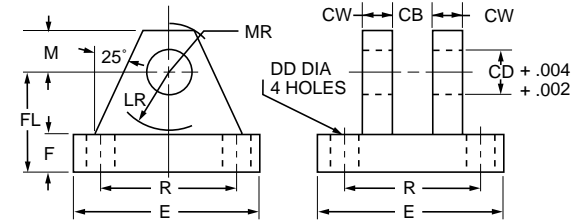


Part Number	CD	CL
0740780000	0.438	1.31
0683680000	0.500	1.88
0683690000	0.750	2.63
0683700000	1.000	3.13
0683710000	1.375	4.13
0683720000	1.750	5.19
0692150000	2.000	5.69
0683740000	2.500	6.19
0683750000	3.000	6.25
0692160000	3.000	6.75
0735450000	3.500	8.25
0821810000	4.000	8.63
0735470000 ¹	4.000	9.00

¹This size supplied with cotter pins.

1. Pivot Pins are furnished with Clevis Mounted Cylinders as standard.
2. Pivot Pins are furnished with (2) Retainer Rings.
3. Pivot Pins must be ordered as a separate item if to be used with Rod Eyes, Rod Clevises, or Clevis Brackets.

Clevis Bracket Dimensions



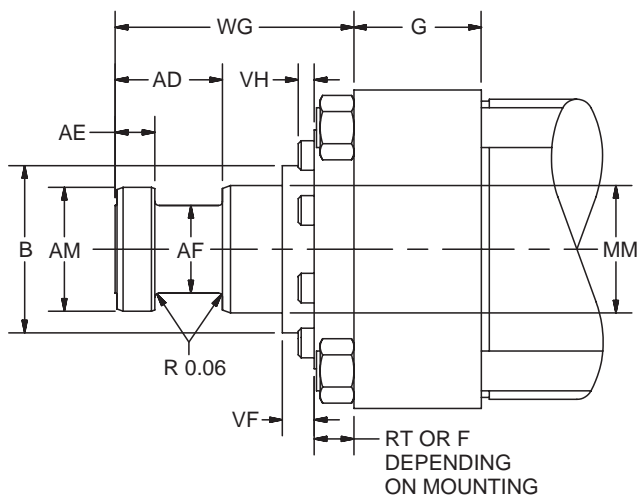
Part Number	CB	CD	CW	DD	E	F	FL	LR	M	MR	R
0740760000	0.47	0.438	0.38	0.27	2.25	0.38	1.00	0.63	0.38	0.50	1.75
0692050000	0.75	0.500	0.50	0.41	3.50	0.50	1.50	0.75	0.50	0.63	2.55
0692060000	1.25	0.750	0.63	0.53	5.00	0.63	1.88	1.19	0.75	0.91	3.82
0692070000	1.50	1.000	0.75	0.66	6.50	0.75	2.25	1.50	1.00	1.25	4.95
0692080000	2.00	1.375	1.00	0.66	7.50	0.88	3.00	2.00	1.38	1.66	5.73
0692090000	2.50	1.750	1.25	0.91	9.50	0.88	3.63	2.75	1.75	2.22	7.50
0692100000	2.50	2.000	1.50	1.06	12.75	1.00	4.25	3.19	2.25	2.78	9.40
0692110000	3.00	2.500	1.50	1.19	12.75	1.00	4.50	3.50	2.50	3.13	9.40
0692120000	3.00	3.000	1.50	1.31	12.75	1.00	6.00	4.25	3.00	3.59	9.40
0692130000	3.50	3.000	1.50	1.31	12.75	1.00	6.00	4.25	3.00	3.59	9.40
0735420000	4.00	3.500	2.00	1.81	15.50	1.69	6.69	5.00	3.50	4.13	12.00
0735430000	4.50	4.000	2.00	2.06	17.50	1.94	7.69	5.75	4.00	4.88	13.75
0735440000	5.00	4.000	2.00	2.06	17.50	1.94	7.69	5.75	4.00	4.88	13.75

Cylinder accessory dimensions conform to NFPA recommended standard NFPT/T3.6.8 R1-1984, NFPA recommended standard fluid power systems - cylinder - dimensions for accessories for cataloged square head industrial cylinders.

Miller “Style 9” Piston Rod End Split Flange Coupling Rod End

- Simplifies alignment
- Reduces assembly time
- Allows full rated hydraulic pressure in push and pull directions
- Available in 0.625" through 10.000" piston rod diameters

Style 9 Rod End



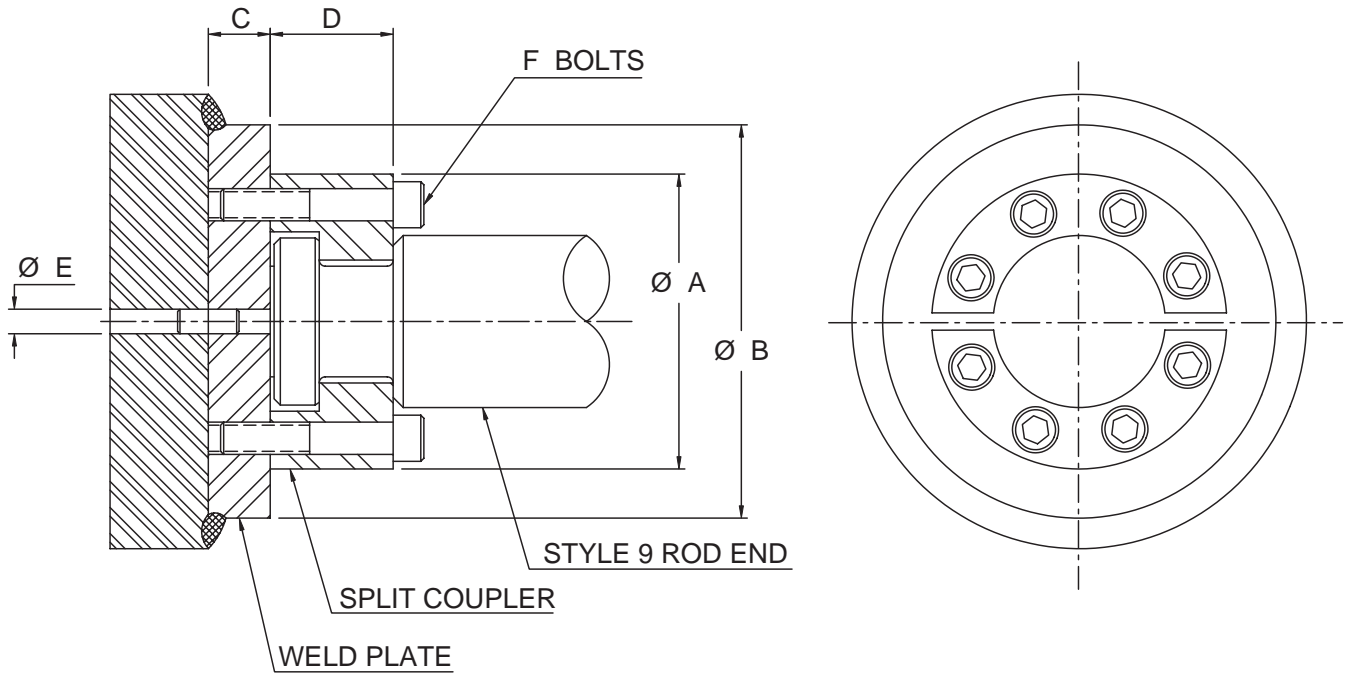
Dimensions Style 9 Rod End

MM Rod Dia.	AD	AE	AF	AM	WG
0.625	0.63	0.25	0.38	0.57	1.75
1.000	0.94	0.38	0.69	0.95	2.38
1.375	1.06	0.38	0.88	1.32	2.75
1.750	1.31	0.50	1.13	1.70	3.13
2.000	1.69	0.63	1.38	1.95	3.75
2.500	1.94	0.75	1.75	2.45	4.50
3.000	2.44	0.88	2.25	2.95	5.00
3.500	2.69	1.00	2.50	3.45	5.63
4.000	2.69	1.00	3.00	3.95	5.75
4.500	3.19	1.50	3.50	4.45	6.50
5.000	3.19	1.50	3.88	4.95	6.63
5.500	3.94	1.88	4.38	5.45	7.50
7.000	4.06	2.00	5.75	6.95	8.44
8.000	4.06	2.00	6.50	7.95	8.69
9.000	4.63	2.38	7.25	8.95	8.75
10.000	4.63	2.38	8.00	9.95	9.75

See previous catalog pages for B, F, G, RT, VF and VH per bore and rod diameter.

“Style 9” Piston Rod End

“Style 9” Piston Rod End
Split Couplers and Weld Plates



⚠ WARNING: Piston rod separation from the machine member can result in severe personal injury or even death to nearby personnel. The cylinder user must make sure the weld holding the weld plate to the machine is of sufficient quality and size to hold the intended load. The cylinder user must also make sure the bolts holding split coupler to the weld plate are of sufficient strength to hold the intended load and installed in such a way that they will not become loose during the machine’s operation.

Table 1 — Part Numbers and Dimensions

ROD DIA.	A	B	C	D	E	F	BOLT SIZE	BOLT CIRCLE	SPLIT COUPLER PART NO.	WELD PLATE PART NO.
0.625	1.50	2.00	.50	.56	.250	4	#10-24 x .94 LG	1.125	1472340062	1481740062
1.000	2.00	2.50	.50	.88	.250	6	.250-20 x 1.25 LG	1.500	1472340100	1481740100
1.375	2.50	3.00	.63	1.00	.250	6	.312-18 x 1.50 LG	2.000	1472340138	1481740138
1.750	3.00	4.00	.63	1.25	.250	8	.312-18 x 1.75 LG	2.375	1472340175	1481740175
2.000	3.50	4.00	.75	1.63	.375	12	.375-16 x 2.25 LG	2.687	1472340200	1481740200
2.500	4.00	4.50	.75	1.88	.375	12	.375-16 x 2.50 LG	3.187	1472340250	1481740250
3.000	5.00	5.50	1.00	2.38	.375	12	.500-13 x 3.25 LG	4.000	1472340300	1481740300
3.500	5.88	7.00	1.00	2.63	.375	12	.625-11 x 3.50 LG	4.687	1472340350	1481740350
4.000	6.38	7.00	1.00	2.63	.375	12	.625-11 x 3.50 LG	5.187	1472340400	1481740400
4.500	6.88	8.00	1.00	3.13	.375	12	.625-11 x 4.00 LG	5.687	1472340450	1481740450
5.000	7.38	8.00	1.00	3.13	.375	12	.625-11 x 4.00 LG	6.187	1472340500	1481740500
5.500	8.25	9.00	1.25	3.88	.375	12	.750-10 x 5.00 LG	6.875	1472340550	1481740550
7.000	10.38	11.00	1.75	4.00	.500	12	1.00-8 x 5.50 LG	8.750	1472340700	1481740700
8.000	11.38	12.00	2.00	4.00	.500	16	1.00-8 x 5.50 LG	9.750	1472340800	1481740800
9.000	13.12	14.00	2.25	4.00	.500	12	1.25-7 x 6.00 LG	11.125	1472340900	1481740900
10.000	14.12	15.00	2.50	4.50	.500	16	1.25-7 x 6.50 LG	12.250	1472341000	1481741000

Note: Screws are not included with coupler or weld plate.

Push and Pull Forces

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	
1.50	1.767	44	88	115	142	177	443	885	1770	3540	5310	.00765
2.00	3.14	79	157	204	251	314	785	1570	3140	6280	9420	.0136
2.50	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	.0213
3.25	8.30	208	415	540	664	830	2075	4150	8300	16600	24900	.0359
4.00	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	.0544
5.00	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	.0850
6.00	28.27	707	1414	1838	2262	2827	7068	14135	28270	56540	84810	.1224
7.00	38.49	962	1924	2502	3079	3849	9623	19245	38490	76980	115470	.1666
8.00	50.27	1257	2513	3268	4022	5027	12568	25135	50270	100540	150810	.2176
10.00	78.54	1964	3927	5105	6283	7854	19635	39270	78540	157080	235620	.3400
12.00	113.10	2828	5655	7352	9048	11310	28275	56550	113100	226200	339300	.4896
14.00	153.94	3849	7697	10006	12315	15394	38485	76970	153940	307880	461820	.6664
16.00	201.06	5027	10053	13069	16085	20106	50265	100530	201060	402120	603180	.8704
18.00	254.47	6362	12724	16541	20358	25447	63618	127235	254470	508940	763410	1.1016
20.00	314.16	7854	15708	20420	25133	31416	78540	157080	314160	628320	942480	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										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	
0.625	.307	8	15	20	25	31	77	154	307	614	921	.0013
1.000	.785	20	39	51	65	79	196	392	785	1570	2355	.0034
1.375	1.49	37	75	97	119	149	373	745	1490	2980	4470	.0065
1.750	2.41	60	121	157	193	241	603	1205	2410	4820	7230	.0104
2.000	3.14	79	157	204	251	314	785	1570	3140	6280	9420	.0136
2.500	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	.0213
3.000	7.07	177	354	460	566	707	1767	3535	7070	14140	21210	.0306
3.500	9.62	241	481	625	770	962	2405	4810	9620	19240	28860	.0416
4.000	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	.0544
4.500	15.90	398	795	1034	1272	1590	3976	7952	15904	31808	47712	.0688
5.000	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	.0850
5.500	23.76	594	1188	1544	1901	2376	5940	11880	23760	47520	71280	.1028
7.000	38.49	962	1924	2502	3079	3849	9621	19243	38485	76970	115455	.1666
8.000	50.27	1257	2513	3267	4021	5027	12566	25133	50265	100530	150795	.2176
9.000	63.62	1590	3181	4135	5089	6362	15904	31809	63617	127234	190851	.2754
10.000	78.53	1964	3927	5105	6283	7854	19635	39270	78540	157080	235620	.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.

Operating Fluids and Temperature Range

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.

Class 1 Seals

Class 1 seals are the standard seals provided in a cylinder assembly. 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). The individual seals may be nitrile (Buna-N), enhanced polyurethane, polymyte, PTFE or filled PTFE.

Class 2 (Nitrile) Seals

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 compatible with Class 2 seals are: Water, Water-Glycol, Water-in Emulsion, Houghto-Safe 27, 620 5040, Mobil Pyrogard D, Shell Iru 905, Ucon Hydrolube J-4. Class 2 seals are nitrile. Lipseal will have polymyte or PTFE back-up washer when required. O-rings will have nitrile back-up washers when required.

Class 3 Seals — Ethylene Propylene (E.P.R.) Seals

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 Class 3 seals are Skydrol 500 and 700. Class 3 seals are Ethylene Propylene. Lipseals will have a PTFE back-up washer when required. O-rings will have EPR back-up washers when required. **Note:** Class 3 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.

Class 4 Seals — Nitrile Seals

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). Class 4 seals are nitrile seals. 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.

Class 5 Seals — Fluorocarbon Seals

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; Mobil Pyrogard 42, 43, 53, and 55. **Note:** In addition, Class 5 seals can be used with fluids listed below under Class 1 or Class 2 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). 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 thread and a pinned piston to rod connection. Class 5 seals are fluorocarbon seals. Lipseals will have PTFE back-up washers. O-rings will have fluorocarbon back-up when required.

Class 6 Seals

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 lipseal piston seals and straight cushions.

Class 8 Seals – Energized PTFE Seals

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. Body and gland o-ring seals will be fluorocarbon. Fluid resistance is comparable to Class 5.

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

Heavy-Duty Hydraulic Cylinders HV2 Series

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 six classes of service. 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

Lipseals with a back-up washers are standard in HV2 Series cylinders and 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.

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 have 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 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 reassembled to withstand the higher temperature service.

Low Friction Hydraulic Seals

Low Friction hydraulic seals are available as an option for both piston and piston rod seals for HV2 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 assemblies and an elastomer wiper seal. The filled PTFE seals are compatible with Class 1, 2, 3, 4 & 5 fluids and provide virtually leak free sealing. The expanders and rod wiper will be nitrile unless Class 3 or 5 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 optional piston seals for HV2 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 Class 6 fluids.

Water Service

HV2 Series hydraulic cylinders can be modified for water operation and supplied with chrome-plated cylinder bore; electrodeless nickel-plated head, cap and piston; chrome-plated precipitation hardened stainless steel piston rod, chrome-plated cushion plungers. 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

Atlas 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.

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 Iru 905 Ucon Hydrolube J-4	-10°F (-23°C) to +165°F (+74°C)
3 Special (EPR) (At extra cost) Note: Class 3 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: Class 5 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 above paragraph on Fluorocarbon seals for recommended temperature range.
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)

Pressure Ratings / Style 4 Minimum Stroke

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 HV2 Series hydraulic cylinders.

Pressure Ratings

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

HV2 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 diameter 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.

**HV2 Series Hydraulic Cylinders
Maximum Pressure Ratings**

Bore Size (Inches)	Rod Diameter (Inches)	4:1 ¹ Design Factor (Tensile)(PSI)	Heavy-Duty Service (PSI)
1.50	0.625	2530	3000
2.00	1.000	2950	3000
2.50	1.000	2340	3000
3.25	1.375	2250	3000
4.00	1.750	2130	3000
5.00	2.000	2170	3000
6.00	2.500	2270	3000
7.00	3.000	2030	3000
8.00	3.500	2040	3000
10.00	4.500	2720	3000
12.00	5.500	2580	3000
14.00	7.000	2320	3000
16.00	8.000	2750	3000
18.00	9.000	2900	3000
20.00	10.000	2640	3000

¹Applies to all mountings except Models 61, 62, 65, 81, 82, 89.

Rod End Style 4 Minimum Stroke

Sufficient clearance must exist between machining for female rod end style 4 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 4 rod end with a stroke shorter than shown in the table is required.

Bore	Rod Dia.	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	Rod Dia.	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	1.13
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

Cylinder Weights

Cylinder Weights

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 piston rod weights per inch shown in Table B. 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 rod diameter weight for the cylinder bore size involved.

Table A Cylinder Weights, in pounds

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
		50, 51, 52, 53, 61, 62, 65, 66, 74	67, 68, 72, 81, 82, 84, 87, 89, 94		D50, D51, D53, D61, D65, D74	D67, D72, D81, D87, D89	
1.50	0.625	7.8	9.0	.5	9.1	10.7	.6
	1.000	8.4	9.3	.6	9.7	10.8	.8
2.00	1.000	11.6	13.2	.8	14.6	16.8	1.0
	1.375	13.5	17.1	1.0	19.4	20.6	1.4
2.50	1.000	17.0	19.5	1.1	21.0	24.5	1.3
	1.750	22.5	25.5	1.5	27.0	30.0	2.2
3.25	1.375	32.0	41.0	1.8	43.0	52.0	2.2
	2.000	37.0	46.0	2.2	48.0	57.0	3.1
4.00	1.750	48.0	53.0	2.5	59.0	63.0	3.2
	2.500	52.0	58.0	3.2	92.0	97.0	4.6
5.00	2.000	76.0	82.0	3.4	96.0	102.0	4.8
	3.500	88.0	86.0	5.2	117.0	123.0	7.9
6.00	2.500	125.0	133.0	5.2	153.0	159.0	6.6
	4.000	133.0	140.0	7.3	182.0	190.0	10.9
7.00	3.000	233.0	242.0	6.7	320.0	339.0	8.7
	5.000	240.0	253.0	10.3	341.0	360.0	15.9
8.00	3.500	262.0	276.0	9.0	323.0	331.0	11.7
	5.500	300.0	309.0	13.0	390.0	411.0	19.7

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
		81, 82	67, 68, 89	65, 66	72, 84		Add to All Mtg. Styles	
10.00	4.500	562	646	684	607	15	43	20
	7.000	620	704	742	665	21	101	32
12.00	5.500	924	1057	1136	1000	22	64	29
	8.000	1022	1155	1234	1097	29	162	43
14.00	7.000	1335	1520	1582	1485	28	101	39
	10.000	1496	1681	1743	1646	39	262	61
16.00	8.000	N/A	2073	2257	2226	35	149	49
	10.000		2181	2364	2334	43	257	65
18.00	9.000		3165	3256	3330	45	198	63
	10.000		3224	3315	3390	50	257	72
20.00	10.000		4231	4406	4551	57	257	79

Table B Piston Rod Weights, in pounds

Rod Dia.	Rod Wt. Per Inch	Rod Dia.	Rod Wt. Per Inch	Rod Dia.	Rod Wt. Per Inch	Rod Dia.	Rod Wt. Per Inch
0.625	.09	2.000	.89	4.000	3.56	7.000	10.89
1.000	.22	2.500	1.40	4.500	4.51	8.000	14.22
1.375	.42	3.000	2.00	5.000	5.56	10.000	22.23
1.750	.68	3.500	2.72	5.500	6.72		

Ports

Ports

HV2 Series cylinders can be supplied with SAE straight O-ring ports or NPTF pipe thread ports. 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.

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

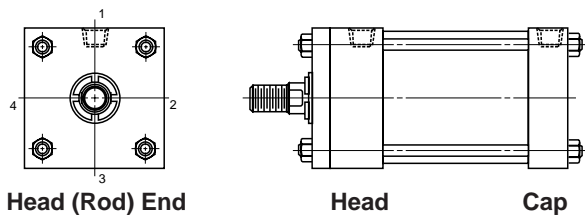


Table A

Mounting Style	Port Position Available	
	Head End	Cap End
51, 52, 53, 61, 62, 65, 66, 87, 89	1, 2, 3 or 4	1, 2, 3 or 4
68, 82, 84, 94	1, 2, 3 or 4	1 or 3
67, 81	1 or 3	1, 2, 3 or 4
72, 74	1	1

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.

Straight Thread Ports

The SAE straight thread O-ring port is recommended for hydraulic applications. Miller will furnish this port configuration at positions shown in Table A. 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 the 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 B.

Table D – Standard Port Sizes

Bore	S SAE	N NPTF	F SAE Code 61 Flange	M ISO 6149	J BSPT R BSPP	G Metric
1.50	8	1/2	N/A	M22 x 1.5	1/2	M22 x 1.5
2.00	8	1/2	N/A	M22 x 1.5	1/2	M22 x 1.5
2.50	8	1/2	1/2*	M22 x 1.5	1/2	M22 x 1.5
3.25	12	3/4	3/4	M27 x 2	3/4	M27 x 2
4.00	12	3/4	3/4	M27 x 2	3/4	M27 x 2
5.00	12	3/4	3/4	M27 x 2	3/4	M27 x 2
6.00	16	1	1	M33 x 2	1	M33 x 2

Table B

SAE Straight Thread O-Ring Ports

Size No.	Tube O.D. (In.)	Thread Size	Size No.	Tube O.D. (In.)	Thread Size
2	0.13	5/16 - 24	12	0.75	1 1/16 - 12
3	0.19	3/8 - 24	—	—	—
4	0.25	7/16 - 20	16	1.00	1 5/16 - 12
5	0.31	1/2 - 20	20	1.25	1 5/8 - 12
6	0.38	9/16 - 18	24	1.50	1 7/8 - 12
8	0.50	3/4 - 16	32	2.00	2 1/2 - 12
10	0.63	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. Miller HV2 Series 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 C

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 BSPP 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 BSPP 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. See table below for standard port size for each bore.

Bore	S SAE	N NPTF	F SAE Code 61 Flange	M ISO 6149	J BSPT R BSPP	G Metric
7.00	20	1 1/4	1 1/4	M42 x 2	1 1/4	M42 x 2
8.00	24	1 1/2	1 1/2	M48 x 2	1 1/2	M48 x 2
10.00	24	1 1/2	2	M48 x 2	1 1/2	M48 x 2
12.00	24	1 1/2	2 1/2	M48 x 2	1 1/2	M48 x 2
14.00	24	1 1/2	1 1/2	M48 x 2	1 1/2	M48 x 2
16.00-20.00	24	—	3	—	—	—

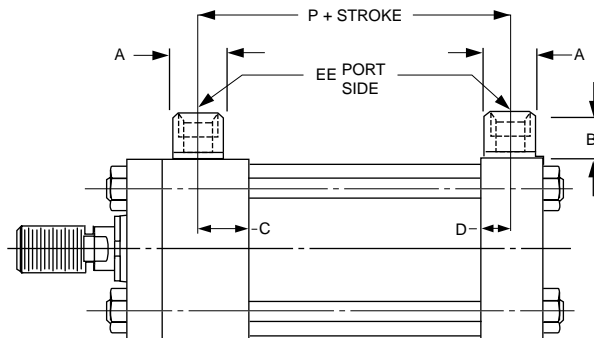
*Available with 1 inch rod diameter only.

Ports

Oversize Ports

Oversize NPTF or SAE straight thread ports can be provided, at an extra charge. 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. HV2 Series 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.



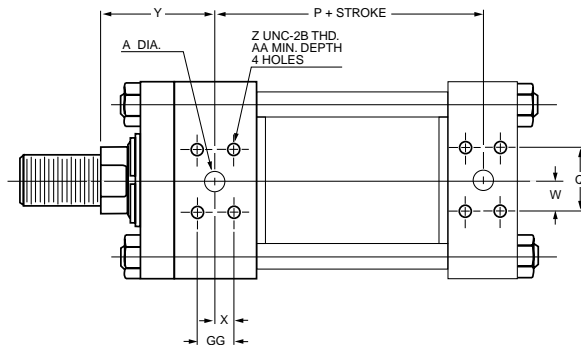
Oversize NPTF Port Boss Dimensions

Bore	EE (NPTF)	A (Dia.)	B	C	D	P
1.50	3/4	1.38	1.00	0.75	0.78	2.91
2.00	3/4	1.38	1.00	0.75	0.78	2.91
2.50	3/4	1.38	1.00	0.75	0.78	3.03
3.25	1	1.75	1.19	0.91	0.88	3.53
4.00	1	1.75	1.19	0.91	0.88	3.78
5.00	1	1.75	1.19	0.91	0.88	4.28
6.00	1 1/4	2.25	1.31	1.13	1.13	5.13
7.00	1 1/2	2.50	1.56	1.38	1.38	5.75
8.00	2	3.00	1.69	1.50	1.50	6.50

Oversize SAE Straight Thread Port Boss Dimensions

Bore	EE (SAE)	A (Dia.)	B	C	D	P
1.50	10 ¹	-	-	-	-	2.88
2.00	10 ¹	-	-	-	-	2.88
2.50	10 ¹	-	-	-	-	3.00
3.25	16	1.75	1.19	0.88	0.88	3.44
4.00	16	1.75	1.19	0.88	0.88	3.69
5.00	16	1.75	1.19	0.88	0.88	4.19
6.00	20 ¹	-	-	-	-	5.19
7.00	24 ¹	-	-	-	-	5.50
8.00	N/A	-	-	-	-	6.25

¹ Port tapped directly into head and cap.



Flange Ports (Code 61, 3000 psi) SAE 4 Bolt Flange Ports

Bore Size	SAE Dash No.	Y	A	P	Q	W	X
2.50 ²	8	2.39	.50	2.97	1.50	.75	.34
3.25 ²	12	2.80	.75	3.41	1.87	.94	.44
		3.17					
		3.05					
4.00 ²	12	3.05	.75	3.66	1.87	.94	.44
		3.42					
		3.17					
5.00 ²	12	3.17	.75	4.16	1.87	.94	.44
		3.42					
		3.42					
6.00	16	3.52	1.00	4.58	2.06	1.03	.52
7.00	20	3.70	1.25	5.59	2.31	1.16	.59
8.00	24	3.84	1.50	6.31	2.75	1.37	.70

Bore Size	SAE Dash No.	Z	AA	GG
2.50 ²	8	5/16 - 18	.81	.69
3.25 ²	12	3/8 - 16	.75	.87
4.00 ²	12	3/8 - 16	.75	.87
5.00 ²	12	3/8 - 16	.75	.87
6.00	16	3/8 - 16	.87	1.03
7.00	20	7/16 - 14	1.00	1.19
8.00	24	1/2 - 13	1.06	1.41

² 2.50", 3.25", 4.00" & 5.00" bores cap-flange port not available on Model 66. Model 62 not available at position 2 or 4. Port flange overhangs cap on Model 68.
³ 2.50" bore head flange port available with 1.000" rod only.

Stroke Data, Stroke Adjusters

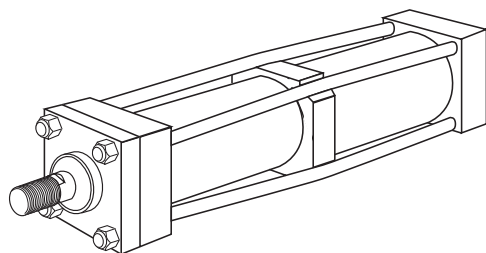
Stroke Data

Miller 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 stroke tolerances run +.031" to -.015" up to 20" stroke, +.031" to -.20" 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 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.

Tie Rod Supports



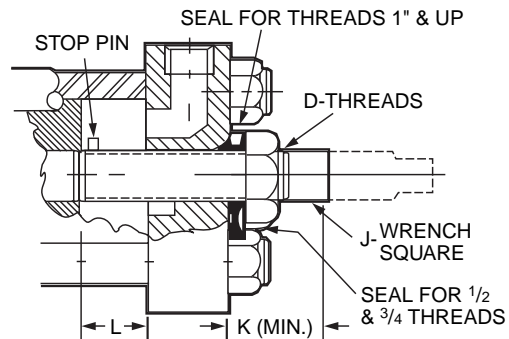
Rigidity of Envelope

The prestressed tie rod construction of cylinders has advantages in rigidity within the limits of the cylinder tube to resist buckling. For long stroke cylinders within practical limits. Tie rod supports (see table below) which move the tie rod centerlines radially outward are used.

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.

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 infrequent¹ adjustment at the uncushioned cap end of a cylinder. Please contact the factory, specifying details of the application and the adjustment required.



Bore Size	D	J	K	L (Max.)
1.50	1/2 - 20	0.31	0.94	5.00
2.00	3/4 - 16	0.44	1.25	8.00
2.50, 3.25	1 - 14	0.63	1.69	9.00
4.00	1 1/2 - 12	0.94	2.13	18.00
5.00	2 - 12	1.31	2.69	20.00
6.00	2 1/2 - 12	1.69	3.13	20.00
7.00	3 - 12	2.00	3.25	20.00
8.00	3 1/2 - 12	2.38	3.50	20.00

¹ 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.

Number of Supports Required	Stroke (Inches)												
	Bore	36	48	60	72	84	96	108	120	132	144	156	168
1.50	—	—	1	1	1	2	2	2	3	3	3	3	4
2.00	—	—	—	1	1	1	1	2	2	2	2	2	3
2.50	—	—	—	—	—	—	1	1	1	1	1	2	2
3.25	—	—	—	—	—	—	—	—	1	1	1	1	1
4.00	—	—	—	—	—	—	—	—	—	—	1	1	1

Note: 5.00" through 8.00" bore sizes — no supports required.

Spherical Bearing Mount Application

Application and Design Data

The spherical bearing life is influenced by many factors, i.e., bearing pressure, load direction oscillating angle and lubrication. The maximum operating pressure ratings of the spherical bearing mountings are based on standard commercial bearing ratings. The 4:1 design factor rating is based on the tensile strength of the material.

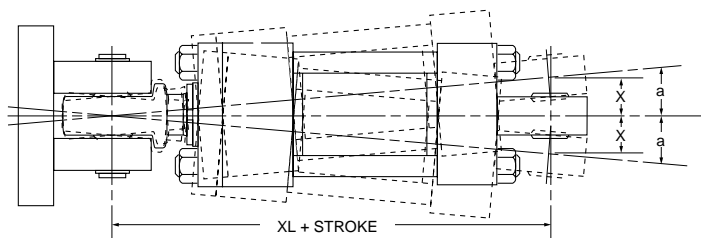
The spherical bearings are dimensioned to ensure a satisfactory bearing life under normal operating conditions. The bearing races are made of through-hardened steel and are precision ground. They are phosphate treated and coated with dry film lubricant to minimize friction of contacting surfaces. In the case of a permanent unidirectional load to the bearing, or other unusual operating conditions, the use of a larger bearing may be required.

For longer bearing life, regular lubrication will protect the spherical plain bearing from premature wear and corrosion. Rust-inhibiting EP greases of lithium/lead base, preferably with molybdenum disulphide additives are particularly suited. The radial bearings have lubricating holes and grooves in the races permitting lubrication. The bearing housings at the cap and rod end are provided with grease fittings for lubrication.

Maximum angle of swivel in relation to the center line of the pivot pin is shown as angle *a* in the table below. It is recommended that this angle is not exceeded when mounting the cylinder.

Mounting Information

Head End Mounting



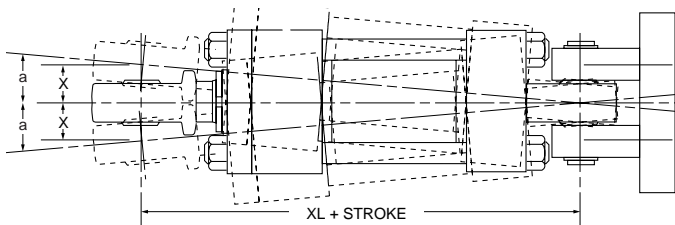
Recommended maximum swivel angle on each side of the cylinder centerline.

Table 1

Bore	Head End Mounted		Cap End Mounted	
	Angle <i>a</i>	Tan. of <i>a</i>	Angle <i>a</i>	Tan. of <i>a</i>
1.50	2.00°	0.035	2.00°	0.035
2.00	2.50°	0.044	4.50°	0.079
2.50	2.50°	0.044	4.50°	0.079
3.25	3.00°	0.052	3.00°	0.052
4.00	2.50°	0.044	3.00°	0.052
5.00	3.00°	0.052	3.00°	0.052
6.00	3.00°	0.052	3.00°	0.052

Note: Dimension X is the maximum off center mounting of the cylinder. To determine dimension X for various stroke lengths multiply distance between pivot pin holes by tangent of angle *a*. For extended position use $X = XL + 2X$ stroke.

Cap End Mounting

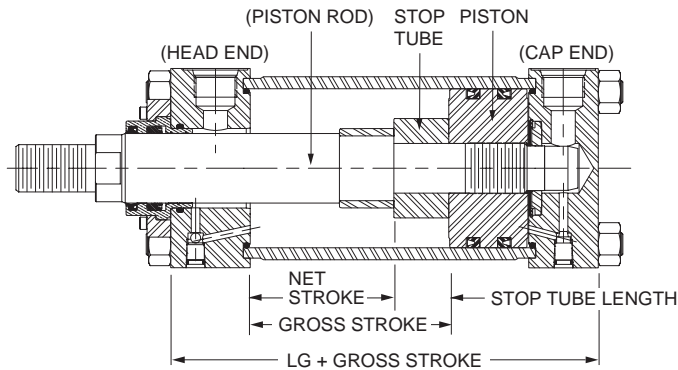


Stop Tubing / Mounting Classes

Stop Tubing

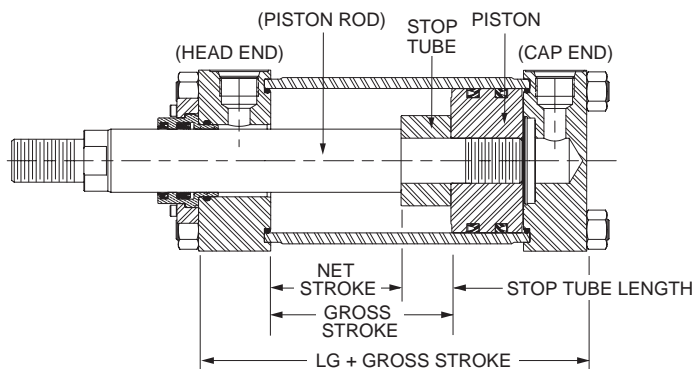
Stop tube is recommended to lengthen the distance between the bushing and piston to reduce bearing loads when the cylinder is fully extended. This is especially true of horizontally mounted and long stroke cylinders. Long stroke cylinders achieve additional stability through the use of a stop tube.

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.

Drawing B



This design is supplied on all non-cushion cylinders.

Mounting Classes

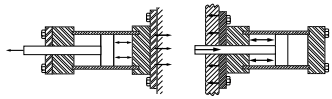
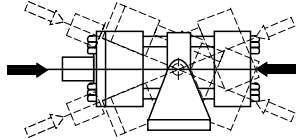
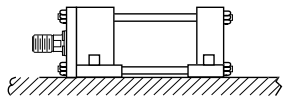
Standard mountings for fluid power cylinders fall into three basic groups. The groups can be summarized as follows:

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.	
<p>Heavy-Duty Service For Thrust Loads For Tension Loads</p>	 <p>Models 52, 66, 68 Models 53, 65, 67</p>
<p>Medium -Duty Service For Thrust Loads For Tension Loads</p>	<p>Models 62, 66 Models 61, 65</p>
<p>Light-Duty Service For Thrust Loads For Tension Loads</p>	<p>Model 62 Model 61</p>
Group 2 PIVOT MOUNTS which absorb force on cylinder centerline.	
<p>Heavy-Duty Service For Thrust Loads For Tension Loads</p>	 <p>Models 81, 89 Models 81, 82, 84, 87, 89</p>
<p>Medium-Duty Service For Thrust Loads For Tension Loads</p>	<p>Model 84 Model 84</p>
Group 3 FIXED MOUNTS which do not absorb force on the centerline.	
<p>Heavy-Duty Service For Thrust Loads For Tension Loads</p>	 <p>Model 72 Model 72</p>
<p>Medium-Duty Service For Thrust Loads For Tension Loads</p>	<p>Model 74 Model 74</p>

Piston Rod Selection Data

How to Use the Chart

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

1. 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.
2. Using this stroke factor, determine the "basic length" from the equation:

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

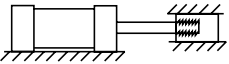
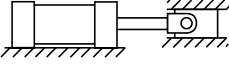
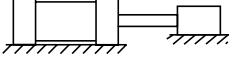
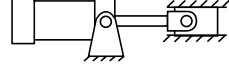

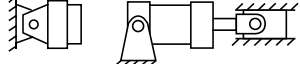
The graph is prepared for standard rod extensions beyond the face of the rod gland retainers. For rod extensions greater than standard, add the increase to the stroke in arriving at the "basic length."

3. Find the load imposed for the thrust application by multiplying the full bore area of the cylinder by the system pressure.
4. Enter the graph along the values of "basic length" and "thrust" as found above and note the point of intersection:
 - A) The correct piston rod size is read from the diagonally curved line labeled "Rod Diameter" next above the point of intersection.
 - B) 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.

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

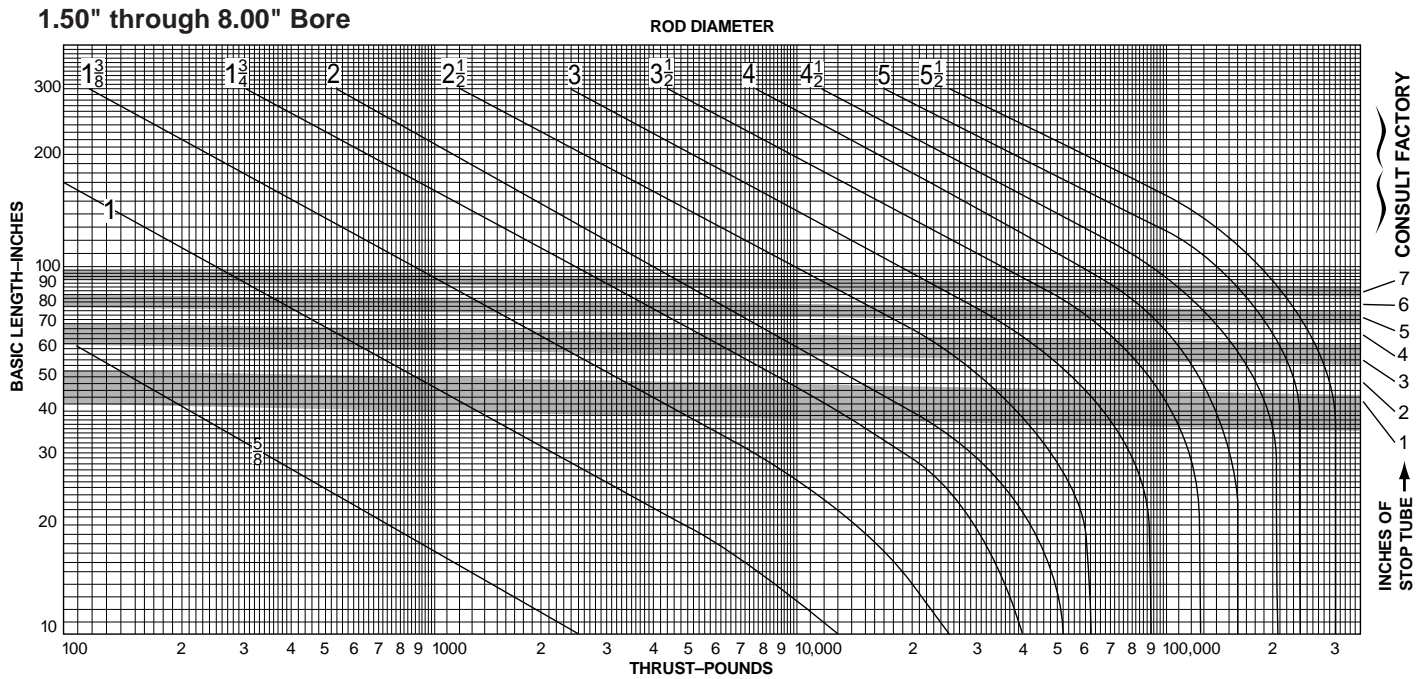
Warning ⚠

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.

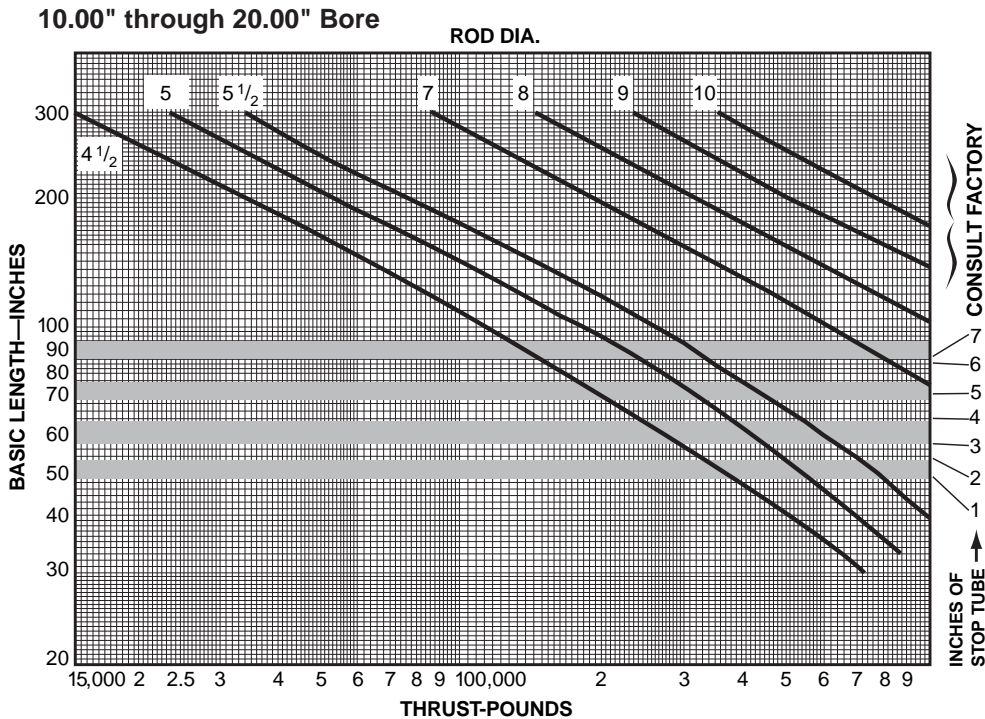
Recommended Mounting Styles for Maximum Stroke and Thrust Loads	Rod End Connection	Case	Stroke Factor
Groups 1 or 3 Long stroke cylinders for thrust loads should be mounted using a heavy-duty mounting style at one end, firmly fixed and aligned to take the principal force. Additional mounting should be 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. See "Tie Rod Supports — Rigidity of Envelope" for a guide. 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 Model 81 — Trunnion on Head	Pivoted and Rigidly Guided	IV 	1.00
Models 87 & 89 — Intermediate Trunnion	Pivoted and Rigidly Guided	V 	1.50
Model 82 — Trunnion on Cap or Clevis on Cap	Pivoted and Rigidly Guided	VI 	2.00

Piston Rod Selection Data

Piston Rod — Stroke Selection Chart



Piston Rod — Stroke Selection Chart



Rod Bushing Drain / Thrust Key Mountings

Rod Bushing Drain

Rod bushing 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 bushing 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 bushing is not easily visible within the equipment. Specify rod bushing drain port option and the drain port location, position 1, 2, 3, or 4.

Drain Port Location

Bore	Rod Dia.	50, 52, 62, 66, 68, 72 (no key), 74 (no key), 81, 82, 84, 87, 89, 94	51 53	61 65	68	72, 74 With Thrust Key Plate
1.50	0.625	Head	Head	Head	Head	Head
	1.000	Full Retainer	Full Retainer	Flange Retainer	Head	Key Retainer
2.00	1.000	Bolted Retainer	Full Retainer	Flange Retainer	Head	Key Retainer
	1.375	Full Retainer	Full Retainer	Flange Retainer	Head	Key Retainer
2.50	1.000	Bolted Retainer	Bolted Retainer	Flange Retainer	Head	Head
	1.375	Bolted Retainer	Bolted Retainer	Flange Retainer	Head	Head
	1.750	Bolted Retainer	Bolted Retainer	Flange Retainer	Head	Key Retainer
3.25	All	Bolted Retainer	Bolted Retainer	Flange Retainer	Head	Head
4.00	All	Bolted Retainer	Bolted Retainer	Head	Head	Head
5.00	2.000 – 3.000	Bolted Retainer	Bolted Retainer	Head	Head	Head
	3.500	Bolted Retainer	Bolted Retainer	Flange Retainer	Head	Key Retainer
6.00 – 8.00	All ¹	Bolted Retainer	Bolted Retainer	Head	Head	Head

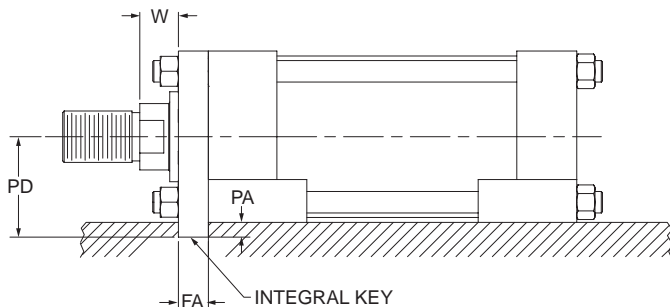
¹On 5.500" diameter piston rods, with drain in position 2 or 4, the port will be offset 18 degrees clockwise from the position specified.

The full square retainer, key retainer, or mounting flange thickness is increased on bore and rod combinations listed in the table at right. The piston rod is extended on 51, 53, 65 and 66 mounts to provide the standard 'W' dimension.

Bore	Rod Dia.	Retainer or Mounting Flange Thickness
1.50	1.000	0.63
2.00	1.375	0.75
2.50	1.750	0.88
3.25	1.750 & 2.000	0.88

Thrust Key Mountings

Thrust key mountings eliminate the need of using fitted bolts or external keys on side mounted cylinders. Cylinder Models 72 and 74 can be provided with the bushing 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.



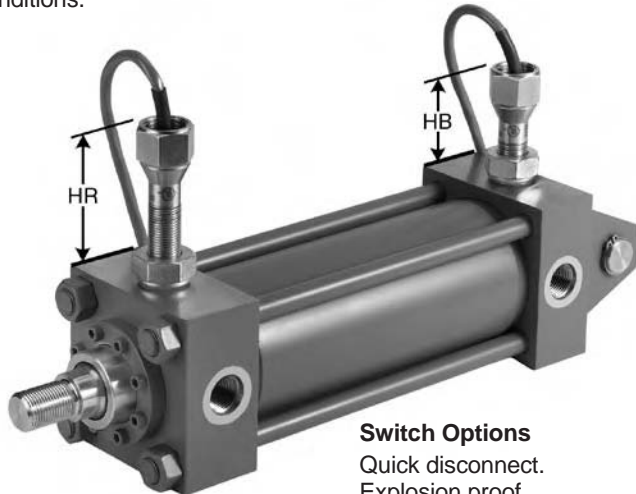
Bore	+0.000" -0.001" Dim. FA	Dim. PA	Dim. PD Models 72, 74
1.50	.361	0.19	1.44
2.00	.611	0.31	1.81
2.50	.611	0.31	2.06
3.25	.736	0.38	2.63
4.00	.861	0.44	2.94
5.00	.861	0.44	3.69
6.00	.986	0.50	4.25
8.00	.986	0.50	5.25

End of Stroke Magnetic Principle Type Proximity Switch

Reliable: Proximity type sensor never contacts cylinder moving parts; eliminating wear and adjustments.

Positive Action: Multiple magnet design provides "snap action." Eliminates creep and false signals.

Versatile: Sealed stainless steel switch body can be used with any operating fluid and is impervious to most environmental conditions.



Switch Options

- Quick disconnect.
- Explosion proof.
- Sub sea, to 2000 feet depths.
- Extra-long leads.

Switch Height

Bore	Rod Dia.	HR	HB
1.50	0.625	2.56	3.25
	1.000	2.75	
2.00	1.000	2.56	3.00
	1.375	2.75	
2.50	1.000	2.31	2.75
	1.375	2.50	
	1.750	2.75	
3.25	1.375	2.94	2.50
	1.750	3.13	
	2.000	3.31	
4.00	1.750	2.88	2.44
	2.000	3.06	
	2.500	2.44	
5.00	2.000	2.31	3.25
	2.500	2.63	
	3.000	2.88	
	3.500	3.13	
6.00	2.500	2.13	1.44
	3.000	2.38	
	3.500	2.63	
	4.000	2.88	
7.00	3.000	3.38	2.63
	3.500	2.13	
	4.000	2.38	
	4.500	2.63	
	5.000	2.94	
8.00	3.500	3.13	2.25
	4.000	3.38	
	4.500	3.63	
	5.000	2.44	
	5.500	2.75	

As shown in the sketches above, these switches are magnetically operated. Dual magnets provide a dependable "snap action" for positive position sensing.

In the "unoperated" position, the magnet assembly is attracted in the direction of the arrow, causing a finely ground stainless steel connecting rod to hold the contacts open.

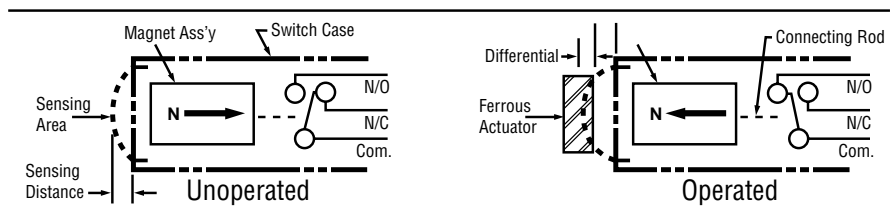
In the "operated" position a ferrous part (cushion or piston) enters the sensing area and attracts the magnet assembly which causes the rod to draw the contacts closed.

How to Order:

To order switches, enter a "9" in the Modified field of the cylinder model code. Describe the modification in notes by specifying:

1. Magnetic end of stroke switch
2. Installation in head, cap, or both ends of the cylinder
3. Location in the head or cap (position #1, 2, 3, or 4) not occupied by a port or mounting

OPERATING PRINCIPLE



Specifications

Switch Type:
Magnetic Principle

Contacts:
Single Pole-Double Throw (SPDT)

Contact Rating¹:
2 Amp at 110-240 VAC (UL & CSA) 100 MA at 12 VDC 50 MA at 24 VDC (CSA)

Note: Check current draw of solenoid valves.

Connection: 36" long, 3 wire, potted in cable. Can be wired Normally Open or Normally Closed. Leads are tagged (Com, N/O, N/C)

Pressure Rating: 3000 PSI
Non Shock

Temperature Range:
-20°F to + 200°F (UL 104°F. Max.)

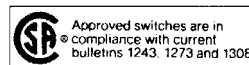
Sensing Gap:
.030 to .060 inch

Trip Point: Factory Set with Piston Bottomed out

Release Point: Approximately 0.25" Piston Travel

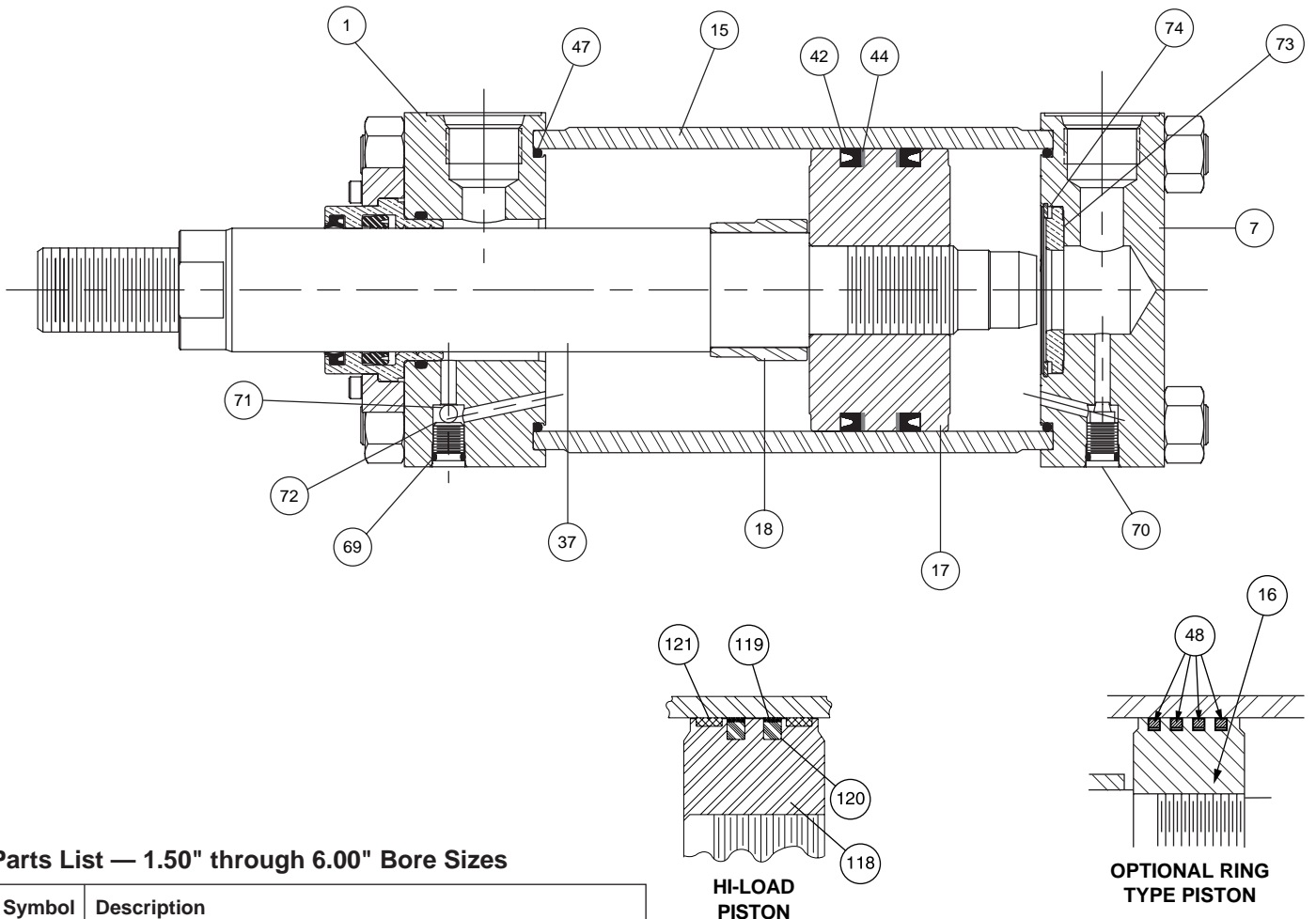
Min. Cyl. stroke 0.50" on 1.50" & 2.00" bore, 0.75" stroke on 2.50" and up.

¹UL and CSA approved for industrial control, general purpose use. If Class I, Division 1 or 2 is required, please specify.



Parts List / Piston and Rod Assemblies

1.50" through 6.00" Bore Sizes



Parts List — 1.50" through 6.00" Bore Sizes

Symbol	Description
1	Head
7	Cap
15	Cylinder tube
16	Piston, ring type
17	Piston, lipseal type
18	Cushion plunger, rod head cushion
19	Tie rod
23	Tie rod nut
27	Retainer
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
122	Retainer bolt

HI-LOAD
PISTON

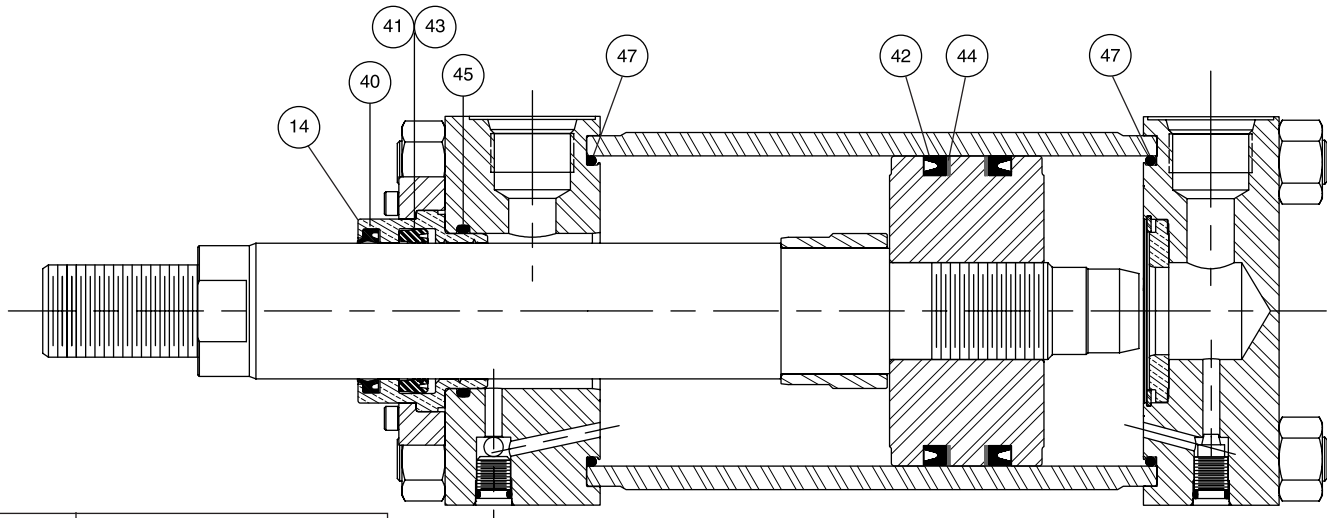
OPTIONAL RING
TYPE PISTON

Piston and Rod Assemblies

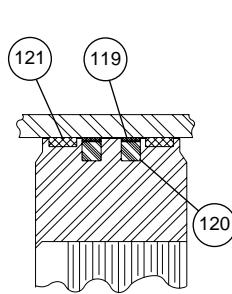
Factory assembled piston and rod assemblies (that include seals for piston type specified) are recommended.

Parts Identification / Seal Kits

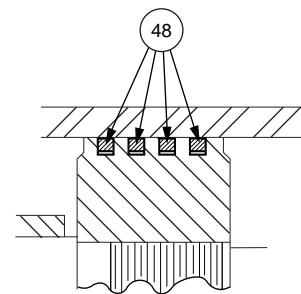
1.50" through 6.00" Bore Sizes



Symbol	Description
14	Bushing
40	Rod Wiper
41	Rod Seal
42	Piston Lipseal
43	Rod Seal Back-up Washer
44	Piston Seal Back-up Washer
45	Bushing to head o-ring
47	End seal o-ring
48	Piston ring
62	Bushing kit
119	Outer Ring
120	Inner Ring
121	Wear Ring



HI-LOAD PISTON



OPTIONAL RING TYPE PISTON

Seal Kits

See Operating Fluids and Temperature Range Page for compatibility.

Bore Size	Class 1 & Class 2 Buna-N				Tie Rod Nut Torque ¹ lb-ft
	Tube Seal Kits (Contains: 2 Each Sym. #47)	Piston Lipseal Kits (Contains: 2 Each Sym. #42, 44 & 47)	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #47, 119, 120 & 121)	
1.50	HV2 ES100 150	HV2 KB100 150	HV2 KB300 150	HV2 KB500 150	18 19
2.00	HV2 ES100 200	HV2 KB100 200	HV2 KB300 200	HV2 KB500 200	45 49
2.50	HV2 ES100 250	HV2 KB100 250	HV2 KB300 250	HV2 KB500 250	45 49
3.25	HV2 ES100 325	HV2 KB100 325	HV2 KB300 325	HV2 KB500 325	120 124
4.00	HV2 ES100 400	HV2 KB100 400	HV2 KB300 400	HV2 KB500 400	131 135
5.00	HV2 ES100 500	HV2 KB100 500	HV2 KB300 500	HV2 KB500 500	312 316
6.00	HV2 ES100 600	HV2 KB100 600	HV2 KB300 600	HV2 KB500 600	528 544

Rod Dia.	Class 1 Polyurethane & Buna-N		
	Bronze Bushing Kits (Contains: 1 Each Sym. #14, 40, 41 & 45)	Nodular Iron Bushing Kits (Contains: 1 Each Sym. #14, 40, 41 & 45)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, & 45)
0.625	HV2 KR110 63	HV2 KR120 63	HV2 KR310 63
1.000	HV2 KR110 100	HV2 KR120 100	HV2 KR310 100
1.375	HV2 KR110 138	HV2 KR120 138	HV2 KR310 138
1.750	HV2 KR110 175	HV2 KR120 175	HV2 KR310 175
2.000	HV2 KR110 200	HV2 KR120 200	HV2 KR310 200
2.500	HV2 KR110 250	HV2 KR120 250	HV2 KR310 250
3.000	HV2 KR110 300	HV2 KR120 300	HV2 KR310 300
3.500	HV2 KR110 350	HV2 KR120 350	HV2 KR310 350
4.000	HV2 KR110 400	HV2 KR120 400	HV2 KR310 400

Bore Size	Class 5 Fluorocarbon			
	Tube Seal Kits (Contains: 2 Each Sym. #47)	Piston Lipseal Kits (Contains: 2 Each Sym. #42, 44 & 47)	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #47, 119, 120 & 121)
1.50	HV2 ES200 150	HV2 KB200 150	HV2 KB400 150	HV2 KB600 150
2.00	HV2 ES200 200	HV2 KB200 200	HV2 KB400 200	HV2 KB600 200
2.50	HV2 ES200 250	HV2 KB200 250	HV2 KB400 250	HV2 KB600 250
3.25	HV2 ES200 325	HV2 KB200 325	HV2 KB400 325	HV2 KB600 325
4.00	HV2 ES200 400	HV2 KB200 400	HV2 KB400 400	HV2 KB600 400
5.00	HV2 ES200 500	HV2 KB200 500	HV2 KB400 500	HV2 KB600 500
6.00	HV2 ES200 600	HV2 KB200 600	HV2 KB400 600	HV2 KB600 600

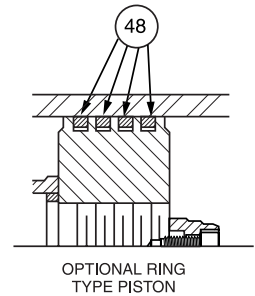
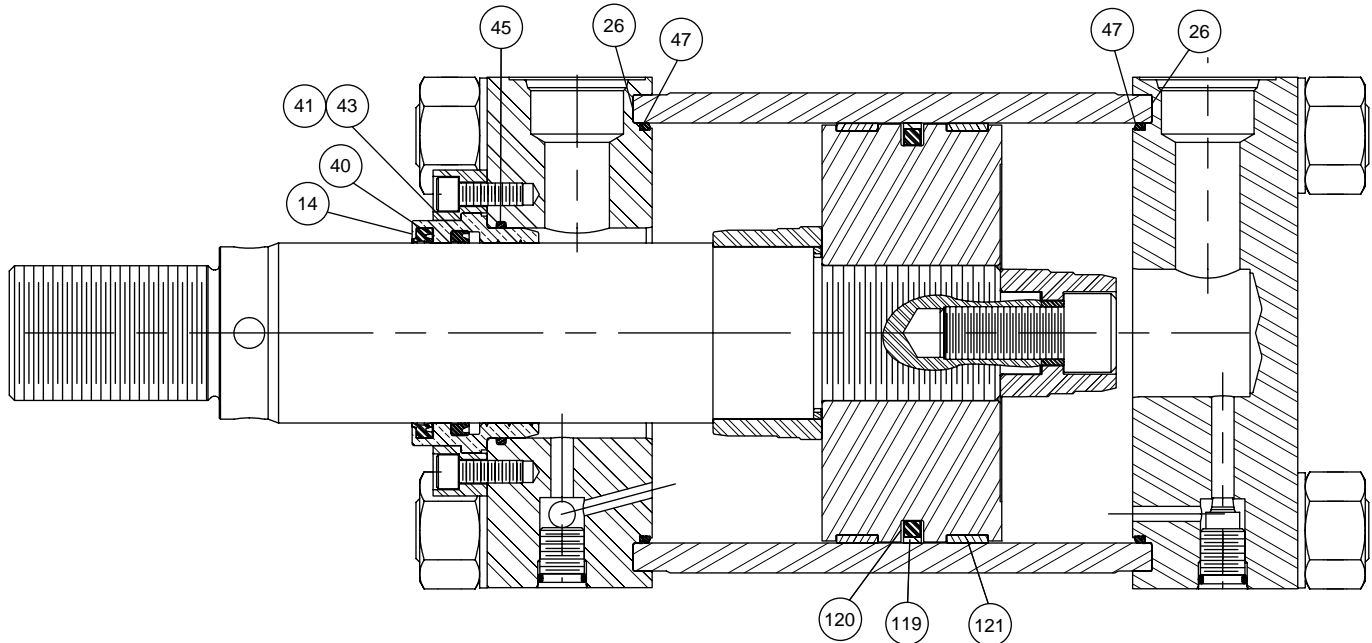
Rod Dia.	Class 5 Fluorocarbon		
	Bronze Bushing Kits (Contains: 1 Each Sym. #14, 40, 41, 43 ² & 45)	Nodular Iron Bushing Kits (Contains: 1 Each Sym. #14, 40, 41, 43 ² & 45)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, 43 ² & 45)
0.625	HV2 KR210 63	HV2 KR220 63	HV2 KR410 63
1.000	HV2 KR210 100	HV2 KR220 100	HV2 KR410 100
1.375	HV2 KR210 138	HV2 KR220 138	HV2 KR410 138
1.750	HV2 KR210 175	HV2 KR220 175	HV2 KR410 175
2.000	HV2 KR210 200	HV2 KR220 200	HV2 KR410 200
2.500	HV2 KR210 250	HV2 KR220 250	HV2 KR410 250
3.000	HV2 KR210 300	HV2 KR220 300	HV2 KR410 300
3.500	HV2 KR210 350	HV2 KR220 350	HV2 KR410 350
4.000	HV2 KR210 400	HV2 KR220 400	HV2 KR410 400

¹When assembling cylinder, be sure to torque the tie rods evenly.

²Item 43 not required for 0.625" and 1.000" rods.

Parts Identification / Seal Kits

7.00" & 8.00" Bore Sizes



Parts Identification

Sym. No.	Description	Sym. No.	Description
14	Bushing	47	End Seal O-Ring
40	Rod Wiper	48	Piston Ring
41	Rod Seal	62	Bushing Kit
43	Rod Seal Back Up Washer	119	Outer Ring
26	End Seal Back Up Washer	120	Inner Ring
45	Bushing to Head O-Ring	121	Wear Ring

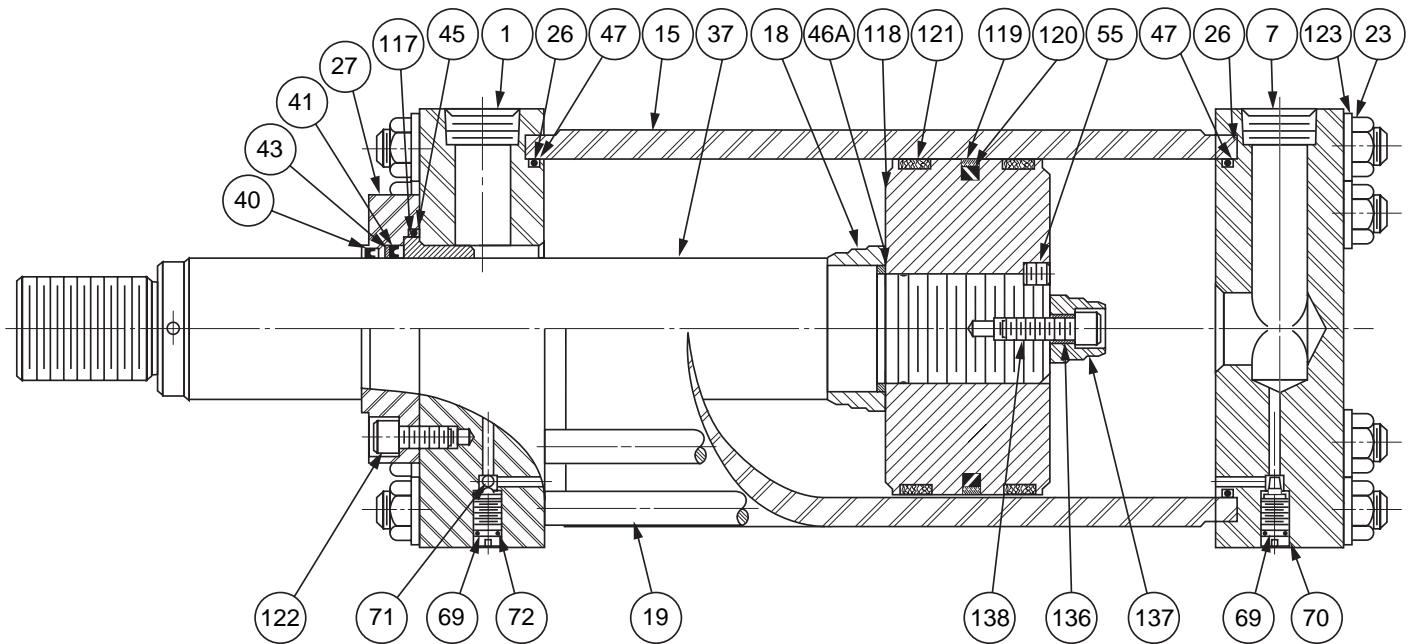
Seal Kits

See Operating Fluids and Temperature Range Page for compatibility.

Rod Dia.	Class 1 Service Polyurethane & Buna-N			Class 5 Service Fluorocarbon		
	Bronze Bushing Kits (Contains: 1 Each Sym. #14, 40, 41, 45)	Nodular Iron Bushing Kits (Contains: 1 Each Sym. #14, 40, 41, 45)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, 45)	Bronze Bushing Kits (Contains: 1 Each Sym. #14, 40, 41, 43, 45)	Nodular Iron Bushing Kits (Contains: 1 Each Sym. #14, 40, 41, 43, 45)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, 43, 45)
3.000	HV2-KR110-300	HV2-KR120-300	HV2-KR310-300	HV2-KR210-300	HV2-KR220-300	HV2-KR410-300
3.500	HV2-KR110-350	HV2-KR120-350	HV2-KR310-350	HV2-KR210-350	HV2-KR220-350	HV2-KR410-350
4.000	HV2-KR110-400	HV2-KR120-400	HV2-KR310-400	HV2-KR210-400	HV2-KR220-400	HV2-KR410-400
5.000	HV2-KR110-500	HV2-KR120-500	HV2-KR310-500	HV2-KR210-500	HV2-KR220-500	HV2-KR410-500
5.500	HV2-KR110-550	HV2-KR120-550	HV2-KR310-550	HV2-KR210-550	HV2-KR220-550	HV2-KR410-550

Bore Size	Class 1 Service Buna-N			Class 5 Service Fluorocarbon		
	Tube Seal Kits (Contains: 2 Each Sym. #47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #26, 47 & 121; 1 Each Sym. #119 & 120)	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #47)	Tube Seal Kits (Contains: 2 Each Sym. #47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #26, 47 & 121; 1 Each Sym. #119 & 120)	Piston Ring Kits (Contains: 4 Each Sym. #48; 2 Each Sym. #47)
7.000	HV2-ES100-700	HV2-KB500-700	HV2-KB300-700	HV2-ES200-700	HV2-KB600-700	HV2-KB400-700
8.000	HV2-ES100-800	HV2-KB500-800	HV2-KB300-800	HV2-ES200-800	HV2-KB600-800	HV2-KB400-800

10.00" through 20.00" Bore Sizes



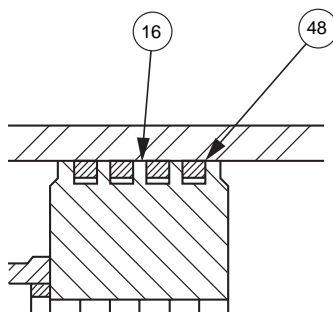
Sym. No.	
1	Head
7	Cap
15	Cylinder
16	Piston Tube – Ring Type Piston
18	Cushion Sleeve
19	Tie Rod
23	Tie Rod Nut – Non-Locking
26	Back-Up Washer, Cylinder Tube
27	Retainer
37	Piston Rod
40	Wiperseal
41	Rod Seal (Polypak)
43	Back-Up Washer, Polypak
45	O-Ring, Bushing to Head
46A	Cushion Sealing Ring
47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

Sym. No.	
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 – 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

Parts Identification / Seal Kits

10.00" through 20.00" Bore Sizes

Optional Cast Iron
Piston Ring 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.

Buna-N

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 on page 57 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 Class 5 seals.

For elevated temperature service above +250°F. (+121°C) specify Class 5 seals. Class 5 seals can operate up to a maximum of +400°F. (+204°C) with reduced service life.

Rod Gland and Rod Seal Kits

Rod Dia.	Class 1 Polyurethane & Buna-N		Class 5 Service Fluorocarbon		Retainer Bolt Torque (Torque values are for bolts installed with lubrication.)
	Rod Gland Kits (Contains: 1 Each Sym. #40, 41, 43, 45 & 117)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, 43, & 45)	Rod Gland Kits (Contains: 1 Each Sym. #40, 41, 43, 45 & 117)	Rod Seal Kits (Contains: 1 Each Sym. #40, 41, 43 & 45)	
4.500	HV2-KR125-450	HV2-KR315-450	HV2-KR225-450	HV2-KR415-450	100-105 lb-ft
5.000	HV2-KR125-500	HV2-KR315-500	HV2-KR225-500	HV2-KR415-500	185-194 lb-ft
5.500	HV2-KR125-550	HV2-KR315-550	HV2-KR225-550	HV2-KR415-550	185-194 lb-ft
7.000	HV2-KR125-700	HV2-KR315-700	HV2-KR225-700	HV2-KR415-700	100-105 lb-ft
8.000	HV2-KR125-800	HV2-KR315-800	HV2-KR225-800	HV2-KR415-800	330-346 lb-ft
9.000	HV2-KR125-900	HV2-KR315-900	HV2-KR225-900	HV2-KR415-900	330-346 lb-ft
10.000	HV2-KR125-1000	HV2-KR315-1000	HV2-KR225-1000	HV2-KR415-1000	330-346 lb-ft

Piston Seal Kits

Bore Size	Class 1 & 2 Buna-N			Class 5 Fluorocarbon		Tie Rod Nut Torque ¹
	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #47 & 26)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #47 & 121 1 Each Sym. #119 & 120)	PolyPak Piston Seal Kits (Contains: 2 Each Sym. #42, 44, & 47)	Piston Ring Kits (Contains: 4 Each Sym. #48 & 2 Each Sym. #47)	Hi-Load Piston Seal Kits (Contains: 2 Each Sym. #47 & 121 1 Each Sym. #119 & 120)	
10.00	HV2-KB300-1000	HV2-KB500-1000	HV2-KB700-1000	HV2-KB400-1000	HV2-KB600-1000	700-716 lb-ft
12.00	HV2-KB300-1200	HV2-KB500-1200	HV2-KB700-1200	HV2-KB400-1200	HV2-KB600-1200	1320-1336 lb-ft
14.00	HV2-KB300-1400	HV2-KB500-1400	HV2-KB700-1400	HV2-KB400-1400	HV2-KB600-1400	1000-1016 lb-ft
16.00 - 20.00	Consult Factory					2900-3000 lb-ft

¹ When assembling the cylinder, be sure to torque the tie rods evenly.

Model Numbers**How to Order HV2 Series Cylinders****Data Required On All Cylinder Orders**

When ordering HV2 Series cylinders, be sure to specify each of the following requirements:

(NOTE: – Duplicate cylinders can be ordered by giving the SERIAL NUMBER from the original cylinder. Factory records supply a quick, positive identification.)

a) Series Designation (“HV2”)**b) Mounting Model**

Specify your choice of mounting – as shown and dimensioned in this catalog.

**c) Bushing Style “B” or “R” – Bronze
“I” or “N” – Iron****d) Piston Rod End Thread Style**

Call out thread style number.
Thread style 2 will be furnished if not otherwise supplied. For special rod ends specify style “X” as indicated below.

e) Cushions (if required)

Specify “Cushion-head end,” “Cushion-cap end” or “Cushion-both ends” as required. If cylinder is to have a double rod and only one cushion is required, be sure to specify clearly which end of the cylinder is to be cushioned.

f) Bore Size**g) Length of Stroke****h) Piston Rod Diameter**

Call out rod diameter. In HV2 Series cylinders, standard rod diameters will be furnished if not otherwise specified, unless length of stroke makes the application questionable.

i) Ports

SAE straight thread is standard.

j) Port Locations**k) Seals****l) Modifications**

Any modifications that are not identified in the cylinder number shown on the following page should be added to the specifications. These can include special fluids, special seals, air bleeds, double rod cylinder with different rod end styles and diameters. For further information consult factory.

Style X Rod End

A style X rod end indicates a special rod end configuration. All special rod ends must be described by at least **all three**: KK; A; or W/WF specified with the rod fully retracted. A sketch or drawing should be submitted for rod ends requiring special machining such as snap ring grooves, keyways,

tapers, multiple diameters, etc. It is good design practice to have this machining done on a diameter at least 0.065 inches smaller than the piston rod diameter. This allows the piston rod to have a chamfer preventing rod seal damage during assembly or maintenance.

Service Policy

When cylinders are returned to the factory for repairs, it is standard policy for Miller Fluid Power to make such part replacements as will put the cylinder in as good as new condition. Should the condition of the returned cylinder be such that expenses for repair exceed the cost of a new one, you will be notified.

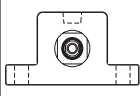
Certified Dimensions

Miller Fluid Power guarantees that all cylinders ordered from this catalog will be built to dimensions shown. All dimensions are certified to be correct, and thus it is not necessary to request certified drawings.

How To Order

How to Order – Example: HV2 72B2N-04.00-8.000-0175 S11T-0

HV2 72 B 2 N - 04.00 - 8.000 - 0175 S 1 1 T - 0

Series	Mounting Style	Bushing	Rod End Style	Cushions	Bore Dia.	Stroke	Rod Dia.	Port Type	Port Location	Seals	Modified
HV2 DHV2 (D = Dbl. Rod End)		B = Bolted Bronze R = Retainer Held Bronze I = Bolted Iron ¹ N = Retainer Held Iron	2 (Standard) 4 5 9 X (Special)	R = Rod End Cushioned C = Cap End Cushioned B = Both Ends Cushioned N = Non-Cushioned				S = SAE N = NPTF F = SAE FLANGE CODE 61 M = ISO 6149 J = BSPT R = BSPP G = METRIC X = SPECIAL (SPECIFY)	Head End Cap End 1 (Std.) 1 2 2 3 3 4 4 	T = Standard (Class 1 Seals) V = Fluorocarbon Seals (Class 5 Seals) E = Fluorocarbon Rod Seal, Rod Wiper & Bushing O-Ring J = H.W.C.F. (Class 6 Seals) W = Water Service H = Energized PTFE Seals (Class 8 Seals) (1.50"-8.00" bore & 1.000"-5.500" rod only)	0 = Standard g ² = Modified

- 1 10.00"-20.00" bore must only use 'I' bolted iron bushing.
- 2 The number 9 refers to special options or modifications that deviate from the standard product offering.

Non-standard modifications and options not identified in the cylinder model number should be added in the notes when placing an order.

Modifications which can be placed under the designator "9" are as follows:

- End-of-Stroke Switches
 - EPS-5, EPS-6, EPS-7, CLS-1, CLS-4 Styles (See bulletin M0840-B11)
 - Magnetic Principle Threaded Body Style
- Special Port Threads
- Cushion Location
- Special Mounts
- Key Retainer
- Bushing Wear Ring (Bronze Bushing only)
- Bushing Drain
- Multiple Ports

Note: The standard #1 port location is at the top of the cylinder, and the standard cushion adjustment screw is in position #2 when facing the rod end of the cylinder. If multiple ports are required, the last number of the part number should be "9", indicating modified and the desired port location specified in the notes.

Rod Bushing Construction
 B = Bolted Iron or Bronze Bushing
 R = Retainer Held Iron or Bronze Bushing
 I = Bolted Iron Only Bushing

Bolted & Full Plate Retainer Held Bushing

Bore	Rod Dia.	52, 62, 66, 68, 72, 74, 81, 82, 84, 89, 94	51, 53	61, 65	67
1.50	0.625	B	R	R	B
	1.000	R	R	R	B
2.00	1.000	B	R	R	B
	1.375	R	R	R	B
2.50	1.000	B	B	B	B
	1.375	B	B	B	B
	1.750	B	B	R	B
3.25	1.375	B	B	B	B
	1.750	B	B	B	B
4.00	2.000	B	B	B	B
	2.500	B	B	B	B
	3.000	B	B	B	B
5.00	2.000	B	B	B	B
	2.500	B	B	B	B
	3.000	B	B	B	B
	3.500	B	B	R	B
6.00	2.500	B	B	B	B
	3.000	B	B	B	B
	3.500	B	B	B	B
7.00	4.000	B	B	B	B
	3.000	B	B	B	B
	3.500	B	B	B	B
	4.000	B	B	B	B
8.00	5.000	B	B	B	B
	3.500	B	B	B	B
	4.000	B	B	B	B
10.00 20.00	5.000	B	B	B	B
	5.500	B	B	B	B
	ALL	I	I	I	I

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 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.

Notes

NOTES

Offer of Sale

The items described in this document and other documents and descriptions provided by Parker Hannifin Corporation, Hydraulics Group, 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 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 expressly conditioned on Buyer's assent to these Terms and Conditions and to the terms and conditions found on-line at www.parker.com/saleterms/. Seller objects to any contrary or additional term or condition of Buyer's order or any other document issued by Buyer.

2. Price Adjustments; Payments. Prices stated on the reverse side or preceding pages of this document are valid for 30 days. After 30 days, Seller may change prices to reflect any increase in its costs resulting from state, federal or local legislation, price increases from its suppliers, or any change in the rate, charge, or classification of any carrier. The prices stated on the reverse or preceding pages of this document do not include any sales, use, or other taxes unless so stated specifically. Unless otherwise specified by Seller, all prices are F.O.B. Seller's facility, and payment is due 30 days from the date of invoice. After 30 days, 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 tender to the carrier at Seller's facility (i.e., when it's on the truck, it's yours). 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 changes in shipping, product specifications or in accordance with Section 13, herein.

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 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 60 days after delivery or, in the case of an alleged breach of warranty, within 30 days after the date within the warranty period on which 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 any amount due to Seller from Buyer) must be commenced within thirteen months from the date of tender of delivery by Seller or, for a cause of action based upon an alleged breach of warranty, within thirteen months from the date within the warranty period on which the defect is or should have been discovered by Buyer.

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. Contingencies. Seller shall not be liable for any default or delay in performance if caused by circumstances beyond the reasonable control of Seller.

8. 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.

9. 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, may be considered obsolete and may be destroyed by Seller after two consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

10. 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.

11. 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. Seller shall have a security interest in, and lien upon, any property of Buyer in Seller's possession as security for the payment of any amounts owed to Seller by Buyer.

12. 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.

13. 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.

14. Limitation on Assignment. Buyer may not assign its rights or obligations under this agreement without the prior written consent of Seller.

15. 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 the agreement. All prior or contemporaneous written or oral agreements or negotiations with respect to the subject matter are herein merged.

16. 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.

17. Termination. This agreement may be terminated by Seller for any reason and at any time by giving Buyer thirty (30) days written notice of termination. In addition, Seller may by written notice immediately terminate this agreement for the following: (a) Buyer commits a breach of any provision of this agreement (b) the appointment of a trustee, receiver or custodian for all or any part of Buyer's property (c) the filing of a petition for relief in bankruptcy of the other Party on its own behalf, or by a third party (d) an assignment for the benefit of creditors, or (e) the dissolution or liquidation of the Buyer.

18. 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. Disputes between the parties shall not be settled by arbitration unless, after a dispute has arisen, both parties expressly agree in writing to arbitrate the dispute.

19. 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.

20. Taxes. Unless otherwise indicated, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of Products.

21. Equal Opportunity Clause. For the performance of government contracts and where dollar value of the Products exceed \$10,000, the equal employment opportunity clauses in Executive Order 11246, VEVRAA, and 41 C.F.R. §§ 60-1.4(a), 60-741.5(a), and 60-250.4, are hereby incorporated.

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