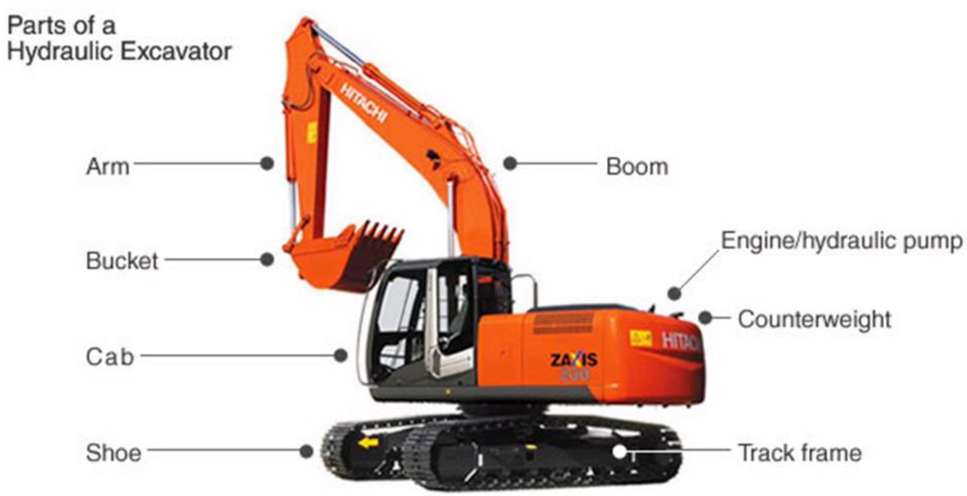
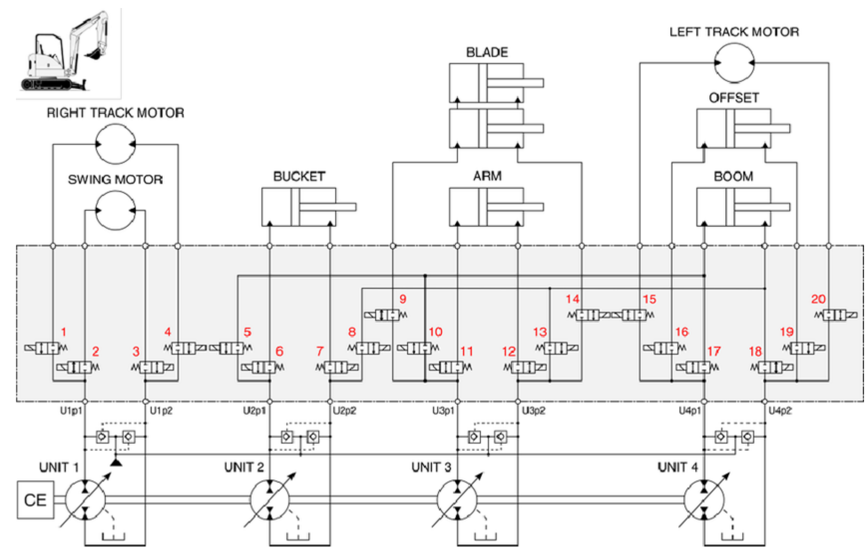
Mech 325 Fluid Power Selection Guide

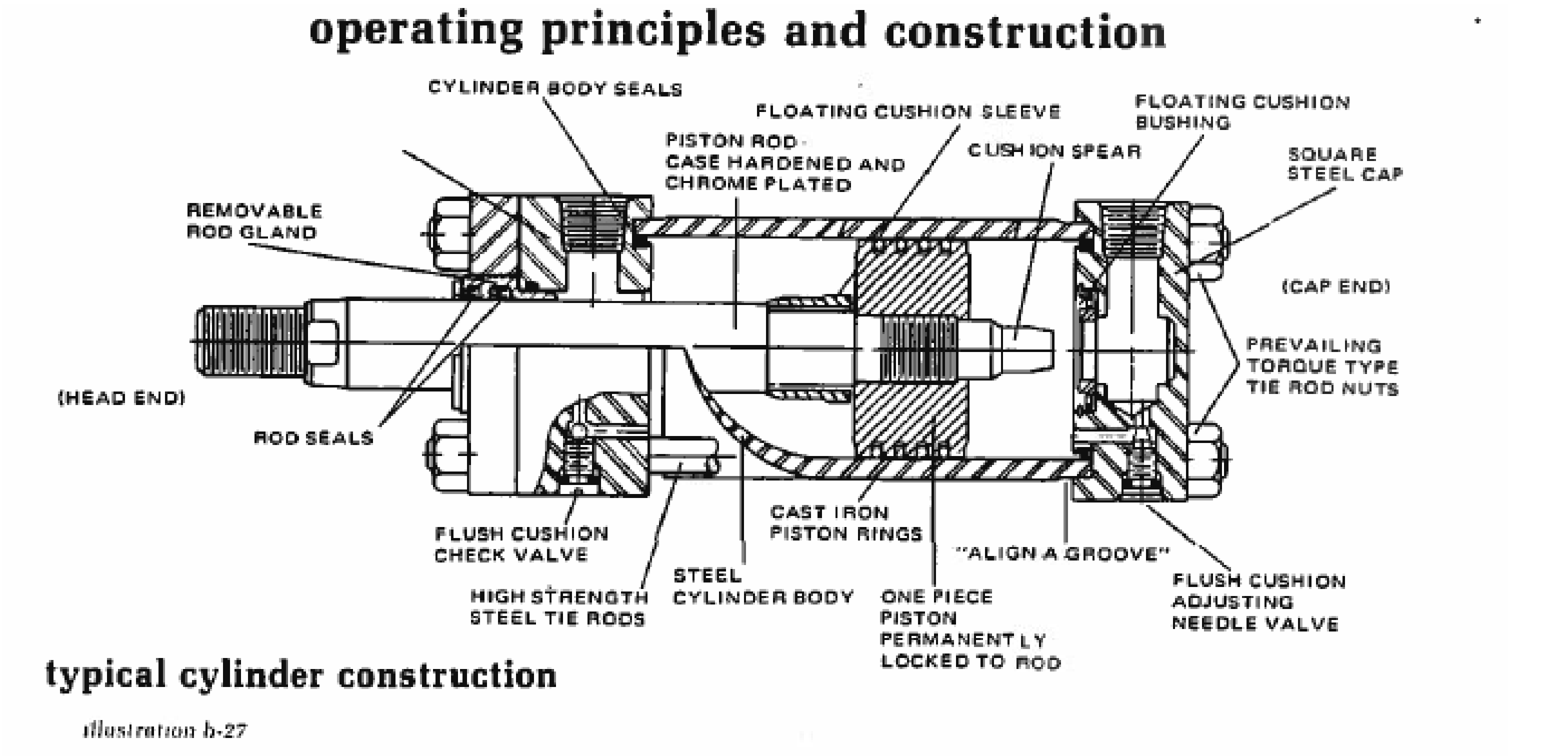




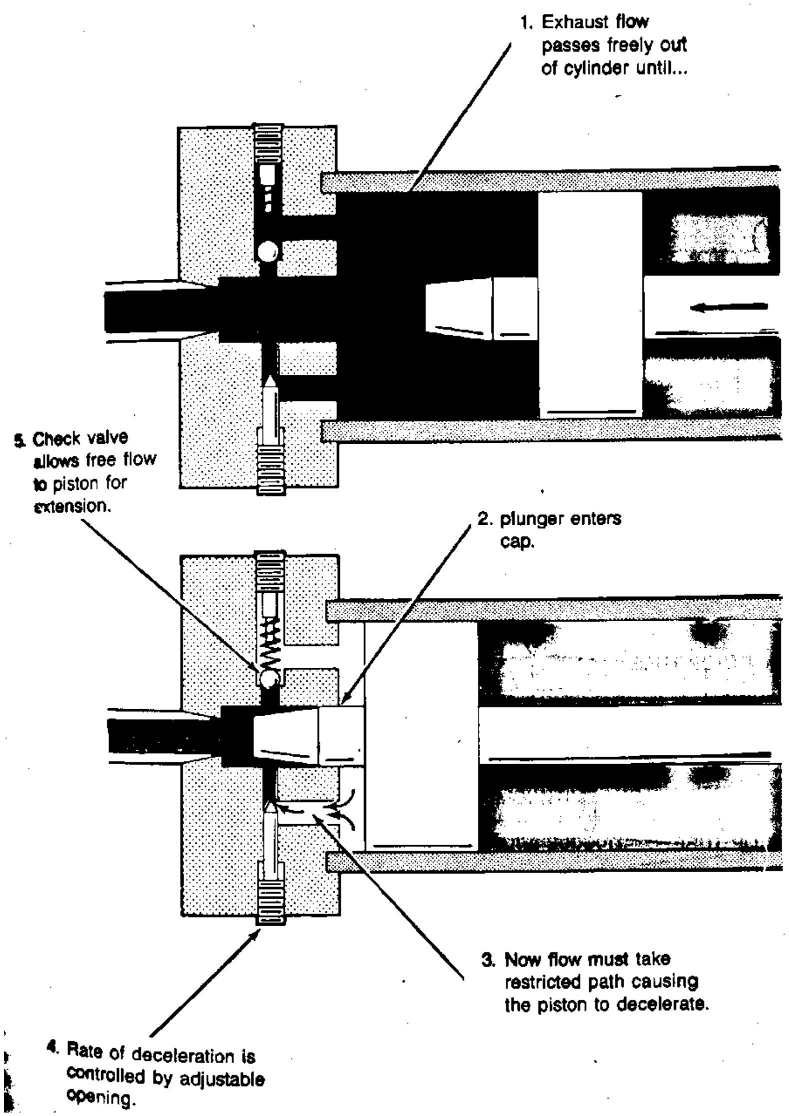
Learning Objectives

1. To learn the basic specifications used in fluid power
2. To learn how actuators are sized
3. To learn how pumps are sized
4. To learn basic motor selection

Fluid Power Selection Guide



Cushions



1. Exhaust flow passes freely out of cylinder until...
5. Check valve allows free flow to piston for extension.
2. plunger enters cap.
3. Now flow must take restricted path causing the piston to decelerate.
4. Rate of deceleration is controlled by adjustable opening.

Top Level Design Requirements

- Application requirements include:
  - Loads (Recognize Mechanical Advantage)
  - Speeds
  - Power Supplies
  - Temperatures
  - Cleanliness
  - Etc.

applications of cylinders
for providing a variety of fundamental mechanical motions.

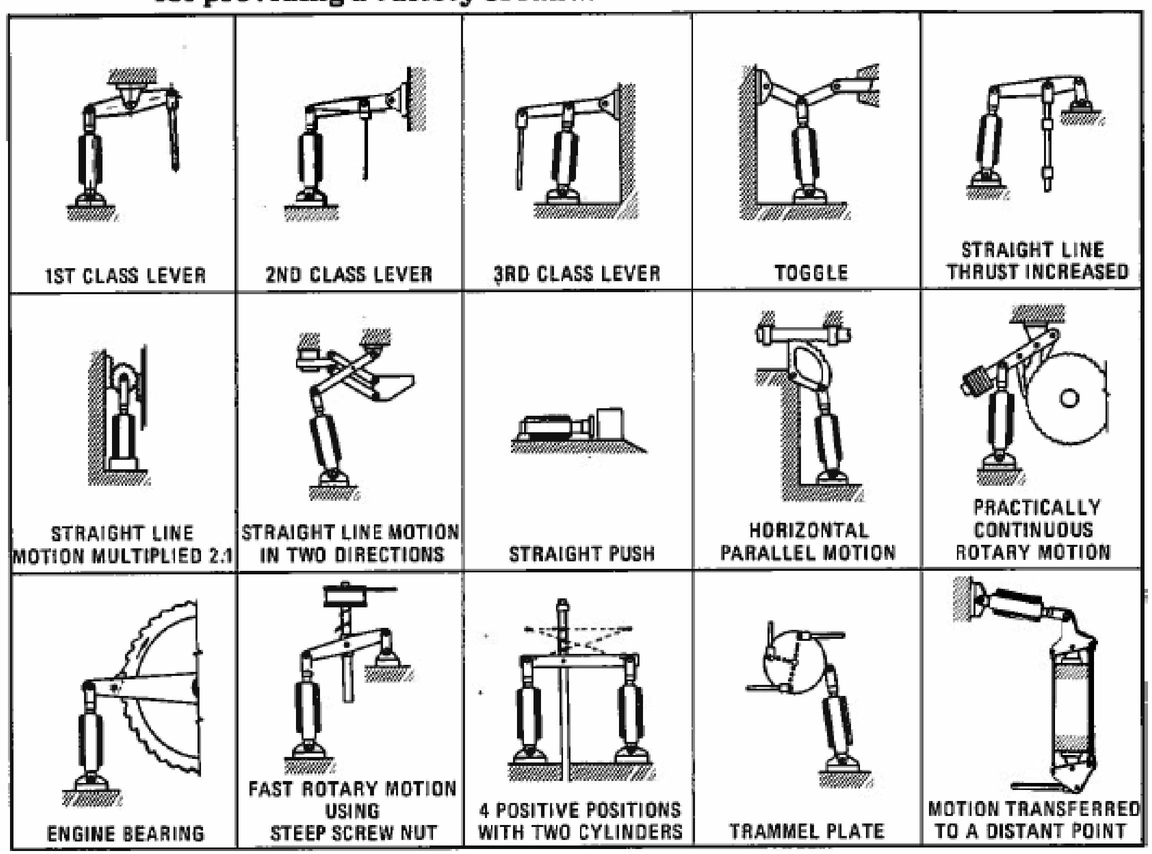
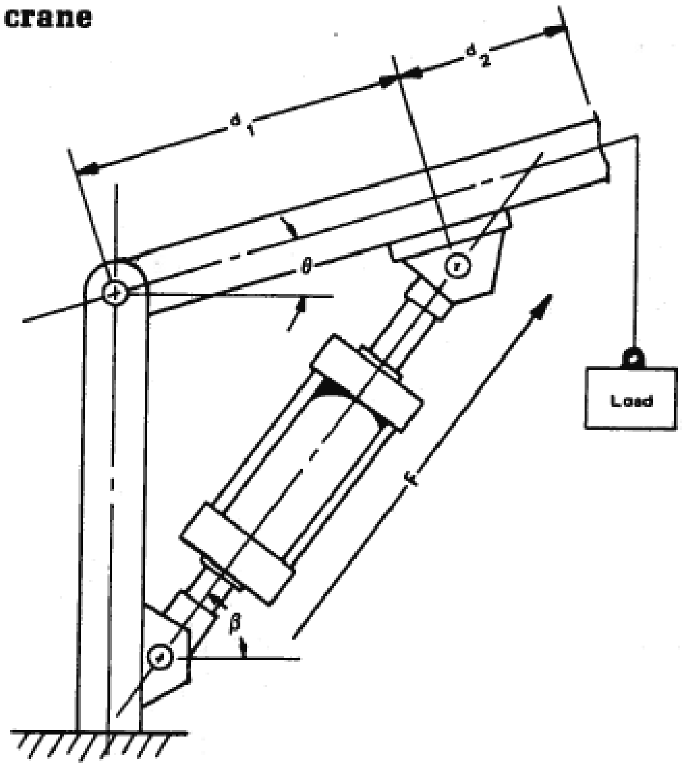


illustration 6-10

Example

crane



Formula:

$$F\sin\beta \times d_1\cos\theta = L(d_1 + d_2)\cos\theta$$

$$F\sin\beta \times d_1 = L(d_1 + d_2)$$

$$L = \frac{F\sin\beta \times d_1}{d_1 + d_2}$$

Where β in minimum angle between center line of cylinder and the horizontal.

Problem:

d_1 = 15 in.

d_2 = 60 in.

L = 1000 lb.

β = 45°

$$L = \frac{F\sin\beta \times d_1}{d_1 + d_2}$$

F = Force

$$F = \frac{L(d_1 + d_2)}{\sin\beta \times d_1}$$

$$F = \frac{1000\,(75)}{.707 \times 15}$$

F = 7071 lb. Force

Cylinder operating at 1000 psi. would require an area of 7 in.^{2}

Use standard 3 1/4 in. bore cylinder.

illustration b-19

Working Pressure and Loads

theoretical push and pull forces for cylinders

CUSTOMARY U.S. UNITS

Cyl. Bore or Piston Rod. Dia. (in.)	Cyl. Bore Size (ϕ mm)	Area (sq. in.)	CYLINDER PUSH STROKE FORCE IN POUNDS AT VARIOUS PRESSURES (PSI)										Displacement per inch of Stroke (gallons)
			50	80	100	500	750	1000	1500	2000	2500	3000	
5/8	15.9	.307	15	25	31	154	230	307	461	614	768	921	.0013
1	25.4	.785	39	65	79	392	588	785	1,177	1,570	1,962	2,355	.0034
1-3/8	34.9	1.490	75	119	149	745	1,118	1,490	2,235	2,980	3,725	4,470	.0065
1-1/2	38.1	1.767	88	142	177	885	1,325	1,770	2,651	3,540	4,425	5,310	.00765
1-3/4	44.5	2.410	121	193	241	1,205	1,808	2,410	3,615	4,820	6,025	7,230	.0104
2	50.8	3.140	157	251	314	1,570	2,357	3,140	4,713	6,280	7,850	9,420	.0136
2-1/2	63.5	4.910	245	393	491	2,455	3,682	4,910	7,364	9,820	12,275	14,730	.0213
3	76.2	7.070	354	566	707	3,535	3,502	7,070	10,604	14,140	17,675	21,210	.0306
3-1/4	82.6	8.300	415	664	830	4,150	6,225	8,300	12,450	16,600	20,750	24,900	.0359
3-1/2	88.9	9.620	481	770	962	4,810	7,215	9,620	14,430	19,240	24,050	28,860	.0416
4	101.6	12.570	628	1,006	1,257	6,285	9,428	12,570	18,856	25,140	31,425	37,710	.0544
5	127.0	19.640	982	1,571	1,964	9,820	14,730	19,640	29,460	39,280	49,100	58,920	.0850
5-1/2	139.7	23.760	1,188	1,901	2,376	11,880	17,820	23,760	35,640	47,520	59,400	71,280	.1028
6	152.4	28.270	1,414	2,262	2,827	14,135	21,203	28,270	42,406	56,540	70,675	84,810	.1224
7	177.8	38.490	1,924	3,079	3,849	19,245	28,868	38,490	57,736	76,980	96,225	115,470	.1666
8	203.2	50.270	2,513	4,022	5,027	25,135	37,703	50,270	75,406	100,540	125,675	150,810	.2176
8-1/2	215.9	56.750	2,838	4,540	5,675	28,375	42,563	56,750	85,125	113,500	142,875	170,250	.2455
10	254.0	78.540	3,927	6,283	7,854	39,270	58,905	78,540	117,810	157,080	196,350	235,620	.3400
12	304.8	113.100	5,655	9,048	11,310	56,550	84,825	113,100	169,650	226,200	282,750	339,300	.4896

table b-1

NOTE: Deduct Force of Poston Rod Size from Bore Size for Pull Applications.

Cylinder Stroke Determination

- One must recognize that hydraulic actuators act as columns under load.
- Recall from solid mechanics that Euler Buckling utilizes an effective length based on the end constraints.

Rather than specifying the column's effective length, many design codes provide column formulas that employ a dimensionless coefficient K called the ***effective-length factor***. K is defined from

$$L_e = KL \qquad (13\text{–}10)$$

Specific values of K are also given in Fig. 13–12. Based on this generality, we can therefore write Euler's formula as

$$\boxed{P_{cr} = \frac{\pi^2 EI}{(KL)^2}} \qquad (13\text{–}11)$$

or

$$\boxed{\sigma_{cr} = \frac{\pi^2 E}{(KL/r)^2}} \qquad (13\text{–}12)$$

Here (KL/r) is the column's ***effective-slenderness ratio***. For example, note that for the column fixed at its base and free at its end, we have $K = 2$, and therefore Eq. 13–11 gives the same result as Eq. 13–9.

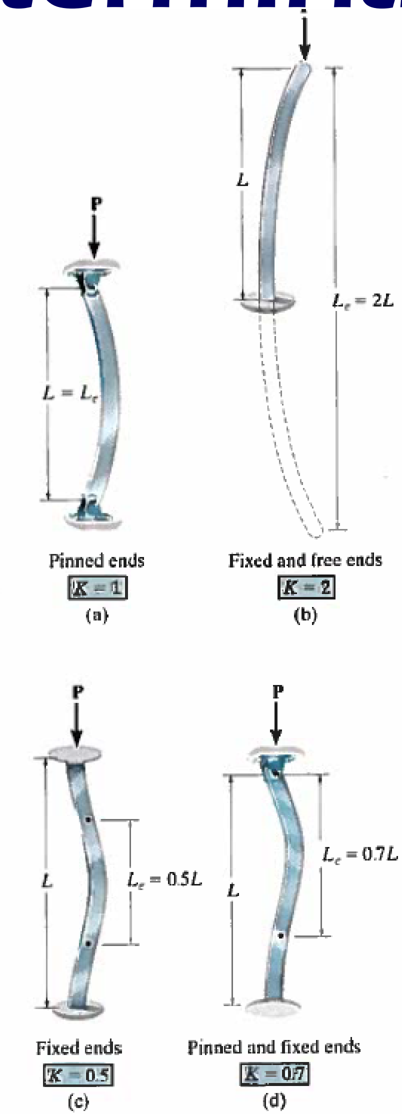


Fig. 13–12

Supports for Cylinders Vary

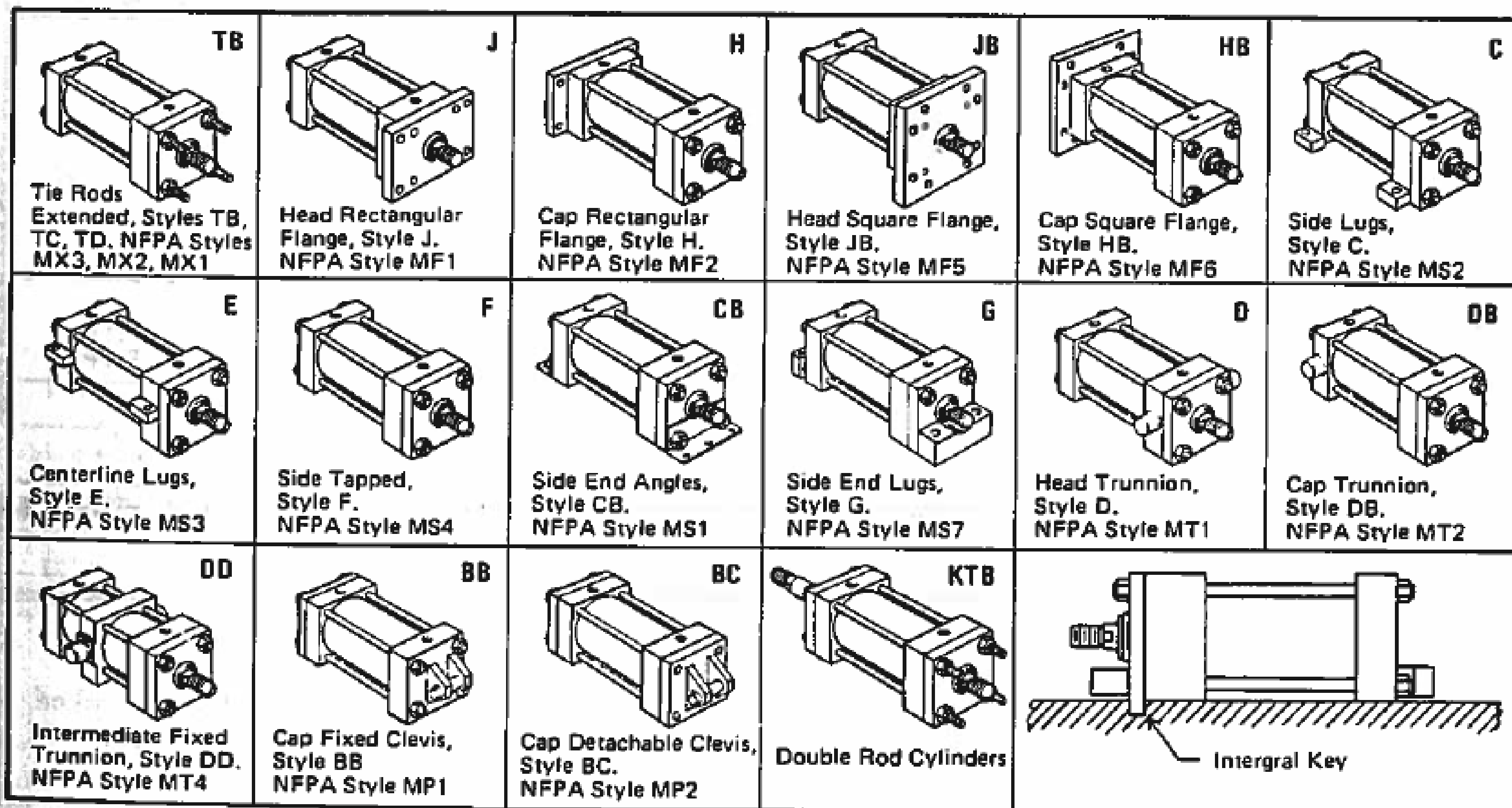


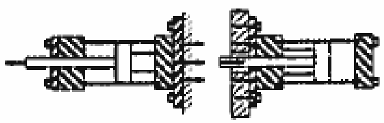
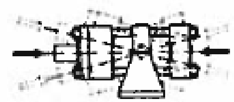
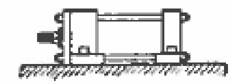
Illustration b-1

*NFPA Syles conform to ANSI Standard, 1393.15-1971

Cylinder Mounting Types

CYLINDER MOUNTING CLASSES

FOR CYLINDERS THAT ARE RECOMMENDED TO 3000 PSI WORKING AND 5000 PSI NON SHOCK SERVICE

	CLASS 1 – GROUP 1	CLASS 2 – GROUP 2	CLASS 1 – GROUP 3
	FIXED MOUNTS which absorb force on cylinder centerline. 	PIVOT MOUNTS which absorb force on cylinder centerline. 	FIXED MOUNTS which do not absorb force on the centerline. 
HEAVY-DUTY SERVICE For Thrust Loads – For Tension Loads –	 Mtg. Styles HB, TC, E Mtg. Styles JB, TB, E	 Mtg. Styles DD, D, DB, BB Mtg. Styles BB, DD, D, DB	 Mtg. Styles C, CP Mtg. Styles C, CP
MEDIUM-DUTY SERVICE For Thrust Loads – For Tension Loads –	 Mtg. Styles H, JB Mtg. Styles J, HB	 – –	 Mtg. Styles G, GP, F, FP Mtg. Styles G, GP, F, FP
LIGHT-DUTY SERVICE For Thrust Loads – For Tension Loads –	 Mtg. Style J Mtg. Style H	 – –	 Mtg. Styles CBP, CB * Mtg. Styles CBP, CB *

* Mounting style CB recommended for maximum pressure of 500 p.s.i. in short stroke applications (to 5"). Longer strokes permit higher pressures. The use of a thrust key is recommended with this mounting. For more detailed information see manufacturer's product catalog.

table b-3

noncenterline cylinder/support

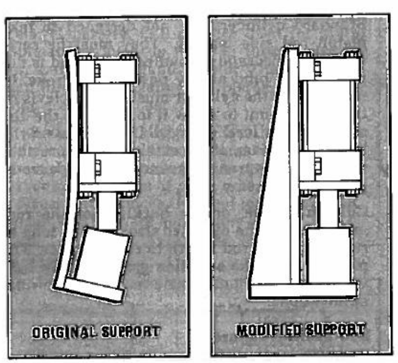


illustration b-33

Stroke Factors

- Stroke Factors are "Effective Lengths" for Piston Rods

piston rod — stroke selection table

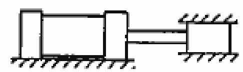
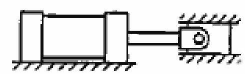
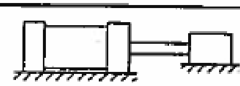
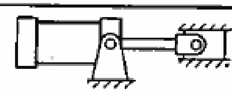
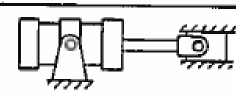
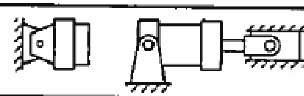
RECOMMENDED MOUNTING STYLES FOR MAXIMUM STROKE AND THRUST LOADS	ROD END CONNECTION	CASE	STROKE FACTOR
CLASS 1 – GROUPS 1 OR 3 Long stroke cylinders for thrust loads should be mounted using a heavy-duty mounting style at one end, firmly fixed and aligned to take the principle force. Additional mounting should be specified at the opposite end, which should be used for alignment and support. An intermediate support may also be desirable for long stroke cylinders mounted horizontally. Machine mounting pads can be adjustable for support mountings to achieve proper alignment.	FIXED AND RIGIDLY GUIDED.	I 	.50
	PIVOTED AND RIGIDLY GUIDED	II 	.70
	SUPPORTED BUT NOT RIGIDLY GUIDED	III 	2.00
CLASS 2 – GROUP 2 Style – Trunnion on Head	PIVOTED AND RIGIDLY GUIDED	IV 	1.00
Style – Intermediate Trunnion	PIVOTED AND RIGIDLY GUIDED	V 	1.50
Style – Trunnion on Cap or Style – Clevis on Cap	PIVOTED AND RIGIDLY GUIDED	VI 	2.00

table b-4

How to Use the Table

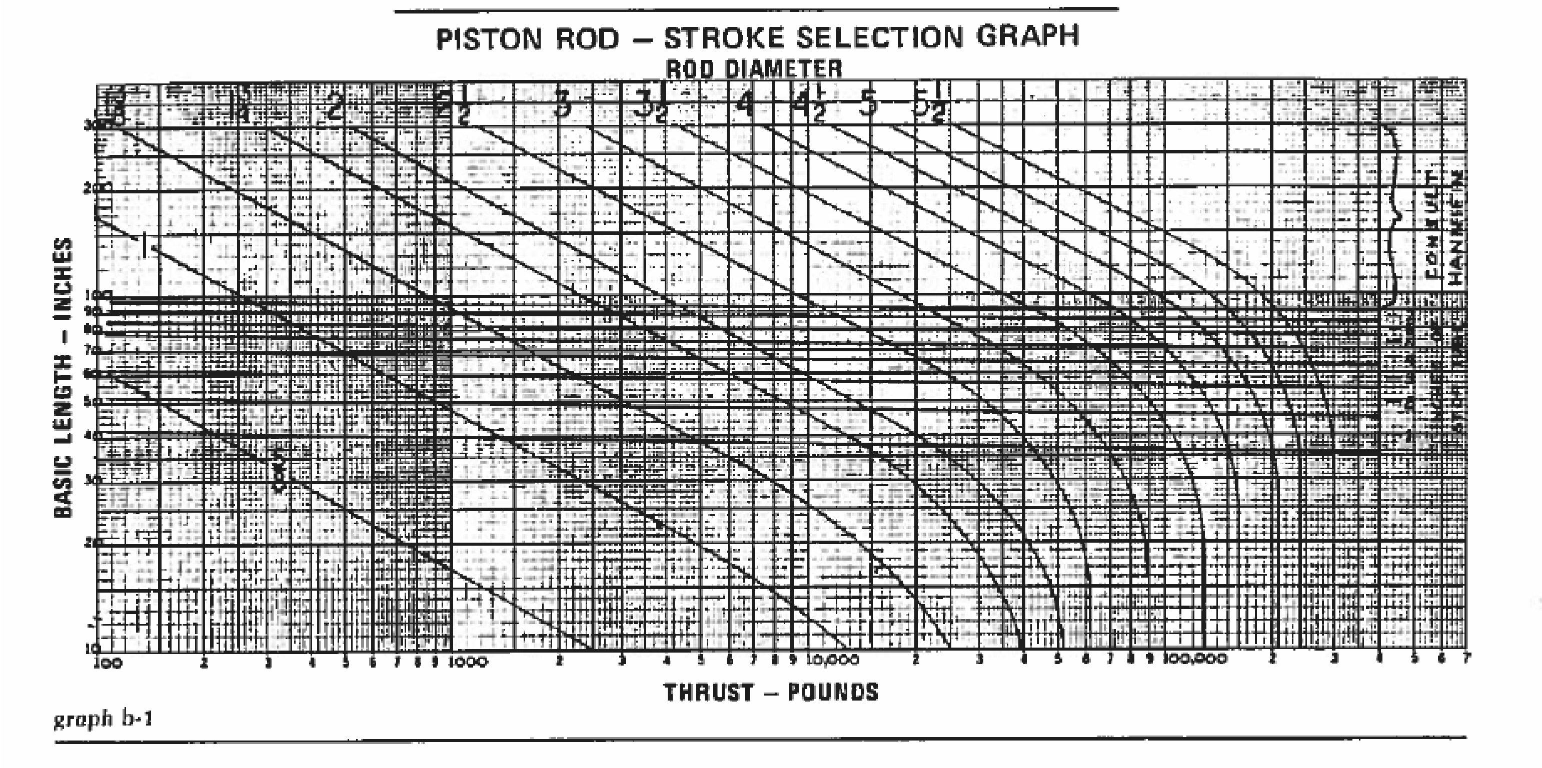
The selection of a piston rod for thrust (push) conditions requires the following steps:

1. Determine the types of cylinder mounting style and rod end connection to be used. Then consult the **table 4** [page b-5] and find the "stroke factor" that corresponds to the conditions used.

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

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

Determination of Rod Diameter



Stop Tubes

Stop Tube

On applications where it is necessary to allow the piston to "bottom out" on the front end, cylinders may be ordered with a stop tube. The stop tube should especially be considered on long strokes if the length between supports exceeds 10 times the rod diameter.

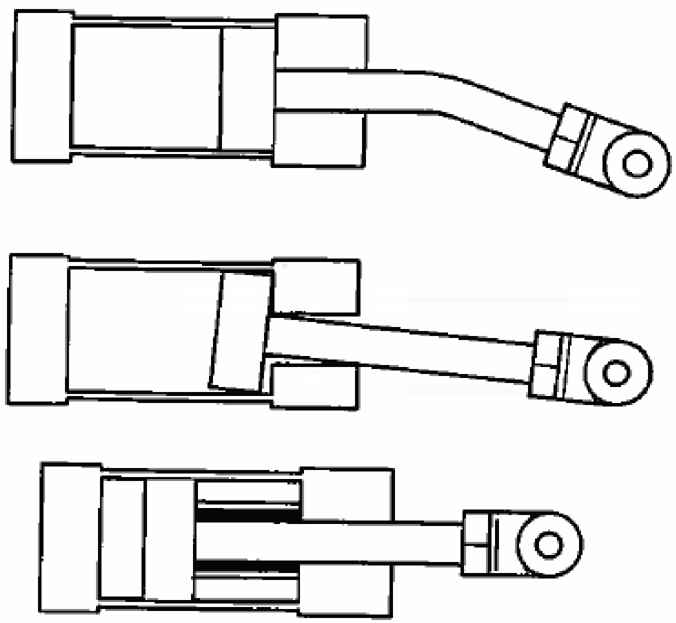


illustration b-30

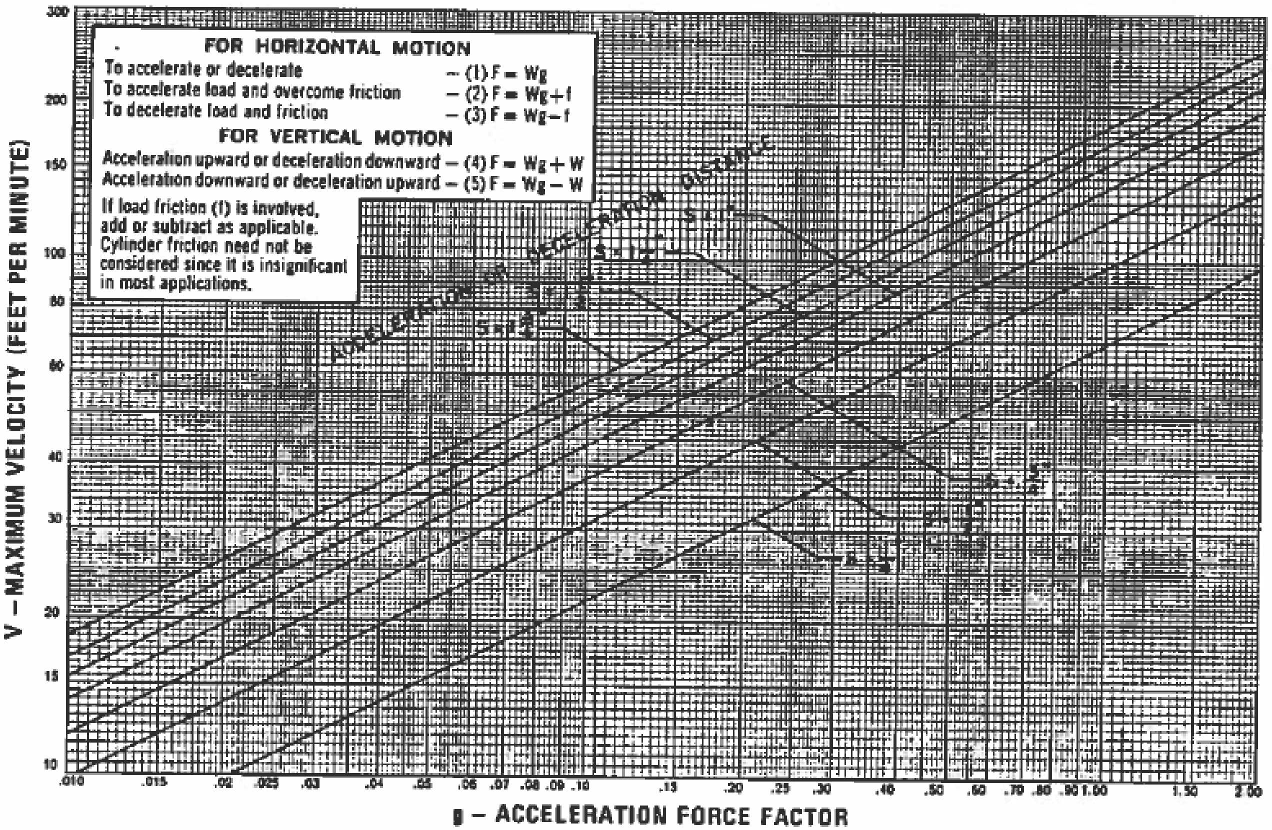
Piston Speed

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

CYLINDER BORE-INCHES	PISTON ROD		CYLINDER NET AREA SQ. IN.	FLUID DISPLACEMENT AT 10 FT. PER MINUTE PISTON VELOCITY		FLUID VELOCITY (IN FEET PER SECOND) THROUGH EXTRA HEAVY PIPE AT 10 F.P.M. PISTON SPEED.								
	DIA.-INCHES	AREA SQ. IN.		G.P.M.	C.F.M.	1/4	3/8	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
1	0	0	0.785	0.41	0.054	1.82	0.92	0.56	0.30	0.183	0.102	0.074	0.045	.....
	1/2	0.196	0.589	0.30	0.041	1.33	0.68	0.41	0.21	0.134	0.075	0.055	0.033	.....
	5/8	0.307	0.478	0.16	0.033	0.71	0.36	0.22	0.12	0.071	0.040	0.029	0.017	.....
1½	0	0	1.77	0.92	0.123	4.09	2.09	1.259	0.680	0.410	0.230	0.167	0.100	.....
	5/8	0.307	1.46	0.76	0.101	3.38	1.73	1.040	0.562	0.338	0.190	0.138	0.082	.....
	1	0.785	0.98	0.51	0.068	2.27	1.16	0.699	0.378	0.228	0.128	0.093	0.055	.....
2	0	0	3.14	1.63	0.218	7.27	3.71	2.238	1.209	0.728	0.408	0.296	0.177	.....
	5/8	0.307	2.84	1.48	0.197	6.56	3.35	2.019	1.091	0.657	0.368	0.267	0.160	.....
	1	0.785	2.36	1.23	0.164	5.45	2.79	1.678	0.907	0.546	0.306	0.222	0.133	.....
	1-3/8	1.485	1.66	0.86	0.115	3.84	1.96	1.180	0.638	0.384	0.215	0.156	0.094	.....
2½	0	0	4.91	2.55	0.341	11.36	5.80	3.496	1.890	1.138	0.638	0.463	0.277	.....
	5/8	0.307	4.60	2.39	0.319	10.65	5.44	3.278	1.771	1.067	0.598	0.434	0.260	.....
	1	0.785	4.12	2.14	0.286	9.54	4.87	2.937	1.587	0.956	0.536	0.389	0.233	.....
	1-3/8	1.485	3.42	1.78	0.237	7.93	4.05	2.439	1.318	0.794	0.445	0.323	0.193	.....
	1-3/4	2.405	2.50	1.30	0.174	5.96	2.96	1.783	0.963	0.580	0.325	0.236	0.141	.....
3¼	0	0	8.30	4.31	0.576	19.20	9.81	5.909	3.193	1.923	1.078	0.783	0.468	.....
	1	0.785	7.51	3.90	0.521	17.38	8.88	5.349	2.891	1.741	0.976	0.708	0.424	.....
	1-3/8	1.485	6.81	3.54	0.473	15.77	8.05	4.851	2.622	1.579	0.885	0.642	0.384	.....
	1-3/4	2.405	5.89	3.06	0.409	13.64	6.96	4.196	2.268	1.366	0.765	0.556	0.333	.....
	2	3.142	5.15	2.68	0.357	11.93	6.09	3.671	1.984	1.195	0.670	0.486	0.291	.....
4	0	0	12.57	6.53	0.872	29.09	14.85	8.95	4.84	2.91	1.63	1.19	0.709	.....
	1	0.785	11.78	6.12	0.818	27.27	13.93	8.39	4.54	2.73	1.53	1.11	0.665	.....
	1-3/8	1.485	11.08	5.76	0.769	25.65	13.10	7.89	4.27	2.57	1.44	1.05	0.625	.....
	1-3/4	2.405	10.16	5.28	0.705	23.52	12.01	7.24	3.91	2.36	1.32	0.96	0.574	.....
	2	3.142	9.42	4.89	0.654	21.82	11.14	6.71	3.63	2.19	1.22	0.89	0.532	.....
	2-1/2	4.909	7.66	3.98	0.532	17.73	9.05	5.45	2.95	1.78	1.00	0.72	0.432	.....
5	0	0	19.64	10.20	1.363	45.45	23.21	13.99	7.56	4.55	2.55	1.85	1.108	.....
	1	0.785	18.85	9.79	1.308	43.64	22.28	13.43	7.26	4.37	2.45	1.78	1.064	.....
	1-3/8	1.485	18.15	9.43	1.260	42.01	21.45	12.93	6.99	4.21	2.36	1.71	1.024	.....
	1-3/4	2.405	17.23	8.95	1.196	39.88	20.37	12.27	6.63	3.99	2.24	1.63	0.973	.....
	2	3.142	16.49	8.57	1.144	38.18	19.50	11.75	6.35	3.82	2.14	1.56	0.931	.....
	2-1/2	4.909	14.73	7.65	1.022	34.09	17.41	10.49	5.67	3.41	1.91	1.39	0.831	.....
	3	7.069	12.57	6.53	0.872	29.09	14.85	8.95	4.84	2.91	1.63	1.19	0.709	.....
	3-1/2	9.621	10.01	5.21	0.695	23.18	11.84	7.13	3.86	2.32	1.30	0.95	0.565	.....
6	0	0	28.27	14.69	1.962	65.45	33.42	20.14	10.88	6.55	3.67	2.67	1.596	.....
	1-3/8	1.485	26.79	13.92	1.859	62.01	31.67	19.08	10.31	6.21	3.48	2.53	1.512	.....
	1-3/4	2.405	25.87	13.44	1.795	59.88	30.58	18.43	9.96	5.60	3.36	2.44	1.460	.....
	2	3.142	25.13	13.06	1.744	58.18	29.71	17.90	9.67	5.83	3.27	2.37	1.418	.....
	2-1/2	4.909	23.37	12.14	1.622	54.1	27.6	16.64	8.99	5.42	3.04	2.20	1.32	.....
	3	7.069	21.21	11.02	1.472	49.1	25.1	15.10	8.16	4.92	2.76	2.00	1.20	.....
	3-1/2	9.621	18.65	9.69	1.294	43.2	22.1	13.29	7.18	4.32	2.42	1.76	1.05	.....
	4	12.566	15.71	8.16	1.090	36.4	18.6	11.19	6.05	3.64	2.04	1.48	0.89	.....

table b-5

Piston Acceleration



$$g = \frac{V^2}{S} \times .0000517$$

Nomenclature

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

Power Requirements

electric motor horsepower

ELECTRIC MOTOR HORSEPOWER REQUIRED TO DRIVE A HYDRAULIC PUMP

GPM	100 PSI	200 PSI	250 PSI	300 PSI	400 PSI	500 PSI	750 PSI	1000 PSI	1250 PSI	1500 PSI	2000 PSI	2500 PSI	3000 PSI
1/2	.04	.07	.09	.11	.14	.18	.26	.35	.44	.53	.70	.88	1.10
1	.07	.14	.18	.21	.28	.35	.52	.70	.88	1.05	1.40	1.76	1.92
1-1/2	.10	.21	.26	.31	.41	.52	.77	1.03	1.29	1.55	2.06	2.58	3.09
2	.14	.28	.35	.42	.56	.70	1.04	1.40	1.76	2.10	2.80	3.53	4.20
2-1/2	.17	.34	.43	.51	.69	.86	1.29	1.72	2.15	2.58	3.44	4.30	5.14
3	.21	.42	.53	.63	.84	1.05	1.56	2.10	2.64	3.15	4.20	5.28	6.30
3-1/2	.24	.48	.60	.72	.96	1.20	1.80	2.40	3.00	3.60	4.80	6.00	7.20
4	.28	.56	.70	.84	1.12	1.40	2.08	2.80	3.52	4.20	5.60	7.04	8.40
5	.35	.70	.88	1.05	1.40	1.75	2.60	3.50	4.40	5.25	7.00	8.80	10.50
6	.42	.84	1.05	1.26	1.68	2.10	3.12	4.20	5.28	6.30	8.40	10.56	12.60
7	.49	.98	1.23	1.47	1.96	2.45	3.64	4.90	6.16	7.35	9.80	12.32	14.70
8	.56	1.12	1.40	1.68	2.24	2.80	4.16	5.60	7.04	8.40	11.20	14.08	16.80
9	.62	1.24	1.55	1.86	2.48	3.10	4.65	6.18	7.73	9.28	12.40	15.56	18.58
10	.70	1.40	1.75	2.10	2.80	3.50	5.20	7.00	8.80	10.50	14.00	17.60	21.00
11	.77	1.54	1.93	2.31	3.08	3.85	5.72	7.70	9.68	11.50	15.40	19.36	23.10
12	.84	1.68	2.10	2.52	3.36	4.20	6.24	8.40	10.50	12.60	16.80	21.00	25.20
13	.89	1.78	2.23	2.67	3.56	4.45	6.68	8.92	11.20	13.40	17.80	22.40	26.72
14	.96	1.92	2.40	2.88	3.84	4.80	7.20	9.60	12.00	14.40	19.20	24.00	28.80
15	1.05	2.10	2.63	3.15	4.20	5.25	7.80	10.50	13.20	15.70	21.00	26.40	31.50
16	1.10	2.20	2.75	3.30	4.40	5.50	8.25	11.00	13.80	16.50	22.00	27.60	33.00
17	1.17	2.34	2.93	3.51	4.68	5.85	8.78	11.70	14.60	17.60	23.40	29.20	35.10
18	1.26	2.52	3.15	3.78	5.04	6.30	9.35	12.60	15.80	18.90	25.20	31.60	37.80
19	1.30	2.60	3.25	3.90	5.20	6.50	9.75	13.00	16.30	19.50	26.00	32.60	39.00
20	1.40	2.80	3.50	4.20	5.60	7.00	10.40	14.00	17.60	21.00	28.00	35.20	42.00
25	1.75	3.50	4.38	5.25	7.00	8.75	13.10	17.50	21.90	26.20	35.00	43.80	52.50
30	2.10	4.20	5.25	6.30	8.40	10.50	15.60	21.00	26.40	31.50	42.00	52.80	63.00
35	2.45	4.90	6.13	7.35	9.80	12.20	18.40	24.50	30.60	36.70	49.00	61.20	73.50
40	2.80	5.60	7.00	8.40	11.20	14.00	20.80	28.00	35.20	42.00	56.00	70.40	84.00
45	3.15	6.30	7.87	9.45	12.60	15.80	23.60	31.50	39.40	47.30	63.00	78.80	94.50
50	3.50	7.00	8.75	10.50	14.00	17.50	26.00	35.00	44.00	52.50	70.00	88.00	105.00
55	3.85	7.70	9.63	11.60	15.40	19.30	28.60	38.50	48.40	57.80	77.00	96.80	115.50
60	4.20	8.40	10.50	12.60	16.80	21.00	31.20	42.00	52.80	63.00	84.00	105.60	126.00
65	4.55	9.10	11.40	13.60	18.20	22.80	33.80	45.50	57.20	68.20	90.00	114.40	136.50

table c-1

The **table c-1**, above is based on a pump efficiency of 85%, and is calculated from the formula:

$$HP = GPM \times PSI \div (1714 \times .85)$$

Electric Motor Selection

table i (c-3)

motor starter, conduit and wire size

3 PHASE MOTOR STARTERS

1/2 TO 20 H.P. MOTOR H.P. 3ø	1/2		3/4		1		1-1/2		2		3		5		7-1/2		10		15		20	
VOLTAGE	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440
Nema Starter Size	00	00	00	00	00	00	00	00	0	00	0	0	1	0	1	1	2	1	2	2	3	2
⊕ Full Load Current	2.0	1.0	2.8	1.4	3.5	1.8	5.0	2.5	6.5	3.3	9.0	4.5	15	7.5	22	11	28	14	40	20	52	26
Fuses – Amps Std. N.E.C.	15	15	15	15	15	15	15	15	20	15	25	15	40	20	60	30	70	35	100	50	150	70
Fuses – Amps Dual Element	5	4	5	4	8	4	8	5	12	8	15	10	25	15	30	20	45	25	60	30	80	40
Circuit Breaker Max. Amps.	15	15	15	15	15	15	15	15	15	15	20	15	30	15	50	20	50	30	70	40	100	50
Minimum Wire Sizes R, RW, T, TW	14	14	14	14	14	14	14	14	14	14	14	14	12	14	10	14	8	12	6	10	4	8
Minimum Wire Sizes RH	14	14	14	14	14	14	14	14	14	14	14	14	12	14	10	14	8·	12	6	10	6	8
Always specify voltage and frequency.																						

3 PHASE MOTOR STARTERS

25 TO 200 H.P. MOTOR H.P. 3ø	25		30		40		50		60		75		100		125		150		200	
VOLTAGE	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440	220	440
Nema Starter Size	3	2	3	3	4	3	4	3	5	4	5	4	5	4	6	5	6	5	6	5
⊕ Full Load Current	64	32	78	39	104	52	125	63	150	75	185	93	246	123	310	155	360	180	480	240
Fuses – Amps Std. N.E.C.	175	80	200	100	300	150	350	175	400	200	500	250	600	350	–	400	–	450	–	600
Fuses – Amps Dual Element	100	50	125	60	175	80	200	100	225	125	300	150	400	200	450	250	600	300	–	400
Circuit Breaker Max. Amps.	125	50	100	70	175	100	200	125	225	125	300	150	400	200	–	250	–	300	–	400
Minimum Wire Sizes R, RW, T, TW	3	8	1	6	00	4	000	3	0000	2	300	0	500	000	–	0000	–	300	–	500
Minimum Wire Sizes RH	4	8	3	6	1	6	00	4	000	3	0000	1	350	00	–	000	–	0000	–	350
Always specify voltage and frequency.																				

SINGLE PHASE MOTOR STARTERS

1/6 TO 5 H.P. MOTOR H.P. 1ø	1/6		1/4		1/3		1/2		3/4		1		1-1/2		2		3		5	
VOLTAGE	115	230	115	230	115	230	115	230	115	230	115	230	115	230	115	230	115	230	115	230
⊕ Full Load Current	4.4	2.2	5.8	2.9	7.2	3.6	9.8	4.9	13.8	6.9	16	8	20	10	24	12	34	17	56	28
Fuses – Amps. Std. N.E.C.	15	15	20	15	25	15	30	15	45	25	50	25	60	30	80	40	100	60	–	90
Circuit Breaker Max. Amps.	15	15	15	15	15	15	30	15	40	20	40	20	50	30	70	30	100	50	–	70
Min. Wire Sizes – R, RH, RW, T, TW	14	14	14	14	14	14	14	14	12	14	12	14	10	14	10	14	6	10	–	8

WIRE & CONDUIT SIZES

	WIRE SIZE AWG or MCM	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500	750	1000
MAXIMUM 3 WIRES IN CONDUIT	Wire Capacity R-RW-T-TW Amps.	15	20	30	40	55	70	80	95	110	125	145	165	195	215	240	260	280	320	400	455
	Wire Capacity RH Amps.	15	20	30	45	65	85	100	115	130	150	175	200	230	255	285	310	335	380	475	545
	CONDUIT SIZE – Inches	1/2	1/2	3/4	3/4	1	1-1/4	1-1/4	1-1/4	1-1/2	2	2	2	2-1/2	2-1/2	2-1/2	3	3	3	3-1/2	4
Volts Drop Per Ampere Per 100 Ft. – 80% P.F.	1 Phase Volts	.4762	.3125	.1961	.1250	.0833	.0538	.0431	.0370	.0323	.0269	.0222	.0190	.0161	.0147	.0131	.0121	.0115	.0101	.0086	.0081
	3 Phase Volts	.4167	.2632	.1677	.1087	.0714	.0463	.0379	.0323	.0278	.0231	.0196	.0163	.0139	.0128	.0114	.0106	.0091	.0088	.0066	.0061

Capacity of conductors in conduit based on room temperature of 30° C. (86° F.)

⊕ The full load currents shown are average values.

standard enclosures for electric motors

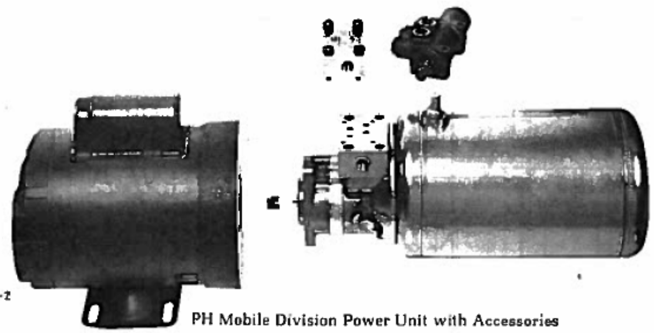


illustration c-2

PH Mobile Division Power Unit with Accessories

Open
The open motor is one having ventilating openings which permit passage of external cooling air over and around the windings.

Drip-Proof
The drip-proof motor is an open motor in which ventilating openings are so constructed that drops of liquid or solids falling on the machine at any angle not greater than 15 degrees from the vertical cannot enter the machine.

Guarded
A guarded motor is an open motor in which ventilating openings are limited to specified size and shape to prevent insertion of fingers or rods to avoid accidental contact with rotating or electrical parts.

Splash-Proof
A splash-proof motor is an open motor in which ventilating openings are so constructed that drops of liquid or solid particles falling on the machine or coming toward the machine in a straight line at any angle not greater than 100 degrees from the vertical cannot enter the machine.

Totally-Enclosed
A totally-enclosed motor is a motor so enclosed as to prevent the free exchange of air between the inside and outside of the case, but not airtight.

Totally-Enclosed Nonventilated (TENV)
A totally-enclosed nonventilated (TENV) motor is a totally-enclosed motor which is not equipped for cooling by means external to the enclosing parts.

Totally-Enclosed Fan-Cooled (TEFC)
A totally-enclosed fan-cooled (TEFC) motor is a totally enclosed motor with a fan to blow cooling air across the external frame. It is a popular motor for use in dusty, dirty, and corrosive atmospheres.

Encapsulated
Encapsulated motor is an open motor in which the windings are covered with a heavy coating of material to protect them from moisture, dirt, abrasion, etc. Some encapsulated motors have only the coil noses coated. In others, the encapsulation material impregnates the windings even in the coil slots. With this complete protection, the motors can often be used in applications which formerly demand totally enclosed motors.

Explosion-Proof
An explosion-proof motor is a totally enclosed motor designed and built to withstand an explosion of gas or vapor within it, and to prevent ignition of gas or vapor surrounding the machine by sparks, flashes or explosions which may occur within the machine casing.

three-phase motor design

Design "B" — A Design "B" motor is a 3-phase squirrel-cage motor designed to withstand full-voltage starting and developing lock-rotor and breakdown torques adequate for general application.

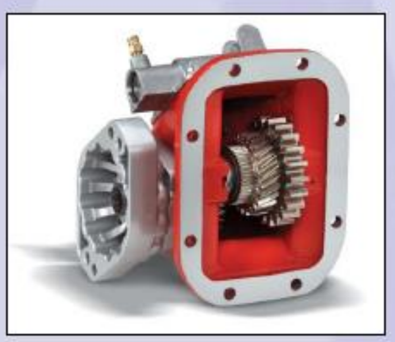
Design "C" — A Design "C" motor is a 3-phase squirrel-cage motor designed to withstand full-voltage starting, developing locked-rotor torque for special high torque applications.

Design "D" — A Design "D" motor is a 3-phase squirrel-cage motor designed to withstand full-voltage starting, developing 275 percent locked-rotor torque (generally referred to as a "high slip" motor).

Power Take Off (PTO)

Applications

The Dump Truck is the Most Common



PTO TORQUE & HORSEPOWER RATINGS

Intermittent service refers to an On-Off operation under load. If maximum HP and/or torque is used for extended periods of time, (5 min. or more every 15 min.) this is considered "Continuous Service" and HP rating of PTO should be reduced by multiplying intermittent value below by .70. Applications with PTO output shaft speeds above 2000 RPM, regardless of duration, are to be considered "Continuous" duty. MAX rated output shaft speed for all Muncie PTOs is 2500 RPM.

Fire Pump applications are calculated within a different category listed on page 3 and are derated by multiplying intermittent value below by .80.

Below is a chart showing the Intermittent and calculated continuous Torque rating of the PTOs included in this catalog. The Application pages may have lower ratings for these PTOs listed. The Application page rating may be adjusted to limit the PTO output to a rating which will not exceed the transmission manufacturers rating. The transmission manufacturer does not differentiate between Intermittent and Continuous; therefore, the Application page rating is never to be exceeded. Refer to this page when there is a question of the rating (Intermittent or Continuous) for the PTO as it is manufactured.

PTO SERIES	SPEED RATIO	INTERMITTENT HP@1000 RPM	INTERMITTENT TORQUE LBS. FT.	CONTINUOUS TORQUE LBS. FT.	INTERMITTENT [KW]@1000 RPM	INTERMITTENT TORQUE [NM]	CONTINUOUS TORQUE [NM]
SG	10	25	130	91	[19]	[176]	[123]
TG	04	54	285	200	[40]	[386]	[270]
	05	51	270	189	[38]	[366]	[256]
	06	47	245	172	[35]	[332]	[232]
	07	44	230	161	[33]	[312]	[218]
	08	44	230	161	[33]	[312]	[218]
	09	39	205	144	[29]	[278]	[195]
	12H	40	180	126	[30]	[244]	[171]
	13H	40	180	126	[30]	[244]	[171]
	15H	37	195	137	[28]	[264]	[185]
	18H	33	175	123	[25]	[237]	[166]
CS6/8	03	57	300	210	[43]	[407]	[285]
	04	57	300	210	[43]	[407]	[285]
	05	57	300	210	[43]	[407]	[285]
	06	57	300	210	[43]	[407]	[285]
	07	57	300	210	[43]	[407]	[285]
	09	52	275	193	[39]	[373]	[261]
	12	52	275	193	[39]	[373]	[261]
	14	52	275	193	[39]	[373]	[261]
SH6/8	05	76	400	280	[57]	[542]	[379]
	07	76	400	280	[57]	[542]	[379]
	09	71	375	263	[53]	[508]	[356]
	12	62	325	228	[46]	[441]	[309]
	13	62	325	228	[46]	[441]	[309]
RG	13	26	140	N/A	[19]	[190]	N/A
RL	03	38	200	N/A	[28]	[271]	N/A
	05	38	200	N/A	[28]	[271]	N/A
82	05	95	500	350	[71]	[678]	[475]
	08	85	450	315	[63]	[610]	[427]
	10	78	410	287	[58]	[556]	[389]
	12	71	375	263	[53]	[508]	[356]
	13	71	375	263	[53]	[508]	[356]
	15	67	350	245	[50]	[475]	[332]
	19	57	300	210	[43]	[407]	[285]

PTO SERIES	SPEED RATIO	INTERMITTENT HP@1000 RPM	INTERMITTENT TORQUE LBS. FT.	CONTINUOUS TORQUE LBS. FT.	INTERMITTENT [KW]@1000 RPM	INTERMITTENT TORQUE [NM]	CONTINUOUS TORQUE [NM]
83	05	95	500	N/A	[71]	[678]	N/A
	06	95	500	N/A	[71]	[678]	N/A
	12	71	375	N/A	[53]	[508]	N/A
FR62	06	29	150	105	[22]	[203]	[142]
FR63	06	36	190	133	[27]	[258]	[181]
FR64	06	36	190	133	[27]	[258]	[181]
GA6B	05	30	158	111	[22]	[214]	[150]
GM6B	05	30	158	111	[22]	[214]	[150]
GB10	06	42	220	154	[31]	[298]	[209]
	07	36	190	133	[27]	[258]	[181]
	09	29	150	105	[22]	[203]	[142]
CD10	05	76	400	280	[57]	[542]	[379]
	06	73	385	270	[54]	[522]	[365]
	07	68	360	252	[51]	[488]	[342]
	08	64	336	235	[48]	[456]	[319]
	10	59	310	217	[44]	[420]	[294]
	12	50	260	182	[37]	[352]	[246]
	15	43	225	158	[32]	[305]	[214]
CD40	07	114	600	420	[85]	[813]	[569]
	12	93	490	343	[70]	[664]	[465]
CS10 /11	05	95	500	350	[71]	[678]	[475]
	06	91	480	336	[68]	[651]	[456]
	07	86	450	315	[64]	[610]	[427]
	08	80	420	294	[60]	[569]	[398]
	10	73	385	270	[54]	[522]	[365]
CS20 /21	06	62	325	228	[46]	[440]	[308]
	07	58	305	214	[43]	[414]	[290]
	08	56	295	207	[42]	[400]	[280]
	10	55	290	203	[41]	[393]	[275]
	12	48	250	175	[36]	[338]	[237]
	15	38	200	140	[28]	[271]	[190]
CS41	07	114	600	420	[85]	[813]	[569]
	10	103	545	382	[76]	[739]	[517]
	12	93	490	343	[70]	[664]	[465]

The HC, PZ, and RS Series PTOs vary in their torque and horsepower ratings and are based on the transmission on which they are mounted. The torque rating of these PTOs are shown on their respective application pages or you may contact Muncie Power Products, Inc. Product Engineering Dept. for this information.