Air Cylinder Force — Extension and Retraction

Force values are theoretical; allow about 5% for cylinder friction. Pressures across top of chart are differentials across cylinder ports and not necessarily air line gauge pressures, because of back pressure in the exhaust line to atmosphere. When designing an air circuit, remember to allow a feed line air pressure at least 25% higher than required by the load to make up for back pressure and flow losses while the cylinder is moving.

For pressures not shown, use effective area of piston and multiply times pressure differential across ports.

Piston Dia. In.	Rod Dia. In.	Travel Dir.	Effec. Area. Sq. In.	Pressure Differential Across Cylinder Ports (PSI)								
				60	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**
1-1/2	None	Extend	1.77	106	124	141	159	177	194	212	230	265
	5/8	Retract	1.46	88	102	117	131	146	161	175	190	219
	1	Retract	0.98	59	69	79	88	98	108	118	128	147
1-3/4	**None**	**Extend**	**2.41**	**144**	**168**	**192**	**216**	**241**	**265**	**289**	**313**	**361**
	5/8	Retract	2.10	126	147	168	189	210	231	252	273	315
	1	Retract	1.62	97	113	130	146	162	178	194	210	227
2	**None**	**Extend**	**3.14**	**188**	**220**	**251**	**283**	**314**	**346**	**377**	**408**	**471**
	5/8	Retract	2.83	170	198	227	255	283	312	340	369	425
	1	Retract	2.36	141	165	188	212	236	259	283	306	353
2-1/2	**None**	**Extend**	**4.91**	**295**	**344**	**393**	**442**	**491**	**540**	**589**	**638**	**736**
	5/8	Retract	4.60	276	322	368	414	460	506	552	598	690
	1	Retract	4.12	247	289	330	371	412	454	495	536	619
	1-3/8	Retract	3.42	205	240	274	308	342	377	411	445	514
3	**None**	**Extend**	**7.07**	**424**	**495**	**565**	**636**	**707**	**778**	**848**	**919**	**1,060**
	1	Retract	6.28	377	440	503	565	628	691	754	817	942
	1-3/4	Retract	4.66	280	326	373	420	466	513	560	606	699
3-1/4	**None**	**Extend**	**8.30**	**498**	**581**	**664**	**747**	**830**	**913**	**995**	**1,078**	**1,244**
	1	Retract	7.51	451	526	601	676	751	826	901	976	1,127
	1-3/8	Retract	6.81	409	477	545	613	681	749	817	885	1,022
	1-3/4	Retract	5.89	353	412	471	530	589	648	707	766	884
3-1/2	**None**	**Extend**	**9.62**	**577**	**673**	**770**	**866**	**962**	**1,058**	**1,155**	**1,251**	**1,443**
	1	Retract	8.84	530	619	707	795	884	972	1,060	1,149	1,325
4	**None**	**Extend**	**12.57**	**754**	**880**	**1,005**	**1,131**	**1,257**	**1,382**	**1,508**	**1,634**	**1,885**
	1	Retract	11.78	707	825	942	1,060	1,178	1,296	1,414	1,532	1,767
	1-3/8	Retract	11.08	665	776	887	997	1,108	1,219	1,330	1,441	1,662
	1-3/4	Retract	10.16	610	711	813	914	1,016	1,118	1,219	1,321	1,524
5	**None**	**Extend**	**19.63**	**1,178**	**1,374**	**1,571**	**1,767**	**1,963**	**2,160**	**2,356**	**2,553**	**2,945**
	1	Retract	18.85	1,131	1,319	1,508	1,696	1,885	2,073	2,262	2,450	2,827
	1-3/8	Retract	18.15	1,089	1,271	1,452	1,634	1,815	1,997	2,178	2,360	2,723
6	**None**	**Extend**	**28.27**	**1,696**	**1,979**	**2,262**	**2,545**	**2,827**	**3,110**	**3,393**	**3,676**	**4,241**
	1-3/8	Retract	26.79	1,607	1,875	2,143	2,411	2,679	2,947	3,215	3,483	4,018
	1-3/4	Retract	25.87	1,552	1,811	2,070	2,328	2,587	2,846	3,104	3,363	3,880
7	**None**	**Extend**	**38.48**	**2,309**	**2,694**	**3,079**	**3,464**	**3,848**	**4,233**	**4,618**	**5,003**	**5,773**
	1-3/8	Retract	37.00	2,220	2,590	2,960	3,330	3,700	4,070	4,440	4,810	5,550
8	**None**	**Extend**	**50.27**	**3,016**	**3,519**	**4,021**	**4,524**	**5,027**	**5,529**	**6,032**	**6,535**	**7,540**
	1-3/8	Retract	48.78	2,927	3,415	3,902	4,390	4,878	5,366	5,854	6,341	7,317
	1-3/4	Retract	47.86	2,872	3,350	3,829	4,307	4,786	5,265	5,743	6,222	7,179
10	**None**	**Extend**	**78.54**	**4,712**	**5,498**	**6,283**	**7,069**	**7,854**	**8,639**	**9,425**	**10,210**	**11,781**
	1-3/4	Retract	76.13	4,568	5,329	6,091	6,852	7,613	8,375	9,136	9,897	11,420
	2	Retract	75.40	4,524	5,278	6,032	6,786	7,540	8,294	9,048	9,802	11,310
12	**None**	**Extend**	**113.1**	**6,786**	**7,917**	**9,048**	**10,179**	**11,310**	**12,441**	**13,572**	**14,703**	**16,965**
	2	Retract	110.0	6,597	7,697	8,796	9,896	10,996	12,095	13,195	14,294	16,493
	2-1/2	Retract	108.2	6,491	7,573	8,655	9,737	10,819	11,901	12,983	14,065	16,228
14	**None**	**Extend**	**153.9**	**9,236**	**10,776**	**12,315**	**13,854**	**15,394**	**16,933**	**18,473**	**20,012**	**23,091**
	2-1/2	Retract	149.0	8,942	10,432	11,922	13,413	14,903	16,393	17,884	19,374	22,354
	3	Retract	146.9	8,812	10,281	11,750	13,218	14,687	16,156	17,624	19,093	22,030

Air Consumption of Cylinders

When designing a machine using air cylinders which operate on a fast, continuously reciprocating program, it may be necessary to estimate the compressor HP capacity to keep the cylinders in continuous operation.

To estimate compressor load, first calculate air consumption of the cylinder(s), then convert this into compressor HP.

Air consumption should be calculated at total pressure required to balance the load plus additional pressure to make up for circuit losses in the piping, directional valve, flow control valves, mufflers, etc. In the chart the pressure values across the top are those set on the pressure regulator serving the circuit. This will automatically include circuit losses in the calculation. The system pressure regulator should, of course, be set no higher than necessary to produce the travel speed required. The total pressure required for load plus losses is often about 25% more than load balance pressure.

How to Use the Chart. The chart at the bottom of this page is set up for standard bore sizes with standard (smallest) rod. The use of a piston rod larger than standard size for a given bore will cause the air consumption to be slightly less than shown, but the difference will be so slight that it can be disregarded.

To use the chart, find cylinder bore in the left column. Follow this line to the column with your expected pressure regulator setting. Figures in the body of the chart are SCF (standard cubic feet) of free air to operate a l" stroke cylinder through one cycle, forward and return. Multiply this figure times your actual cylinder stroke, then times the number of complete cycles per minute. The final result will be the SCFM (standard cubic feet per minute) which must be supplied by the air compressor on a continuous basis.

This chart was calculated using compression ratios from the required HP chart. Consumption was calculated assuming the cylinder piston will be allowed to stall, at least momentarily, at each end of its stroke, giving it time to fill with air to full pressure regulator setting. If reversed at either end before reaching full stall, air consumption will be slightly less than shown.

Calculation Example: Estimate the SCFM consumption of a 4" bore air cylinder having a 28" stroke, to cycle 11 times a minute. Assume the load balance pressure for this cylinder is 65 PSI.

Solution: The pressure regulator will probably have to be set for a pressure of 80 PSI to take care of circuit flow losses in addition to load balance.

Use the 80 PSI column and the 4" bore line. The chart shows 0.091 SCF for a l" stroke. Then SCFM air flow required will be:

SCFM =.091 x 28 x 11 = 28.0

Converting SCFM Into Compressor HP: Use the chart on page 58 to convert SCFM into HP according to the kind of compressor in use.

Cylinder Air Consumption (SCF) per 1" Stroke, Forward and Return

Cyl. Bore	Rod Dia.	50 PSI	60 PSI	70 PSI	80 PSI	90 PSI	100 PSI	110 PSI	120 PSI	130 PSI	140 PSI	150 PSI	160 PSI
1.50	5/8	.008	.010	.011	.012	.013	.015	.016	.017	.018	.020	.021	.022
2.00	5/8	.015	.018	.020	.022	.025	.027	.029	.032	.034	.036	.039	.041
2.50	5/8	.024	.028	.032	.035	.039	.043	.047	.050	.054	.058	.062	.065
3.00	1	.035	.040	.046	.051	.056	.062	.067	.071	.076	.081	.087	.092
3.25	1	.040	.047	.053	.059	.065	.071	.077	.084	.090	.096	.102	.109
4.00	1	.062	.072	.081	.091	.100	.110	.120	.129	.139	.148	.158	.168
5.00	1	.098	.113	.128	.143	.159	.174	.189	.204	.219	.233	.249	.265
6.00	1-3/8	.140	.162	.184	.205	.227	.249	.270	.292	.313	.334	.357	.379
8.00	1-3/8	.252	.291	.330	.369	.408	.447	.486	.525	.564	.602	.642	.682
10.0	1-3/4	.394	.455	.516	.576	.637	.698	.759	.820	.881	.940	1.00	1.07
12.0	2	.568	.656	.744	.831	.919	1.01	1.09	1.18	1.27	1.36	1.45	1.54
14.0	2-1/2	.771	.891	1.01	1.13	1.25	1.37	1.49	1.61	1.74	1.85	1.98	2.10

Regulator Outlet PSI (At Least 25% Above Load Balance PSI)

Converting SCFM Into Compressor HP

Compression of air is an inefficient process because part of the energy is lost as heat of compression and can never be recovered. By over-compressing the air and then reducing it to a lower pressure through a regulator, the system losses are increased. The amount of this loss is nearly impossible to calculate, but on the average system may amount to 5 or 10%. Also, there is a small loss due to flow resistance through the regulator.

After finding the SCFM to operate the cylinder, refer to the tables on page 58. Convert into HP according to the kind of compressor used. Add 5 to 10% for the miscellaneous losses described above. This should be very close to the actual HP capacity needed.

Example: Find compressor HP needed to cycle a 4" bore air cylinder through a 28" stroke, 11 times a minute, against a load resistance of 1000 lbs.

Solution: A 4" bore cylinder working at 80 PSI would balance the 1000 lb. load. Add 25% more pressure (20 PSI) and set the pressure regulator at 100 PSI. From above table, air consumption would be:

.110 x 28 (stroke) x 11 (times a minute) = 33.88 SCFM

Refer to page 58. Assume a 2-stage compressor. At 100 PSI, 0.164 HP is required for each 1 SCFM. Total HP = 0.164 x 33.88= 5.56 HP. Add 5% (or 0.278 HP) for miscellaneous losses. Total compressor HP = 5.56 + 0.278 = 5.84 HP.

Horsepower Required for Compressing Air

Single-Stage Compressor, 85% Eff.		Two-Stage Compressor, 85% Eff.		Three-Stage Compressor, 85% Eff.		Single-Stage Compressor, 85% Eff.		Two-Stage Compressor, 85% Eff.		Three-Stage Compressor, 85% Eff.	
PSIG	**HP***	**PSIG**	**HP***	**PSIG**	**HP***	**PSIG**	**HP***	**PSIG**	**HP***	**PSIG**	**HP***
5	.021	50	.116	100	.159	80	.160	200	.220	850	.335
10	.033	60	.128	150	.190	85	.165	210	.224	900	.340
15	.056	70	.138	200	.212	90	.170	220	.228	950	.345
20	.067	80	.148	250	.230	95	.175	230	.232	1000	.350
25	.079	90	.155	300	.240	100	.179	240	.236	1050	.354
30	.089	100	.164	350	.258	110	.191	250	.239	1100	.358
35	.099	110	.171	400	.269	120	.196	260	.243	1150	.362
40	.108	120	.178	450	.279	130	.204	270	.246	1200	.366
45	.116	130	.185	500	.289	140	.211	280	.250	1250	.370
50	.123	140	.190	550	.297	150	.218	290	.253	1300	.374
55	.130	150	.196	600	.305	160	.225	300	.255	1350	.378
60	.136	160	.201	650	.311	170	.232	350	.269	1400	.380
65	.143	170	.206	700	.317	180	.239	400	.282	1450	.383
70	.148	180	.211	750	.323	190	.244	450	.289	1500	.386
75	.155	190	.216	800	.329	200	.250	500	.303	1550	.390

***HP to compress 1 SCFM from 0 PSIG to the values shown.**

Dimensions of Standard (Schedule 40) Pipe

Dimensions, flow ratings, and pressure ratings in this chart are for black or galvanized steel pipe, standard weight, Schedule 40. Nothing heavier is ever needed for shop air.

Identify the size of existing plumbing by wrapping string around the pipe. Mark the length an compare this length with circumference values in the chart.

Pipe Size, NPT	1/8"	1/4"	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
Outside Diameter	.405	.540	.675	.840	1.05	1.315	1.660	1.900	2.375
Inside Diameter	.269	.364	.493	.622	.824	1.049	1.380	1.610	2.067
Wall Thickness	.068	.088	.091	1.09	.113	.133	.140	.145	.154
Circumference	1-9/32	1-11/16	2-1/8	2-5/8	3-5/16	4-1/8	5-7/32	5-31/32	7-15/32
Flow Area	.0568	.1040	.1908	.3037	.5330	.8649	1.495	2.035	3.354
Equiv. Tube O.D.	1/4"	3/8"	1/2"	5/8"	3/4"	1"	1-1/4"	1-1/2"	2"
Tap Drill Dia.	R	7/16"	37/64"	23/32"	59/64"	1-5/32"	1-1/2"	1-47/64"	2-7/32"
Working PSI	2238	2170	1790	1730	1435	1350	1125	1020	860
Burst PSI	13,430	13,030	10,785	10,380	8600	8090	6740	6100	5180

Working pressure at a safety factor of 6.

Pump Down Time for Evacuating Tanks

Figures in the body of this chart show the running time, in minutes, of a 1 SCFM vacuum pump to evacuate a tank with cubic foot or gallon capacity shown at the top of the chart, to the degree of vacuum in the left column. Divide chart values by the free running displacement of your vacuum pump. If your pump has 5 SCFM displacement, running time will be 1/5th the values in the chart.

For any degree of vacuum: $T = \frac{V}{D} \times Ln(\frac{A}{A-B})$

T is pumping time, in minutes. V is volume of tank, in cubic feet. D is free running displacement of pump. A is deadhead rating of vacuum pump (with inlet blocked). B is desired vacuum level, in "Hg.

Tank Volume, in Cubic Feet or Gallons

Cu. Feet	**1-1/2**	**2-1/4**	**3-1/2**	**5**	**7-1/2**	**10**	**17-1/2**	**25**	**40**	**55**	**85**	**130**
Gallons	11.2	16.8	26.2	37.4	56.1	74.8	131	187	300	411	636	972
Vac. "Hg	**Time, in minutes, to Evacuate Tank**											
10	.66	.99	1.5	2.2	3.3	4.4	7.7	11.1	17.7	24.3	37.6	57.5
12	.84	1.3	2.0	2.8	4.2	5.6	9.8	14.0	22.4	30.8	47.6	72.7
14	1.0	1.6	2.4	3.5	5.2	6.9	12.1	18.3	27.7	38.1	58.9	90.1
16	1.3	1.9	3.0	4.2	6.4	8.5	14.8	21.2	33.9	46.6	72.0	110
18	1.5	2.3	3.6	5.1	7.1	10.3	18.0	25.7	41.2	56.6	87.5	134

Pipe Size Recommended for Air Distribution Lines

Figures in this chart show recommended standard weight pipe sizes. Part of these data were taken from the standards of the Air Compressor Research Council, and show the minimum pipe sizes, according to length of run, that should be used if pressure loss is to be held to a reasonable minimum. Larger pipe may be used if economics permit.

If the actual SCFM (standard cubic feet per minute) of air flow is known, use the first column of the chart. If it is not known, an estimate may be made by using the compressor horsepower as a guide and using the last column instead of the first. This may, however, be misleading because the piping should actually be sized on the maximum intermittent flow as it is used in the system, and this could be considerably greater than the steady rate of the compressor. Experience and judgement should be used. A larger pipe than indicated should be used if high flows may occur intermittently for short periods.

SCFM	**Length of Run - Feet**									**Comp.**
Air Flow	**25**	**50**	**75**	**100**	**150**	**200**	**300**	**500**	**1000**	**HP**
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	1
18	1/2	1/2	1/2	3/4	3/4	3/4	3/4	1	1	3
30	3/4	3/4	3/4	3/4	1	1	1	1-1/4	1-1/4	5
45	3/4	3/4	1	1	1	1	1-1/4	1-1/4	1-1/4	7-1/2
60	3/4	1	1	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	10
90	1	1	1-1/4	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	2	15
120	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2	2	2	20
150	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	2	2	2	2-1/2	25
180	1-1/4	1-1/2	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2	30
240	1-1/4	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2	3	40
300	1-1/2	2	2	2	2	2-1/2	2-1/2	3	3	50
360	1-1/2	2	2	2	2-1/2	2-1/2	2-1/2	3	3	60
450	2	2	2	2-1/2	2-1/2	3	3	3	3-1/2	75
600	2	2-1/2	2-1/2	2-1/2	3	3	3	3-1/2	4	100
750	2	2-1/2	2-1/2	3	3	3	3-1/2	3-1/2	4	125

Air Pressure Loss Through Schedule 40 Pipe

Figures in the body of the chart are pressure losses in PSI for the first 100 feet of clean commercial pipe. If necessary to compute beyond 100 feet, remember the entry pressure into the second section will be less by the amount of loss in the first section. Notice that the chart shows entry pressures of 80 and 125 PSI only. Loss figures for other entry pressures can be estimated by proportion. Remember to use absolute rather than gauge pressures when working proportion problems.

SCFM	**1/2" NPT**		**3/4" NPT**		**1" NPT**		**1-1/4" NPT**		**1-1/2" NPT**	
Free Air	**80 PSI**	**125 PSI**	**80 PSI**	**125 PSI**	**80 PSI**	**125 PSI**	**80 PSI**	**125 PSI**	**80 PSI**	**125 PSI**
10	.45	.30	.11	.08	.04	.02				
20	1.75	1.15	.40	.28	.15	.08				
30	3.85	2.55	.90	.60	.30	.20				
40	6.95	4.55	1.55	1.05	.45	.30				
50	10.5	7.00	2.40	1.60	.75	.50	.18	.12		
60			3.45	2.35	1.00	.70	.25	.17		
70			4.75	3.15	1.35	.90	.35	.23	.16	.10
80			6.15	4.10	1.75	1.20	.45	.30	.20	.14
90			7.75	5.15	2.25	1.50	.55	.40	.25	.17
100			9.60	6.35	2.70	1.80	.65	.45	.30	.20
125			15.5	9.8	4.20	2.80	1.05	.70	.45	.32
150			23.0	14.5	5.75	4.00	1.45	1.00	.65	.45
175					8.10	5.45	2.00	1.30	.90	.60
200					10.9	7.10	2.60	1.75	1.15	.80
250							4.05	2.65	1.80	1.20
300							5.80	3.85	2.55	1.70
350							7.90	5.15	3.55	2.35
400							10.3	6.75	4.55	3.05
450									5.80	2.80
500									7.10	4.70

Figures in the chart are PSI pressure losses for the first 100 feet of pipe

AAA PRODUCTS INTERNATIONAL NEMA Enclosure Classifications and Types

Type 1: General Purpose- intended for indoor use primarily to provide a degree of protection against contact with the enclosed parts in locations without unusual service conditions.

Type 2: Drip proof- intended for indoor use primarily to provide a degree of protection against limited amounts of falling water or dirt.

Type. 3: Rain tight, Dust tight and Sleet (Ice) Resistant- intended for outdoor use primarily to provide a degree of protection against windblown dust, rain and sleet; undamaged by the formation of ice on the enclosure.

Type 3S: Rain tight, Dust tight and Sleet (Ice) Resistant - intended for outdoor use primarily to provide a degree of protection against windblown dust, rain and sleet; external mechanism remains operable when ice laden.

Type 3R: Rainproof, Sleet (Ice) Resistant-intended for outdoor use primarily to provide a degree of protection against falling rain and sleet, undamaged by the formation of ice on the enclosure.

Type 4: Watertight and Dust tight - intended for indoor or outdoor use to provide a degree of protection against splashing water, water seepage, falling or hose-directed water and severe external condensation; undamaged by the formation of ice on the enclosure.

Type 4X: Watertight, Dust tight and Corrosion Resistant- same as Type 4Enclosure, but provides additional protection to resist corrosion.

Type 6: Submersible- intended for indoor or outdoor use to provide a degree of protection against entry of water during submersion at a limited depth. (Tested to 6' for 30 minutes).

Type 6p: Submersible- same as Type 6 Enclosure, but provides prolonged submersion protection at a limited depth. (Tested to 6'for 24 hours).

Type 7 (A, B, C and D): Explosion- proof, Class I, Division I, Groups A, B, C and D Hazardous Locations - designed to contain an internal explosion without causing an external hazard when installed in the indicated atmospheres and locations. Class I, Division I locations are those in which hazardous atmospheres are, or may be, present under normal operating conditions. These enclosures are also suitable for Class I, Division 2 locations in which hazardous atmospheres are present only in case of accidental rupture or breakdown of equipment, or abnormal operation. Type I General Purpose Enclosures may be permitted in a Class I, Division 2 location subject to the approval authority (Ref: National Electrical Code 501-3, b3).

Group designations are described in the National Electrical Code as follows:

Group A- Atmospheres containing acetylene

Group B - Atmospheres containing hydrogen

Group C - Atmospheres containing ethyl-ether vapors, ethylene or cyclopropane

Group D - Atmospheres Containing gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzol, lacquer, solvent vapors or natural gas

Type 9 (E, F and G): Dust-Ignition, proof, Class II, Groups E, F and G Hazardous Locations- designed to prevent the entrance of dust, and the enclosed devices do not produce sufficient heat to cause external surface temperatures capable of igniting dust on the enclosure or in the surrounding atmosphere. Class II, Division 1 locations are those in which combustible dust is, or may be, present under normal operating conditions. These enclosures are also suitable for Class II, Division 2 locations in which hazardous dust is present only under abnormal conditions.

Group designations are described in the National Electrical Code as follows:

Group E - Atmospheres containing metal dust, including aluminum, magnesium, their commercial alloys, and other metals of similarly hazardous characteristics.

Group F - Atmospheres containing carbon black, coal or coke dust

Group G -Atmospheres containing flour, starch or grain dust

Type 12: Intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping noncorrosive liquids.

Type 13: Intended for outdoor use primarily to provide a degree of protection against dust, spraying of water, oil, and non corrosive material.

National Electrical Manufacturers Association (NEMA Standard 250)

AAA PRODUCTS INTERNATIONAL
IEC/IP Environmental Protection Ratings

The degree of protection provided by an enclosure is indicated by an IP code. This code is made up of two numbers. The first number is the degree of protection against solid foreign objects. The second number is the degree of protection against water.

For example, the IP rating of IP65 designates total protection from dust and protection from water jets from any direction.

First Number: Protection against solid foreign objects.

Number	Description
0	No Protection
1	Protected against solid foreign objects of 50mm diameter and greater.
2	Protected against solid foreign objects of 12.5mm diameter and greater.
3	Protected against solid foreign objects of 2.5mm diameter and greater.
4	Protected against solid foreign objects of 1.0mm diameter and greater.
5	Ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the apparatus or to impair safety.
6	No ingress of dust.

Rough Conversions Between Ratings.

NEMA rating	UL rating	CSA Rating	Apprx. IEC/IP rating
1	1	1	IP23
2	2	2	IP30
3	3	3	IP64
3R	3R	3R	IP32
4	4	4	IP65
4X	4X	4X	IP66
6	6	6	IP67
12	12	12	IP55
13	13	13	IP65

Second Number: Protection against water.

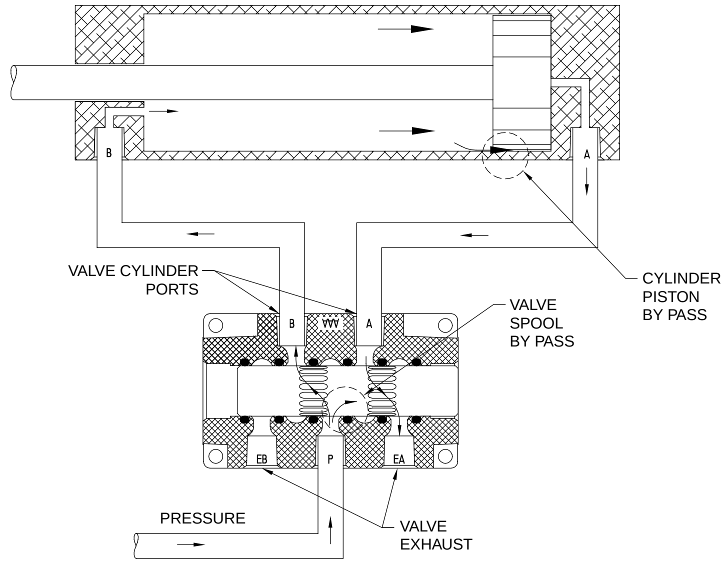
Number	Description
0	No Protection
1	Vertically falling water drops shall have no harmful effects.
2	Vertically falling water drops shall have no harmful effects when the enclosure is tilted at any angle up to 15 degrees on either side of the vertical axis.
3	Water sprayed at an angle up to 60 degrees on either side of the vertical axis shall have no harmful effects.
4	Water splashed against the enclosure from any direction shall have no harmful effects.
5	Water projected in jets against the enclosure from any direction shall have no harmful effects.
6	Water projected in powerful water jets against the enclosure from any direction shall have no harmful effects.
7	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under standardized conditions of pressure and time.
8	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under conditions which shall be agreed between manufacturer and user but which are more severe than for numeral 7.

Cylinder and Valve Testing

On an air system if air is detected escaping from a 4-way valve exhaust while the cylinder is stopped, this air is either blowing by worn-out piston seals, or is leaking across the spool in the 4-way valve. These two by pass paths are shown in the figure.

Most air cylinders and valves have soft seals and should be leaktight. However, those air valves having a metal-to-metal seal between spool and body may be expected to have a small amount of by pass.

If by pass is noted, it is more likely to be coming through the cylinder than across the valve spool, and the cylinder should be tested first.



CYLINDER TESTING

Run the piston to one end of its stroke and leave it stalled in this position under pressure. Crack the fitting on the exhaust end of the cylinder to check for air by pass. After checking, tighten the fitting and run the piston to the opposite end of the barrel and repeat the test. Occasionally a cylinder will leak at one point in its stroke due to a scratch or dent in the barrel. check suspected positions in mid stroke by installing a positive stop at the suspected position and run the piston rod against it for testing. Once in a great while a piston seal may leak intermittently. This is usually caused by a soft packing or O-ring moving slightly or rolling into different positions on the piston, and is more likely to happen on cylinders of large bore. Pistons with metal ring seals can be expected to have a small amount of by pass across the rings, and even those “leaktight” soft seals may have a small by-pass during break-in of new seals or after seals are well worn.

4-WAY VALVE TESTING

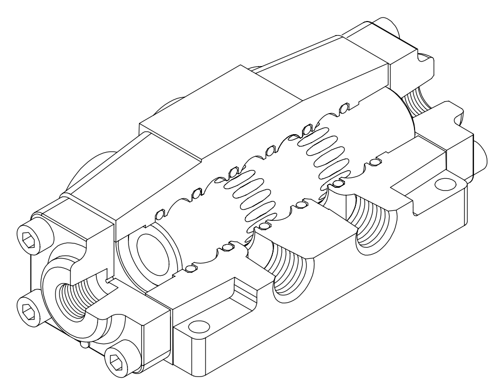
For testing 4-way valves, either air or hydraulic, it is necessary to obtain access to the exhaust or tank return ports so that the amount of by pass can be observed. To make the test, disconnect both cylinder lines and plug these ports on the valve. Start up the system and shift the valve to one working position. Any flow out the exhausts or tank return line while the valve is under pressure is the amount of by pass. Repeat the test in all other working positions of the valve.

INTERNALLY PILOTED SOLENOID VALVE TESTING

Standard solenoid models are assembled for "internal pilot operation"; that is, they derive shifting pressure for the spool from the valve inlet port. When testing an internally piloted solenoid valve, do not let air free flow through the cylinder port. This flow is normally so great, that back pressure to shift the spool can not be adequately generated. To test a internally piloted valve, either plug the cylinder port, place a muffler in the cylinder port, or attach the cylinder port to a short piece of hose to generate a slight back pressure to shift the valve.

TO REPLACE O-RINGS

Use a sharp tool such as a pick or scribe to remove the old rings. Use an air hose, and solvent if necessary, to thoroughly clean out the grooves in the body. The new rings can be inserted with the fingers in the 1/2" and larger bodies. Install 3 rings from each end of the valve. For the 1/4" and 3/8" valve bodies, use a pair of tweezers with angle point, starting ring in groove in one side and working around. After installing rings, lightly grease the spool and body bore before assembly, using Magnalube®-G grease or O-ring grease. Never use oil or any other grease. If tweezers are not available, slip the spool into the bore, as a guide, to just below a groove, and work the ring into the groove with a small rod.



Cut-away View of 1/4" Double Piloted Valve