THEORETICAL PUSH AND PULL FORCES FOR HYDRAULIC CYLINDERS

DETERMINE FORCE REQUIRED — TO SELECT A CYLINDER FOR AN APPLICATION, FIRST DETERMINE THE MAXIMUM PUSH AND/OR PULL FORCE REQUIRED TO DO THE JOB. THEN USE THIS CHART TO SELECT THE CYLINDER THAT GIVES THE NECESSARY FORCE FOR YOUR APPLICATION. IT SHOULD BE NOTED THAT THE FORCE REQUIREMENTS DERIVED BY FORMULA ARE ONLY THEORETICALLY CORRECT. OTHER FORCES MUST BE PROVIDED FOR.

PRESSURE DROP - WHICH MEANS THAT WORKING PRESSURE AT THE CYLINDER PORT WILL BE SOMEWHAT LESS THAN SYSTEM PRESSURE - SHOULD BE ALLOWED FOR IN SUCH CALCULATIONS. A MARGIN FOR OVERCOMING FRICTION IN THE CYLINDER LIKEWISE MUST BE ADDED.

A CERTAIN AMOUNT OF THE FORCE THAT A CYLINDER CAN EXERT IS COUNTER ACTED BY THE FRICTION DEVELOPED THROUGH THE PACKING AND TO A LESSER EXTENT BY THE WEIGHT OF THE PISTON. THE AMOUNT REQUIRED TO COUNTER ACT THESE RESISTANCES HAS BEEN REDUCED IN THESE CYLINDERS TO LESS THAN 5% OF THE CYLIDERS THEORETICAL POWER.

BORE DIA.	ROD DIA.	CYL. WORK	WORK AREA SQ.IN.	WORKING PRESSURE P.S.I.					
				500	1000	1500	2000	2500	3000
1.50"		PUSH	1.77	885	1770	2655	3540	4425	5310
	0.625	PULL	1.46	730	1460	2190	2920	3650	4380
	1.00	PULL	.98	490	980	1470	1960	2450	2940
2.00"		PUSH	3.14	1570	3140	4710	6280	7850	9420
	1.00	PULL	2.36	1180	2360	3540	4720	5900	7080
	1.375	PULL	1.66	830	1660	2490	3320	4150	4980
2.50"		PUSH	4.91	2455	4910	7365	9820	12275	14730
	1.00	PULL	4.12	2060	4120	6180	8240	10300	12360
	1.375	PULL	3.42	1710	3420	5130	6840	8550	10260
	1.75	PUSH	2.50	1250	2500	3750	5000	6250	7500
3.25"		PUSH	8.30	4150	8300	12450	16600	20750	24900
	1.375	PULL	6.81	3405	6810	10215	13620	17025	20430
	1.75	PULL	5.89	2945	5890	8835	11780	14725	17670
	2.00	PULL	5.15	2575	5150	7725	10300	12875	15450
4.00"		PUSH	12.57	6285	12570	18855	25140	31425	37710
	1.75	PULL	10.16	5080	10160	15240	20320	25400	30480
	2.00	PULL	9.42	4710	9420	14130	18840	23550	28260
	2.50	PULL	7.66	3830	7660	11490	15320	19150	22980
5.00"		PUSH	19.64	9820	19640	29460	39280	49100	58920
	2.00	PULL	16.49	8245	16490	24735	32980	41225	49470
	2.50	PULL	14.73	7365	14730	22095	29460	36825	44190
	3.00	PULL	12.57	6285	12570	18855	25140	31425	37710
	3.50	PULL	10.01	4710	9420	14130	18840	23550	28260
6.00"		PUSH	28.27	14135	28270	42405	56540	70675	84810
	2.50	PULL	23.37	11685	23370	35055	46740	58425	70110
	3.00	PULL	21.21	10605	21210	31815	42420	53025	63630
	3.50	PULL	18.65	9325	18650	27975	37300	46625	55950
	4.00	PULL	15.71	7855	15710	23565	31420	39275	47130
7.00"		PUSH	38.48	19240	38480	57720	76960	96200	115440
	3.00	PULL	31.42	15710	31420	47130	62840	78550	94260
	3.50	PULL	28.86	14430	28860	43290	57720	72150	86580
	4.00	PULL	25.92	12960	25920	38880	51840	64800	77760
	5.00	PULL	18.85	9425	18850	28275	37700	47125	56550
8.00"		PUSH	50.27	25135	50270	75405	100540	125675	150810
	3.50	PULL	40.64	20320	40640	60960	81280	101600	121920
	4.00	PULL	37.70	18850	37700	56550	75400	94250	113100
	5.00	PULL	30.63	15315	30630	45945	61260	76575	91890
	5.50	PULL	26.51	13255	26510	39765	53020	66275	79530
10.00"		PUSH	78.54	39270	78540	117810	157080	196350	235620
	4.50	PULL	62.64	31320	62640	93960	125280	156600	187920
	5.00	PULL	58.91	29455	58910	88365	117820	147275	176730
	5.50	PULL	54.78	27390	54780	82170	109560	136950	164340
	7.00	PULL	40.06	20030	40060	60090	80120	100150	120180
12.00"		PUSH	113.10	56550	113100	169650	226200	282750	339300
	4.50	PULL	97.19	48595	97190	145785	194380	242975	291570
	5.00	PULL	93.46	46730	93460	140190	186920	233650	280380
	5.50	PULL	89.34	44670	89340	134010	178680	223350	268020
	7.00	PULL	74.61	37305	74610	111915	149220	186525	223830

BASIC HYDRAULIC CYLINDER FORMULA

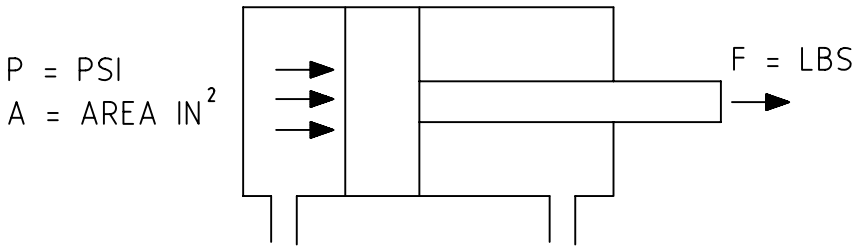
THE CYLINDER OUTPUT FORCES ARE DERIVED FROM THE FORMULA.

$$F = P \times A$$

WHERE F = FORCE IN POUNDS

P = PRESSURE AT THE CYLINDER IN POUNDS PER SQUARE INCH

A = EFFECTIVE AREA OF CYLINDER PISTON IN SQUARE INCHES



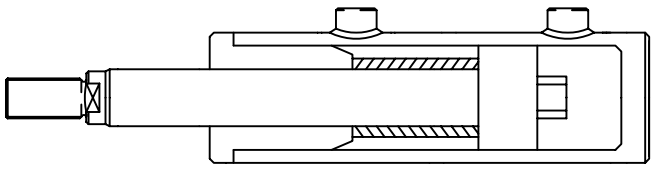
STOP TUBE AND PISTON ROD STROKE SELECTION

THE STOP TUBE IS A GENERALLY ACCEPTED AND PREFERRED METHOD OF REDUCING PISTON AND BEARING LOADS ON LONG PUSH STROKE CYLINDERS. IT MINIMIZES THE JACK-KNIFE EFFECT AND REDUCES BEARING PRESSURE.

AS ILLUSTRATED BELOW THE STOP TUBE IS PLACED BETWEEN THE PISTON AND THE CYLINDER GLAND TO RESTRICT THE EXTENDED POSITION OF THE ROD SO THAT THE LENGTHENED SPACE BETWEEN THE PISTON AND GLAND PROVIDES ADDITIONAL STRENGTH AND SIDE SUPPORT FOR THE EXTENDED ROD

STOP TUBES ARE NORMALLY USED FOR STROKES EXCEEDING 40 INCHES OR MORE. THE BASIC LENGTH OF THE CYLINDER IS INCREASED BY THE STOP TUBE LENTH.

$$\text{STOP TUBE LENGTH (INCH)} = \frac{\text{STROKE (INCH)} - 40\ \text{(INCH)}}{10}$$



THE PISTON ROD IN A CYLINDER ACTS AS A COLUMN UNDER THRUST (PUSH) CONDITIONS. IT IS ,THEREFORE, SUBJECTED TO BOTH COMPRESSIVE STRESSES AND BUCKLING STRESSES. CONSEQUENTLY, IT MAY BE NECESSARY TO INCREASE THE ROD DIAMETER TO ACHIEVE THE NECESSARY COLUMN "STRENGTH".

THE VALUE OF "K" SHOWN IN THE TABLES ARE OUR RECOMMENDED MAXIMUM EQUIVALENT "K" LENGTH FOR NORMAL HORIZONTAL AND VERTICAL APPLICATIONS UNDER LIGHT TO MEDIUM SHOCK LOADS. FOR HEAVY DUTY SHOCK LOADING AND HIGH CYCLING, CHOOSE THE NEXT ROD SIZE LARGER THAN SHOWN BY THE TABLE.

PROCEDURE

1. DETERMINE ACTUAL LENGTH "L" FROM THE APPLICABLE DIAGRAM REMEMBERING TO ADD IN STOP TUBE AND ANY ADDITIONAL ROD EXTENSION
2. CALCULATE "K" FROM FORMULA ADJACENT TO EACH DIAGRAM GROUP.
3. DETERMINE CYLINDER THRUST FROM APPLICABLE FORMULA.
4. FIND ROD SIZE FROM TABLE BY READING ACROSS LINE FROM THE PUSH (LOAD) FIGURE UNTIL THE FIRST FIGURE EXCEEDING CALCULATED "K" IS REACHED. RECOMMENDED ROD DIAMETER IS THEN READ FROM THE TOP OF THE TABLE.
5. IF PISTON ROD EXCEEDS MAXIMIUM ROD SIZE AVAILABLE IN CYLINDER BORE, THEN USE LARGER BORE CYLINDER AT REDUCED PRESSURE

MILLIMETRE TABLE OF "K"

PUSH kN	ROD DIAMETER													
	16	25	35	44	51	64	76	89	102	114	127	140	152	178
1	1300													
2	920	2300												
2.5	820	2050	3920											
3	750	1870	3540											
4	650	1620	3070	5000	6450									
5	580	1450	2740	4500	5800									
6	530	1320	2500	4100	5300									
8	460	1140	2160	3500	4600	7100								
10	410	1020	1930	3150	4100	6400								
12	380	940	1760	2900	3750	5850								
14	350	870	1630	2670	3450	5400								
18	310	770	1440	2350	3050	4750	6870							
22	280	690	1300	2130	2750	4300	6200	8500						
26		640	1190	1950	2550	3950	5700	7850						
30		590	1120	1820	2350	3700	5300	7300						
35		550	1020	1680	2200	3400	4900	6700	8800					
40		510	960	1570	2050	3200	4600	6300	8200					
45		480	910	1480	1930	3000	4350	5900	7700	9700	12100			
50		460	860	1400	1830	2850	4100	5600	7320	9250	11200			
60			790	1280	1670	2600	3750	5100	6650	8400	10200			
80			680	1120	1450	2250	3250	4420	5790	7300	9100	11000		
100			610	990	1300	2000	2900	4000	5150	6550	8100	10000	11800	15800
150				810	1060	1630	2360	3230	4200	5300	6610	8100	9650	12800
200					910	1420	2050	2800	3660	4600	5750	7000	8350	11200
250						1260	1820	2500	3250	4120	5150	6250	7450	10000
300							1660	2280	2950	3760	4700	5700	6800	9100
350							1540	2100	2760	3500	4350	5300	6300	8400
400							1440	1970	2600	3260	4080	4930	5650	7800
500								1750	2310	2920	3620	4400	5250	7000
750									1880	2370	2970	3600	4250	5650
1000										2050	2570	3110	3700	4880
1250											2310	2790	3300	4370
1500											2200	2550	3020	4000
1750												2350	2800	3700
2000													2600	3450

THIS AREA OVER MAX. THRUST ABILITY OF PISTON ROD

INCH TABLE OF "K"

PUSH lb.f	ROD DIAMETER													
	5/8	1	1 3/8	1 3/4	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	7
200	54													
500	34	86	165											
600	31	78	150											
800	27	67	129	207	270									
1000	24	60	115	185	241									
1200	22	55	105	170	221									
1400	20	51	97	156	205									
1600	19	48	90	146	192									
1800	18	45	85	138	181	280								
2000	17	43	80	131	171	267								
2500	15	38	72	117	153	238								
3000	14	35	65	107	140	218								
4000	12	30	57	93	121	189	272							
5000	11	27	50	83	108	172	243	330						
6000		25	46	76	99	154	221	301						
7000		23	42	70	91	143	205	280						
8000		21	39	66	85	134	192	262	342					
9000		20	37	62	80	126	181	246	323					
10000		19	35	59	76	119	171	234	307	386				
12000		17	32	54	70	109	156	212	279	351	435			
16000			27	47	60	94	135	184	241	305	375			
20000			24	42	54	84	122	165	216	272	336	405		
30000				34	44	69	99	134	176	222	274	330	390	
40000				29	38	60	86	116	152	193	238	286	337	
50000					34	54	77	103	136	172	212	256	300	405
60000						49	70	94	124	157	193	233	250	370
80000							61	82	107	136	167	202	278	320
100000							55	73	96	122	150	181	228	285
125000								66	86	109	134	162	192	255
150000								60	78	99	123	148	175	234
200000									68	86	106	127	152	202
250000										77	94	114	146	180
300000											86	104	124	165
350000												96	115	152
400000												90	107	142

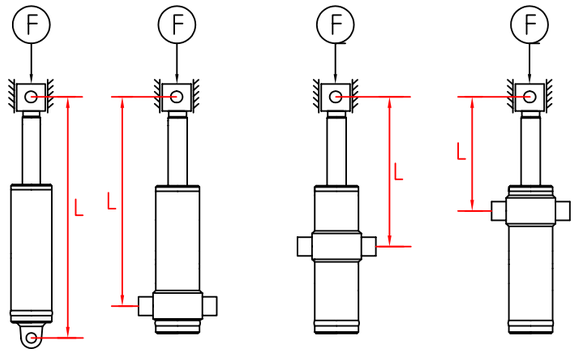
THIS AREA OVER MAX. THRUST ABILITY OF PISTON ROD

PISTON ROD BUCKLING LOAD EXAMPLES

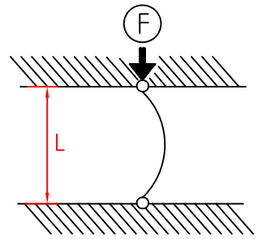
INSTALLATION SITUATION OF CYLINDERS

FREE BUCKLING LENGTH (K)

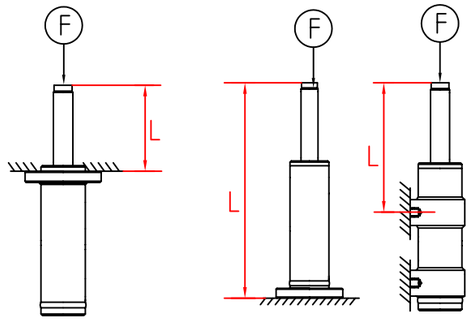
SITUATION 1
BOTH ENDS PIVOTED AND GUIDED (ROUND)



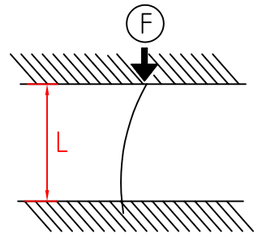
K = L



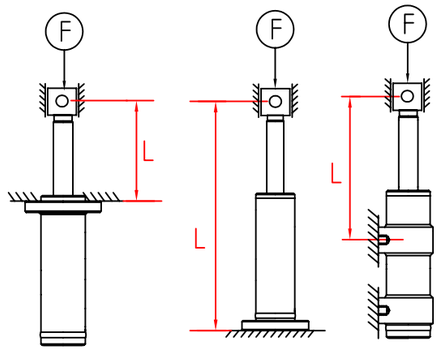
SITUATION 2
ONE END FIXED AND ONE END FREE.



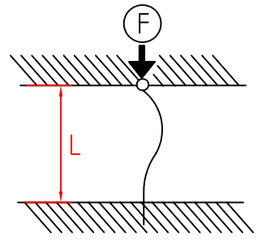
K = 2L



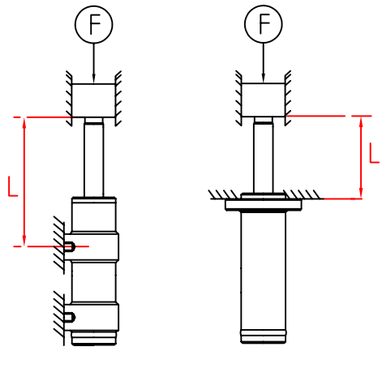
SITUATION 3
ONE END GUIDED AND PIVOTED AND ONE END FIXED



$K = L \times \sqrt{\frac{1}{2}}$



SITUATION 4
BOTH ENDS FIXED AND GUIDED



$K = \frac{L}{2}$