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 RESISTANCE'S HAS BEEN REDUCED IN THESE CYLINDERS TO LESS THAN 5% OF THE CYLINDERS 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
	0.875	PULL	1.17	585	1170	1755	2340	2925	3510
	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
	1.375	PULL	3.42	1710	3420	5130	6840	8550	10260
	1.75	PULL	2.50	1250	2500	3750	5000	6250	7500
3.00"		PUSH	7.07	3535	7070	10605	14140	17675	21210
	1.75	PULL	4.66	2330	4660	6990	9320	11650	13980
	2.00	PULL	3.93	1965	3930	5895	7860	9825	11790
4.00"		PUSH	12.57	6285	12570	18855	25140	31425	37710
	2.00	PULL	9.42	4710	9420	14130	18840	23550	28260
	2.50	PULL	7.66	3830	7660	11490	15320	19150	22980
	3.00	PULL	5.50	2750	5500	8250	11000	13750	16500
4.50"		PUSH	15.90	7950	15900	23850	31800	39750	47700
	2.00	PULL	12.76	6380	12760	19140	25520	31900	38280
	2.50	PULL	11.00	5500	11000	16500	22000	27500	33000
	3.00	PULL	8.84	4420	8840	13260	17680	22100	26520
5.00"		PUSH	19.64	9820	19640	29460	39280	49100	58920
	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
	4.00	PULL	7.07	3535	7070	10605	14140	17675	21210
5.50"		PUSH	23.79	11895	23790	35685	47580	59475	71370
	2.50	PULL	18.88	9440	18880	28320	37760	47200	56640
	3.00	PULL	16.72	8360	16720	25080	33440	41800	50160
	3.50	PULL	14.16	7080	14160	21240	28320	35400	42480
	4.00	PULL	11.22	5610	11220	16830	22440	28050	33660
6.00"		PUSH	28.27	14135	28270	42405	56540	70675	84810
	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
	4.50	PULL	12.37	6185	12370	18555	24740	30925	37110
	5.00	PULL	8.64	4320	8640	12960	17280	21600	25920

BORE DIA.	ROD DIA.	CYL. WORK	WORK AREA SQ.IN.	WORKING PRESSURE P.S.I. 500	1000	1500	2000	2500	3000
6.50"		PUSH	33.18	16590	33180	49770	66360	82950	99540
	3.00	PULL	26.11	13055	26110	39165	52220	65275	78330
	3.50	PULL	23.56	11780	23560	35340	47120	58900	70680
	4.00	PULL	20.62	10310	20620	30930	41240	51550	61860
	4.50	PULL	17.28	8640	17280	25920	34560	43200	51840
	5.00	PULL	13.55	6775	13550	20325	27100	33875	40650
7.00"		PUSH	38.49	19245	38490	57735	76980	96225	115470
	3.50	PULL	28.86	14430	28860	43290	57720	72150	86580
	4.00	PULL	25.92	12960	25920	38880	51840	64800	77760
	4.50	PULL	22.58	11290	22580	33870	45160	56450	67740
	5.00	PULL	18.85	9425	18850	28275	37700	47125	56550
7.50"		PUSH	44.18	22090	44180	66270	88360	110450	132540
	3.50	PULL	34.56	17280	34560	51840	69120	86400	103680
	4.00	PULL	31.61	15805	31610	47415	63220	79025	94830
	4.50	PULL	28.28	14140	28280	42420	56560	70700	84840
	5.00	PULL	24.54	12270	24540	36810	49080	61350	73620
8.00"		PUSH	50.27	25135	50270	75405	100540	125675	150810
	4.00	PULL	37.70	18850	37700	56550	75400	94250	113100
	4.50	PULL	34.36	17180	34360	51540	68720	85900	103080
	5.00	PULL	30.63	15315	30630	45945	61260	76575	91890
	6.00	PULL	21.99	10995	21990	32985	43980	54975	65970
9.00"		PUSH	63.62	31810	63620	95430	127240	159050	190860
	4.50	PULL	47.71	23855	47710	71565	95420	119275	143130
	5.00	PULL	43.98	21990	43980	65970	87960	109950	131940
	5.50	PULL	39.86	19930	39860	59790	79720	99650	119580
	6.00	PULL	36.34	18175	36350	54525	72700	90875	109050
	7.00	PULL	25.13	12565	25130	37695	50260	62825	75390
10.00"		PUSH	78.54	39270	78540	117810	157080	196350	235620
	5.00	PULL	58.91	29455	58910	88365	117820	147275	176730
	5.50	PULL	54.78	27390	54780	82170	109560	136950	164340
	6.00	PULL	50.27	25135	50270	75405	100540	125675	150810
	7.00	PULL	40.06	20030	40060	60090	80120	100150	120180
	8.00	PULL	28.27	14135	28270	42405	56540	70675	84810

BASIC HYDRAULIC CYLINDER FORMULA

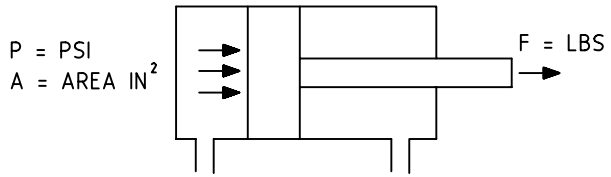
THE CYLINDER OUTPUT FORCES ARE DERIVED FROM THE FORMULA.

$$F = P \times A$$

WHERE F = FORCE IN POUNDS

P = PRESSURE AT THE CYLINDER IN POUNDS PER SQUARE INCH

A = EFFECTIVE AREA OF CYLINDER PISTON IN SQUARE INCHES



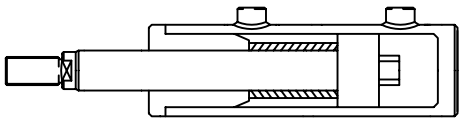
STOP TUBE AND PISTON ROD STROKE SELECTION

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 LENGTH.

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



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 MAXIMUM ROD SIZE AVAILABLE IN CYLINDER BORE, THEN USE LARGER BORE CYLINDER AT REDUCED PRESSURE

MILLIMETRE TABLE OF "K"

PUSH	ROD DIAMETER													
kN	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	ROD DIAMETER													
lb.f	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

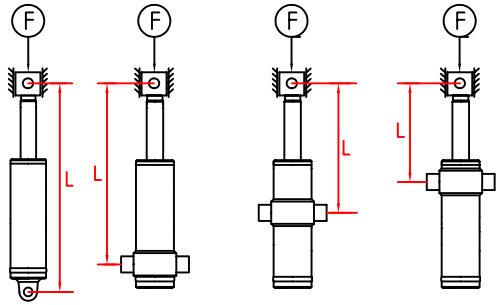
THIS AREA OVER MAX. THRUST ABILITY OF PISTON ROD

PISTON ROD BUCKLING LOAD EXAMPLES

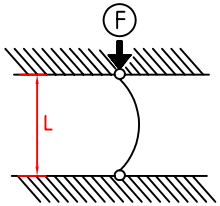
INSTALLATION SITUATION OF CYLINDERS

FREE BUCKLING LENGTH (K)

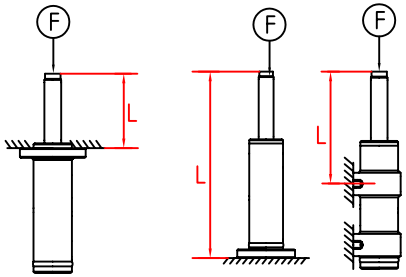
SITUATION 1
BOTH ENDS PIVOTED AND GUIDED (ROUND)



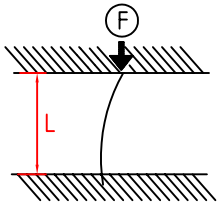
$K = L$



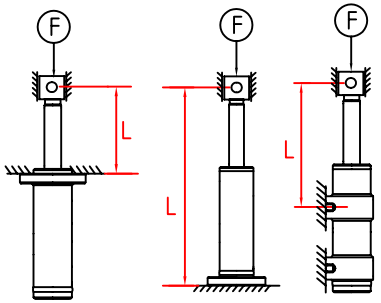
SITUATION 2
ONE END FIXED AND ONE END FREE.



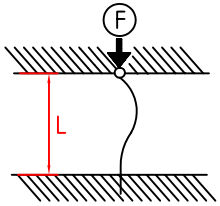
$K = 2L$



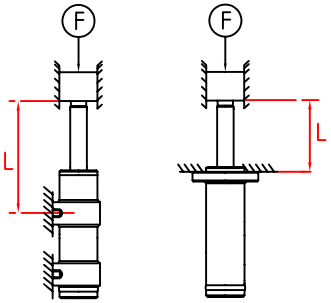
SITUATION 3
ONE END GUIDED AND PIVOTED AND ONE END FIXED



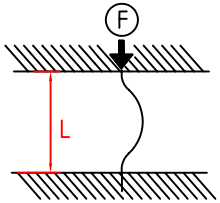
$K = L \times \sqrt{\frac{1}{2}}$



SITUATION 4
BOTH ENDS FIXED AND GUIDED



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



HYDRAULIC CYLINDER GENERAL INFORMATION

HANDLING OF HYDRAULIC CYLINDERS

- CARE SHOULD BE TAKEN AT ALL TIMES TO PREVENT DAMAGE TO CYLINDER OR INJURY TO PERSONNEL.
- WHENEVER POSSIBLE MAKE SURE THAT THE CYLINDER IS IN FULLY RETRACTED POSITION AND THAT THE PISTON IS RESTRAINED FROM EXTENDING BY GRAVITY OR OTHER MEANS.
- AVOID THE USE OF CHAINS WRAPPED AROUND THE CYLINDER AS THESE CAN SLIP AND CAUSE CONSIDERABLE DAMAGE, ESPECIALLY TO THE PISTON ROD.

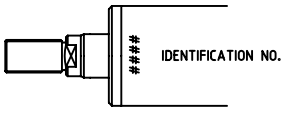
STORAGE OF HYDRAULIC CYLINDERS

WHEN STORAGE PERIODS ARE REQUIRED THE FOLLOWING PROCEDURES ARE RECOMMENDED :

- THE CYLINDER MUST BE STORED INDOORS IN A DRY AND NON-CORROSIVE ENVIRONMENT.
- PROTECTION PLUGS FITTED TO PORTS MUST BE LEFT ON AT ALL TIMES.
- PROTECT THE CYLINDER FROM INTERNAL CORROSION AND EXTERNAL CORROSION. IT IS RECOMMENDED THE CYLINDER BE FILLED WITH OPERATING FLUID.
- STORAGE IN A VERTICAL POSITION IS RECOMMENDED WITH THE PISTON ROD FACING UPWARDS. THIS WILL MINIMIZE STATIC SIDE LOADS ON THE SEALS AND CORROSION DUE TO POSSIBLE CONDENSATION IF THE CYLINDER IS NOT FILLED.
- IF VERTICAL STORAGE IS NOT POSSIBLE THEN THE CYLINDER CAN BE STORED HORIZONTALLY. HOWEVER FOR LONG PERIODS OF STORAGE THE CYLINDER MUST BE FILLED WITH THE WORKING FLUID AND ROTATION OF THE CYLINDER ON A FORTNIGHTLY BASIS IS RECOMMENDED.

IDENTIFICATION

- IN ALL CASES IDENTIFICATION OF THE CYLINDER IS STAMPED ON THE FRONT END, AS ILLUSTRATED. IN THE CASE THE CYLINDER IS SPECIAL THE IDENTIFICATION IS THE DRAWING NUMBER (H/L00####).



CYLINDER INSTALLATION

- ALL CYLINDERS ARE INDIVIDUALLY TESTED BEFORE SHIPMENT TO ASSURE FREEDOM FROM DEFECTS. IT IS RECOMMENDED THAT THE SHIPPING PLUGS IN THE CYLINDER PORTS NOT BE REMOVED DURING INSTALLATION UNTIL ACTUAL PIPING CONNECTIONS ARE TO BE MADE.

CYLINDER MOUNTING

- ALIGN THE CYLINDER CAREFULLY KEEPING MOUNTING SURFACES SQUARE, PARALLEL, CONCENTRIC AND TRUE (AS APPLICABLE) WITH THE WORK DIRECTION.

- TRUNNION AND PIVOT MOUNTED CYLINDERS SWIVEL IN ONE DIRECTION ONLY WITH TRUNNION PINS AND PIVOT PINS DESIGNED TO CARRY SHEAR LOADS ONLY. TRUNNION AND PIVOT BEARINGS MUST FIT CLOSELY FOR THE ENTIRE LENGTH OF THE PIN WITH TRUNNION BEARINGS HELD RIGIDLY AND IN ACCURATE ALIGNMENT.

- FLUSH MOUNTED CYLINDERS (TAPPED & LUG MOUNT) SHOULD BE PINNED OR KEYED TO PREVENT SHIFTING FROM LOAD APPLICATION.

- PIPE CONNECTIONS : ALL CONNECTING PIPES ENDS SHOULD BE DE-BURRED AND INSIDE SHOULD BE CLEANED OF SCALE, RUST AND DIRT. REMOVE SHIPPING PLUGS AND MAKE PROPER PIPE CONNECTION.

- CYLINDER OPERATION : OPERATE THE CYLINDER SEVERAL TIMES TO MAKE SURE IT IS FUNCTIONING PROPERLY. CHECK FOR LEAKS.

CUSHION ADJUSTMENT

- CUSHIONED CYLINDERS ARE ADJUSTED AND TESTED AT THE FACTORY, BUT MAY REQUIRE ADDITIONAL ADJUSTMENT AFTER CONNECTION TO THE WORK LOAD. TO INCREASE THE EFFECTIVENESS OF THE REAR CUSHION ONLY (FRONT CUSHIONS ARE NON-ADJUSTABLE) TURN THE ADJUSTING SCREW CLOCKWISE TO OBTAIN DESIRED CUSHIONING ACTION. TO DECREASE CUSHIONING ACTION, TURN ADJUSTING SCREW COUNTER-CLOCKWISE.

NOTE : IF INSTALLATION IS COMPLETE AND CYLINDER DOES NOT FUNCTION PROPERLY, CHECK THE FOLLOWING.

(1) POOR ADJUSTMENT OF THE CYLINDER WITH ITS MATING PIECES.
(2) INSUFFICIENT PRESSURE OR LEAKAGE.

CUSHION ADJUSTMENT

- CLEAN FLUID IS ESSENTIAL TO PROLONG THE SATISFACTORY OPERATION OF HYDRAULIC EQUIPMENT. KEEP OIL TANKS COVERED AND PROVIDE AN ADEQUATE FILTER.
- WITH A VERY MINOR AMOUNT OF ATTENTION AND UNDER ORDINARY CONDITIONS HYDROIL CYLINDER WILL EFFICIENTLY OPERATE FOR AT LEAST AS LONG A PERIOD AS IS GENERALLY REQUIRED OF THE EQUIPMENT OF WHICH IT IS A PART.
- SEAL REPLACEMENTS MAY BE REQUIRED AT INTERVALS ACCORDING TO THE MANNER IN WHICH THEY ARE USED.