before we can work out the details. These things are the length. width. thickness and the weight the spring has to support. The length can be scaled from the prototype or some arbitrary length chosen. The width can also be scaled or taken as the frame width or less. Thickness is a matter of choice remembering that a thick spring leaf will make the locomotive ride stiff and a thin one will cause it to bounce. I feel that on 1½" locomotives of average size a spring of from .035 to .060 will give good results. Weight is something that is hard to come by but with a little calculation it can be approximated close enough to give good results. Now for the formula:

$$\frac{\text{Load in tons x length of spring in inches x 11}}{\text{width in inches x (thickness of one leaf in sixteenth)}^2}$$

gives the number of leaves needed for each spring.

Working out a typical problem we have:

Total weight on drivers .... 400 lbs
Number of springs 6
Weight each spring has to support 400/6= 66 lbs
Length of spring .... 3.5"
Width of spring .... .375"
Thickness of one leaf .... .050"

number of leaves $= \dfrac{Lt \times l \times 11}{w \times t^2} = \dfrac{.033 \times 3.5 \times 11}{.375 \times .69} = 5$ leaves

Lt----66/2000-----.033
l---------------- 3.5
w---------------- .375
t^2--------------- .69 $(.050/.062)^2$

b. Deflection

The amount a spring will deflect is calculated by the use of the formula below. This is understood to be only approximate but will serve as a guide as to how much to allow for in the set when in the free state.

$$\frac{\text{(lengths of spring in inches)}^3 \text{ x 1.5}}{\text{width in inches x (thickness in sixteenths)}^3 \text{ x number of leaves}} =$$

deflection in sixteenths per ton.

In our example we will fill in the known quantities

l = 3.5 inches
w = .375 inches
t = .050/.062 = .8
n = 5

We now have $\frac{3.5^3 \times 1.5}{.375 \times 8^3} = \frac{64.3}{.94} = 6.8$ sixteenths of an inch deflection per ton. 6.8 x .062 = .42"

Since our load is only 66 pounds this 66/2000 = .033 of one ton. To get the deflection we will take .42 x .033 which gives us .014" total deflection.

In order that the spring will remain straight under load we will make the ends of the spring 1/32" higher than the center.

CONCLUSION

We have omitted any mention of valve gears as it is a very deep study and many fine publications are available for those who wish to pursue the subject in detail.
It is our hope that the information contained herein will answer some of the questions which come up in the designing of live steam locomotives and enable the model engineer to better enjoy the world's finest hobby.

CONCLUSION
OPERATING SUGGESTIONS FOR STEAM LOCOMOTIVES

1. ALWAYS BE SURE that water level in boiler is at least 1/2 inch above crown sheet, gauge glass should be set up so that when glass shows empty there is still 1/2 inch of water over crown sheet. Failure to observe this NUMBER ONE RULE could result in severe boiler damage. Water level should be maintained as close as possible to 1/2 glass. NEVER PUT OIL IN A BOILER!
2. When firing up be sure that boiler is properly filled with water. Warm broiler up slowly with a gentle draft. Force firing a cold boiler sets up tremendous stresses which may eventually cause cracks to form in boiler plates. This is especially important in large boilers. It is advisable that engine be set up so that compressed air does not have to be pumped into boiler to fire up. Air in boiler is the most prominent source of rust, and water may be forced back into your air compressor, if this suggestion is not observed.
3. It is always a good idea to blow down a boiler every few hours so that precipitates do not compact themselves around the base of the mud ring. About five or ten seconds for each blowndown is sufficient for clearing out this sediment.
4. Always make sure that locomotive is properly lubricated every hour of operation:

   (a) Use Steam Cylinder oil in cylinder lubricator only. This thick oil is designed to give best lubrication under the high temperatures within the cylinders and valve chambers.

(b) Since crossheads are always quite hot, cylinder oil is good here too, although SAE 30 weight is sufficient.

(c) Be sure and oil every moving valve gear bearing especially eccentrics of engines equipped with Stevenson gear.

(d) If engine has an axle pump, oil the eccentric and wrist pin. This is an easy item to forget. It is not necessary to oil the ram since this is usually coated with water droplets and could be a source of oil entering the boiler.

(e) None of the teflon bearings which your engine may be equipped with should ever need lubrication.

5. Smoke Box, flues and ash pan should be cleaned every few hours of operation, frequently depending upon type of fuel being used. Flues may be cleaned with a 16 gauge shot gun brush. When cleaning out flues, ash pan, etc., avoid spilling ashes onto running gear. Bearings are very sensitive to abrasives.
6. The use of Red Devil Soot Removers will help to reduce build up of soot in the flues between brushings.
7. After each run clean the entire locomotive with kerosene to remove accumulated dirt and help to prevent rust. Care should be taken to wash dirt away from bearings rather than into them.
8. It is advisable to always carry in your tool box a set of appropriate tools, about a foot of asbestos-graphite, string packing, an extra water gauge glass and a small selection of scale bolts and nuts. Without these items a very minor mishap could spoil a day's run.
9. Store engines with nitrogen in the boiler if practical. Boilers should be pressure tested once each year using a hydrostatic testing procedure:

(a) Turn off pressure gauge and water glass or remove them and plug holes.

(b) Remove safety valves.

(c) Fill boiler to top of dome with water. BLEED OUT ALL AIR.

(d) Plug any open holes.

(e) Using hand pump or equivalent means and reading from an accurate gauge, pump boiler pressure to one and a half times normal pop off pressure and maintain this pressure for one minute.

(f) Any serious leaks should be corrected immediately.

(g) Reinstall safety valves one at a time and check accuracy of their settings.

(h) Test is complete.

TABLES

TABLE I

Circumference and Areas of Circles

DIAMETER	CIRCUM-FERENCE	AREA	DIAMETER	CIRCUM-FERENCE	AREA
1/64	0.0491	0.0002	1 1/2	4.7124	1.7671
1/32	0.0982	0.0008	1 9/16	4.9087	1.9175
1/16	0.1964	0.0031	1 5/8	5.1051	2.0739
3/32	0.2945	0.0060	1 11/16	5.3014	2.2365
1/8	0.3927	0.0123	1 3/4	5.4978	2.4053
5/32	0.4909	0.0192	1 13/16	5.6941	2.5802
3/16	0.5890	0.0276	1 7/8	5.8905	2.7612
7/36	0.6872	0.0376	1 15/16	6.0868	2.9483
1/4	0.7854	0.0491	2	6.2832	3.1416
9/32	0.8836	0.0621	2 1/16	6.4795	3.3410
5/16	0.9817	0.0767	2 1/8	6.6759	3.5466
11/32	1.0799	0.0928	2 3/16	6.8722	3.7583
3/8	1.1781	0.1105	2 1/4	7.0686	3.9761
13/32	1.2763	0.1296	2 5/16	7.2649	4.2000
7/16	1.3745	0.1503	2 3/8	7.4613	4.4301
15/32	1.4726	0.1726	2 7/16	7.6576	4.6664
1/2	1.5708	0.1964	2 1/2	7.8540	4.9087
17/32	1.6690	0.2217	2 9/16	8.0503	5.1572
9/16	1.7672	0.2485	2 5/8	8.2467	5.5119
19/32	1.8653	0.2769	2 11/16	8.4430	5.6727
5/8	1.9635	0.3068	2 3/4	8.6394	5.9496
21/32	2.0617	0.3382	2 13/16	8.8357	6.2126
11/16	2.1598	0.3712	2 7/8	9.0321	6.4918
23/32	2.2580	0.4057	2 15/16	9.2284	6.7771
3/4	2.3562	0.4418	3	9.4248	7.0686
25/32	2.4544	0.4794	3 1/8	9.8175	7.6699
13/16	2.5525	0.5185	3 1/4	10.2102	8.2958
27/32	2.6507	0.5595	3 3/8	10.6029	8.9462
7/8	2.7489	0.6013	3 1/2	10.9956	9.7211
29/32	2.8471	0.6450	3 5/8	11.3883	10.321
15/16	2.9452	0.6903	3 3/4	11.7810	11.945
31/32	3.0434	0.7371	3 7/8	12.1737	11.793
1	3.1416	0.7854	4	12.5664	12.566
1 1/16	3.3379	0.8866	4 1/8	12.9591	13.364
1 1/8	3.5343	0.9940	4 1/4	13.3518	14.186
1 3/16	3.7306	1.1075	4 3/8	13.7445	15.033
1 1/4	3.9270	1.2272	4 1/2	14.1372	15.904
1 5/16	4.1233	1.3530	4 5/8	14.5299	16.800
1 3/8	4.3197	1.4849	4 3/4	14.9226	17.721
1 7/16	4.5160	1.6230	4 7/8	15.3153	18.665
			5	15.7080	19.635

TABLE I (continued)

DIAMETER	CIRCUM-FERENCE	AREA	DIAMETER	CIRCUM-FERENCE	AREA
5 1/4	16.9934	21.648	8	25.1327	50.265
5 1/2	17.2788	23.758	8 1/4	25.9181	53.456
5 3/4	18.0642	25.967	8 1/2	26.7035	56.745
6	18.8496	28.274	8 3/4	27.4889	60.132
6 1/4	19.6340	30.680	9	28.2743	63.617
6 1/2	20.4204	33.183	9 1/4	29.0597	67.201
7	21.9911	38.485	9 1/2	29.8451	70.882
7 1/4	22.7765	41.282	9 3/4	30.6305	74.662
7 1/2	23.5619	44.179	10	31.4159	78.540
7 3/4	24.3473	47.173			

TABLE II

Inches to Decimals of a Foot

INCHES	FOOT	INCHES	FOOT	INCHES	FOOT
1/4	0.0208	2 3/4	0.2292	6 1/4	0.5208
5/16	0.0260	2 7/8	0.2396	6 1/2	0.5417
3/8	0.0312	3	0.2500	6 3/4	0.5625
7/16	0.0365	3 1/8	0.2604	7	0.5833
1/2	0.0417	3 1/4	0.2708	7 1/4	0.6042
9/16	0.0469	3 3/8	0.2813	7 1/2	0.6250
5/8	0.0521	3 1/2	0.2917	7 3/4	0.6406
11/16	0.0573	3 5/8	0.3021	8	0.6666
3/4	0.0625	3 7/8	0.3229	8 1/4	0.6875
13/16	0.0678	4	0.3333	8 1/2	0.7083
7/8	0.0730	4 1/8	0.3437	8 3/4	0.7292
15/16	0.0781	4 1/4	0.3542	9	0.7500
1	0.0833	4 3/8	0.3654	9 1/4	0.7708
1 1/8	0.0937	4 1/2	0.3750	9 1/2	0.7917
1 1/4	0.1042	4 5/8	0.3854	9 3/4	0.8125
1 3/8	0.1146	4 3/4	0.3958	10	0.8333
1 1/2	0.1250	4 7/8	0.4062	10 1/4	0.8542
1 5/8	0.1354	5	0.4167	10 1/2	0.8750
1 3/4	0.1458	5 1/8	0.4271	10 3/4	0.8958
1 7/8	0.1562	5 1/4	0.4375	11	0.9167
2	0.1666	5 3/8	0.4479	11 1/4	0.9375
2 1/8	0.1771	5 1/2	0.4583	11 1/2	0.9583
2 1/4	0.1875	5 5/8	0.4687	11 3/4	0.9792
2 3/8	0.1979	5 3/4	0.4792	12	1.0000
2 1/2	0.2083	5 7/8	0.4896		
2 5/8	0.2187	6	0.5000		

TABLE III

Inches to Square Root to Square

INCHES	SQ. ROOT	SQUARE	INCHES	SQ. ROOT	SQUARE
1.000	1.00000	1.00000	6.375	2.52488	40.64063
1.125	1.06066	1.26563	6.500	2.54951	42.25000
1.250	1.11803	1.56250	6.625	2.57391	43.89063
1.375	1.17260	1.89063	6.750	2.59808	45.56250
1.500	1.22474	2.25000	6.875	2.62202	47.26563
1.625	1.27475	2.64063	7.000	2.64575	49.00000
1.750	1.32288	3.06250	7.125	2.66927	50.76563
1.875	1.36931	3.51563	7.250	2.69258	52.56250
2.000	1.41421	4.00000	7.375	2.71570	54.39063
2.125	1.45774	4.51563	7.500	2.73861	56.25000
2.250	1.50000	5.06250	7.625	2.76134	58.14063
2.375	1.54110	5.64063	7.750	2.78388	60.06250
2.500	1.58114	6.25000	7.875	2.80624	62.01563
2.625	1.62019	6.89063	8.000	2.82843	64.00000
2.750	1.65831	7.56250	8.125	2.85044	66.01563
2.875	1.69558	8.26563	8.250	2.87228	68.06250
3.000	1.73205	9.00000	8.375	2.89396	70.14063
3.125	1.76777	9.76563	8.500	2.91548	72.25000
3.250	1.80278	10.56250	8.625	2.93684	74.39063
3.375	1.83712	11.39063	8.750	2.95804	76.56250
3.500	1.87083	12.25000	8.875	2.97909	78.76563
3.625	1.90394	13.14063	9.000	3.00000	81.00000
3.750	1.93649	14.06250	9.125	3.02076	83.26563
3.875	1.96850	15.01563	9.250	3.04138	85.56250
4.000	2.00000	16.00000	9.375	3.06186	87.89063
4.125	2.03101	17.01563	9.500	3.08221	90.25000
4.250	2.06155	18.06250	9.625	3.10242	92.64063
4.375	2.09165	19.14063	9.750	3.12250	95.06250
4.500	2.12132	20.25000	9.875	3.14245	97.51563
4.625	2.15058	21.39063	10.000	3.16228	100.00000
4.750	2.17945	22.56250	10.125	3.18198	102.51563
4.875	2.20794	23.76563	10.250	3.20156	105.06250
5.000	2.23607	25.00000	10.375	3.22102	107.64063
5.125	2.26385	26.26563	10.500	3.24037	110.25000
5.250	2.29129	27.56250	10.625	3.25960	112.89063
5.375	2.31840	28.89063	10.750	3.27872	115.56250
5.500	2.34521	30.25000	10.875	3.29773	118.26563
5.625	2.37171	31.64063	11.000	3.31662	121.00000
5.750	2.39792	33.06250	11.125	3.33542	123.76563
5.875	2.42384	34.51563	11.250	3.35410	126.56250
6.000	2.44949	36.00000	11.375	3.37268	129.39063
6.125	2.47487	37.51563	11.500	3.39117	132.25000
6.250	2.50000	39.06250	11.625	3.40955	135.14063

TABLE III (continued)

INCHES	SQ. ROOT	SQUARE	INCHES	SQ. ROOT	SQUARE
11.750	3.42783	138.06250	15.000	3.87298	225.00000
11.875	3.44601	141.01563	15.125	3.88909	228.76563
12.000	3.46410	144.00000	15.250	3.90512	232.56250
12.125	3.48210	147.01563	15.375	3.92110	236.39063
12.250	3.50000	150.06250	15.500	3.93700	240.25000
12.375	3.51781	153.14063	15.625	3.95285	244.14063
12.500	3.53553	156.25000	15.750	3.96863	248.06250
12.625	3.55317	159.39063	15.875	3.98434	252.01563
12.750	3.57071	162.56250	16.000	4.00000	256.00000
12.875	3.58818	165.76563	16.125	4.01559	260.01563
13.000	3.60555	169.00000	16.250	4.03113	264.06250
13.125	3.62284	172.26563	16.375	4.04660	268.14063
13.250	3.64005	175.56250	16.500	4.06202	272.25000
13.375	3.65718	178.89063	16.625	4.07738	276.39063
13.500	3.67423	182.25000	16.750	4.09268	280.56250
13.625	3.69121	185.64063	16.875	4.10792	284.76563
13.750	3.70810	189.06250	17.000	4.12311	289.00000
13.875	3.72492	192.51563	17.125	4.13824	293.26563
14.000	3.74166	196.00000	17.250	4.15331	297.56250
14.125	3.75832	199.51563	17.375	4.16833	301.89063
14.250	3.77492	203.06250	17.500	4.18330	306.25000
14.375	3.79144	206.64063	17.625	4.19821	310.64063
14.500	3.80789	210.25000	17.750	4.21307	315.06250
14.625	3.82426	213.89063	17.875	4.22788	319.51563
14.750	3.84057	217.56250	18.000	4.24264	324.00000
14.875	3.85681	221.26563			

TABLE IV

Strength of Model Engineers Hex Head Bolts made of Steel
—Course Thread—

SIZE	O.D.	STRESS AREA	SAFE LOAD LBS.	TAP DRILL SIZE	CLEARANCE DRILL SIZE
1-64	0.073	0.0026	20	53	5/64
2-56	0.086	0.0036	27	51	3/32
3-48	0.099	0.0048	36	5/64	7/64
4-40	0.112	0.0060	45	43	1/8
5-40	0.125	0.0079	60	39	9/64
6-32	0.138	0.0090	68	36	23
8-32	0.164	0.0139	105	29	15
10-24	0.190	0.0174	131	25	5
1/4-20	0.250	0.0317	225	8	17/64
5/16-18	0.3125	0.0522	392	F	21/64

Continued on next page

TABLE IV (continued)

SIZE	O.D.	STRESS AREA	SAFE LOAD LBS.	TAP DRILL SIZE	CLEARANCE DRILL SIZE
3/8-16	0.375	0.0773	581	5/16	25/64
7/16-14	0.4375	0.1060	795	U	29/64
1/2-13	0.5000	0.1416	1062	27/64	33/64
9/16-12	0.5625	0.1816	1362	31/64	37/64
5/8-11	0.6250	0.2256	1692	17/32	41/64
3/4-10	0.7500	0.3340	2505	21/32	49/64
7/8-9	0.875	0.4612	3459	49/64	57/64
1-8	1.000	0.6051	4539	7/8	1-1/32

NOTE: FOR BRASS BOLTS MULTIPLY SAFE LOAD BY .67
FOR ALLEN BOLTS MULTIPLY SAFE LOAD BY 1.5

TABLE V

Strength of Model Engineers Hex Head Bolts made of Steel
—Fine Thread—

SIZE	O.D.	STRESS AREA	SAFE LOAD LBS.	TAP DRILL SIZE	CLEARANCE DRILL SIZE
0-80	0.0600	0.0018	14	3/64	51
1-72	0.0730	0.0027	20	53	5/64
2-64	0.0860	0.0039	29	50	3/32
3-56	0.0990	0.0052	39	46	7/64
4-48	0.1120	0.0065	48	42	1/8
5-44	0.1250	0.0082	62	37	9/64
6-40	0.1380	0.0101	75	33	23
8-36	0.1640	0.0146	110	29	15
10-32	0.1900	0.0199	149	21	5
1/4-28	0.2500	0.0362	272	3	17/64
5/16-24	0.3125	0.0579	434	I	21/64
3/8-24	0.3750	0.0876	657	Q	25/64
7/16-20	0.4375	0.1185	888	W	29/64
1/2-20	0.5000	0.1597	1197	29/64	33/64
9/16-18	0.5625	0.2026	1520	33/64	37/64
5/8-18	0.6250	0.2555	1916	37/64	41/64
3/4-16	0.7500	0.3724	2793	11/16	49/64
7/8-14	0.8750	0.5088	3816	13/16	57/64
1-14	1.0000	0.6624	4968	15/16	1-1/32
1/4-32	0.2500	0.0377	282	7/32	17/64
5/16-32	0.3125	0.0622	467	9/32	21/64
3/8-32	0.3750	0.0929	696	11/32	25/64
7/16-28	0.4375	0.1270	953	13/32	29/64
1/2-28	0.5000	0.1695	1271	15/32	33/64

NOTE: FOR BRASS BOLTS MULTIPLY SAFE LOAD BY .67
FOR ALLEN BOLTS MULTIPLY SAFE LOAD BY 1.5

TABLE VI

Mean Effective Pressure Constants

1/4	stroke	equals	boiler	pressure	X	.597
1/3	"	"	"	"	"	.670
3/8	"	"	"	"	"	.743
1/2	"	"	"	"	"	.847
5/8	"	"	"	"	"	.919
2/3	"	"	"	"	"	.937
3/4	"	"	"	"	"	.966
7/8	"	"	"	"	"	.992

TABLE VII

Volumes of Saturated Steam

Gauge Pressure	Cubic inches of steam per cubic inch of water	Temperature F
50	406	298
60	355	308
70	316	316
75	299	320
80	285	324
85	271	328
90	258	332
95	247	335
100	237	338
110	219	345
120	204	350
125	197	353
135	184	358
150	169	366
175	150	378
200	131	388
225	117	397
250	107	406

TABLE VIII

Strength of Materials

Material	Tensile strength in pounds per sq. in.
Aluminum	
cast	15,000
cast high strength	26,000
bar stock 2011-T3 excellent machining	54,000
bar stock 2011-T8 excellent machining	59,000
bar stock 2024-T4 good machining	68,000
structural shapes 6061-T6 excellent for car frames	45,000
Copper	
sheet hard	46,000
sheet soft	33,000
rod hard	45,000
rod soft	32,000
Brass	
bar stock free cutting	58,000
bar stock high lead	73,000
Bronze	
#1012 Everdur	95,000
Tobin bronze	63,000
Steel	
C1018 cold finished bar	82,000
Stressproof - excellent machining, fine finish	125,000
Stainless	
Type 303 free machining	75,000
Type 321 fair machining	75,000
Type 416 good machining - annealed condition	75,000
Type 416 poor machining in heat treated condition	90,000-200,000
Iron	
cast grey	18,000
cast malleable	28,000

TABLE IX

O-Rings used as Valve Seats

O-rings are particularly suited for use as valve seats. They absorb shock loads, and are soft enough to seal at all pressures, even when dirt and grit are present in the system. They are ideal for check valves where the fluid pressure helps to make the seal. High-pressure check valves can maintain 20,000 psi for weeks. Properly applied, they can be used on relief and angle-valve seats for all pressures.

TABLE VI

Mean Effective Pressure Constants

1/4	stroke	equals	boiler	pressure	X	.597
1/3	"	"	"	"	"	.670
3/8	"	"	"	"	"	.743
1/2	"	"	"	"	"	.847
5/8	"	"	"	"	"	.919
2/3	"	"	"	"	"	.937
3/4	"	"	"	"	"	.966
7/8	"	"	"	"	"	.992

TABLE VII

Volumes of Saturated Steam

Gauge Pressure	Cubic inches of steam per cubic inch of water	Temperature F
50	406	298
60	355	308
70	316	316
75	299	320
80	285	324
85	271	328
90	258	332
95	247	335
100	237	338
110	219	345
120	204	350
125	197	353
135	184	358
150	169	366
175	150	378
200	131	388
225	117	397
250	107	406

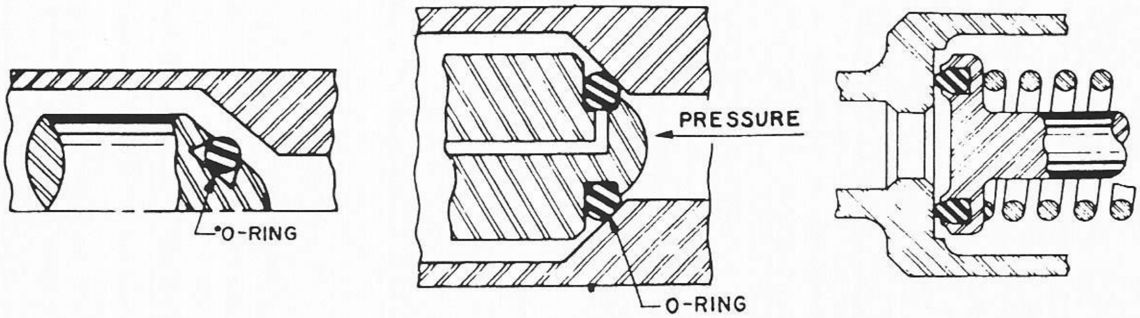


Fig. 2. Groove Designs to Prevent Blow-Out.

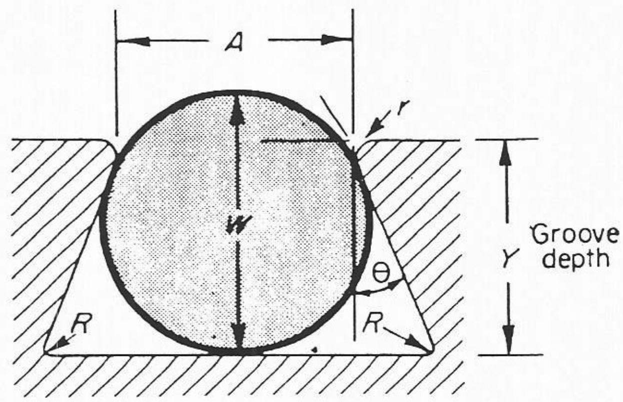


Fig. 3. Standard Dovetail Groove Sizes for O-Ring Seals

Standard Size and Installation Data

O-Ring Size No.	O-Ring W		A Groove Length, Sharp Edge tolerance ± 0.002	A Groove Length, Rounded tolerance ± 0.002	Y Groove Depth ± 0.000-0.002	Radius r	Radius R
004 thru 028	0.070	0.003	0.057	0.063	0.052	0.005	1/64
110 thru 149	0.103	0.003	0.085	0.090	0.083	0.010	1/64
210 thru 274	0.139	0.004	0.115	0.120	0.115	0.010	1/32
325 thru 349	0.210	0.005	0.160	0.170	0.180	0.015	1/32
425 thru 460	0.275	0.006	0.220	0.235	0.234	0.015	1/16

$\theta = 24° \pm 1°$

First cut groove, leaving sharp edge at corners, then round off to A dimension.

One of the design problems with O-ring valve seats is to prevent the ring from blowing out of the groove. This will happen with a square or rectangular groove, if a high-pressure differential exists across the valve seat at the moment of opening, Fig. 1.

In most cases, blowout occurs if the differential pressure is more than 100 psi. Since blowout is similar to extrusion, it helps to use harder O-ring compounds that can withstand higher pressures before elongating. One way of preventing blowout is by use of a dovetail groove design, Figure 3. Other methods of preventing blowout are to mechanically spin metal around the O-ring and secure it in the groove, or, vulcanize and bond the synthetic rubber into the valve-seat groove. By venting the groove, pressure cannot build up underneath the O-ring, and it remains in its seat, Fig. 2.

Fig. 1

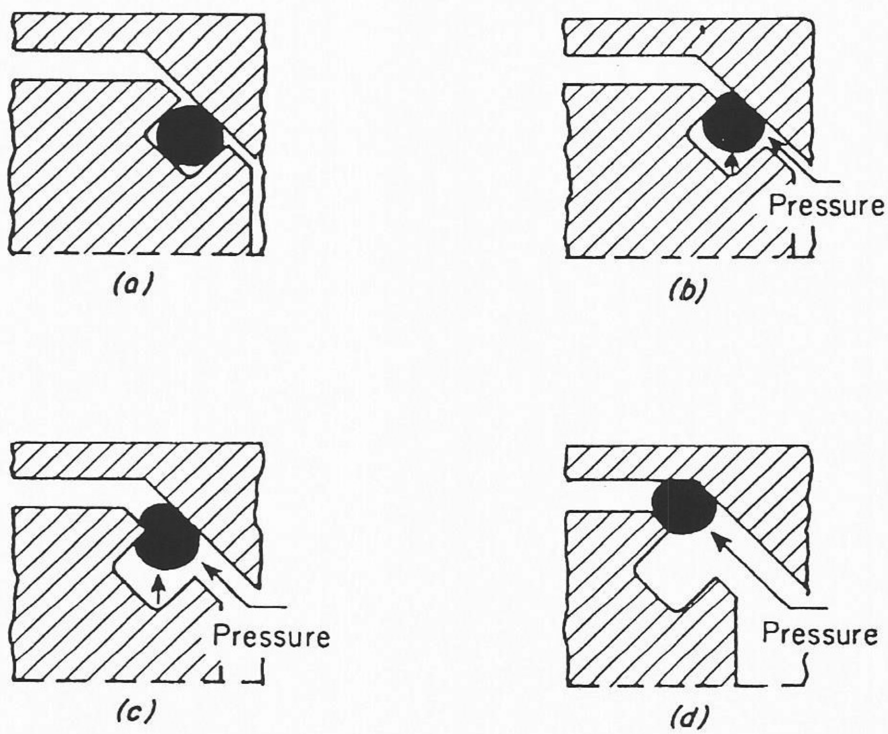


Fig. 1 -- Blowout of O-ring used as a valve seat. As the valve opens, the space between the two faces becomes larger. The pressure acts on the O-ring. The ring continues to seal the opening until it is completely stretched out of the groove.

TABLE X

Pattern Shrinkage Allowance

Cast iron	1/8 inch per foot
Brass	3/16 " " "
Steel	1/4 " " "
Aluminum	3/16 " " "

TABLE XI

Standard Keyways and Setscrews

Diameter of Hole	St'd Keyway		Recommended Setscrew
	W	d	
5/16 to 7/16"	3/32"	3/64"	10-32
1/2 to 9/16	1/8	1/16	1/4-20
5/8 to 7/8	3/16	3/32	5/16-18
15/16 to 1 1/4	1/4	1/8	3/8-16
1 5/16 to 1 3/8	5/16	5/32	7/16-14
1 7/16 to 1 3/4	3/8	3/16	1/2-13
1 13/16 to 2 1/4	1/2	1/4	9/16-12
2 5/16 to 2 3/4	5/8	5/16	5/8-11
2 13/16 to 3 1/4	3/4	3/8	3/4-10
3 5/16 to 3 3/4	7/8	7/16	7/8-9
3 13/16 to 4 1/2	1	1/2	1-8
4 19/16 to 5 1/2	1 1/4	7/16	1 1/8-7
5 9/16 to 6 1/2	1 1/2	1/2	1 1/4-6

TABLE XII

Proportionate Weight of Castings to Weight of Wood Patterns

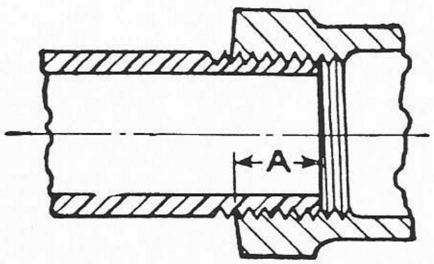
A Pattern Weighing One Pound (Less Weight of Core Prints)

Made of	Cast Iron	Brass	Copper	Bronze	Bell Metal	Zinc
Pine or Fir	16	15.8	16.7	16.3	17.1	13.5
Oak	9	10.1	10.4	10.3	10.9	8.6
Beech	9.7	10.9	11.4	11.3	11.9	9.1
Linden	13.4	15.1	16.7	15.5	16.3	12.9
Pear	10.2	11.5	11.9	11.8	12.4	9.8
Birch	10.6	11.9	12.3	12.2	12.9	10.2
Alder	12.8	14.3	14.9	14.7	15.5	12.2
Mahogany	11.7	13.2	13.7	13.5	14.2	11.2
Brass	0.85	0.95	0.99	0.98	1.0	0.81

TABLE XIII

Length of Thread

LENGTH OF THREAD ON PIPE SCREWED INTO VALVES OR FITTINGS TO MAKE A TIGHT JOINT



Size Inches	Dimen. A Inches	Size Inches	Dimen. A Inches
1/8	1/4	2 1/2	15/16
1/4	3/8	3	1
3/8	3/8	3 1/2	1 1/16
1/2	1/2	4	1 1/8
3/4	9/16	5	1 1/4
1	11/16	6	1 5/16
1 1/4	11/16	8	1 7/16
1 1/2	11/16	10	1 5/8
2	3/4	12	1 3/4

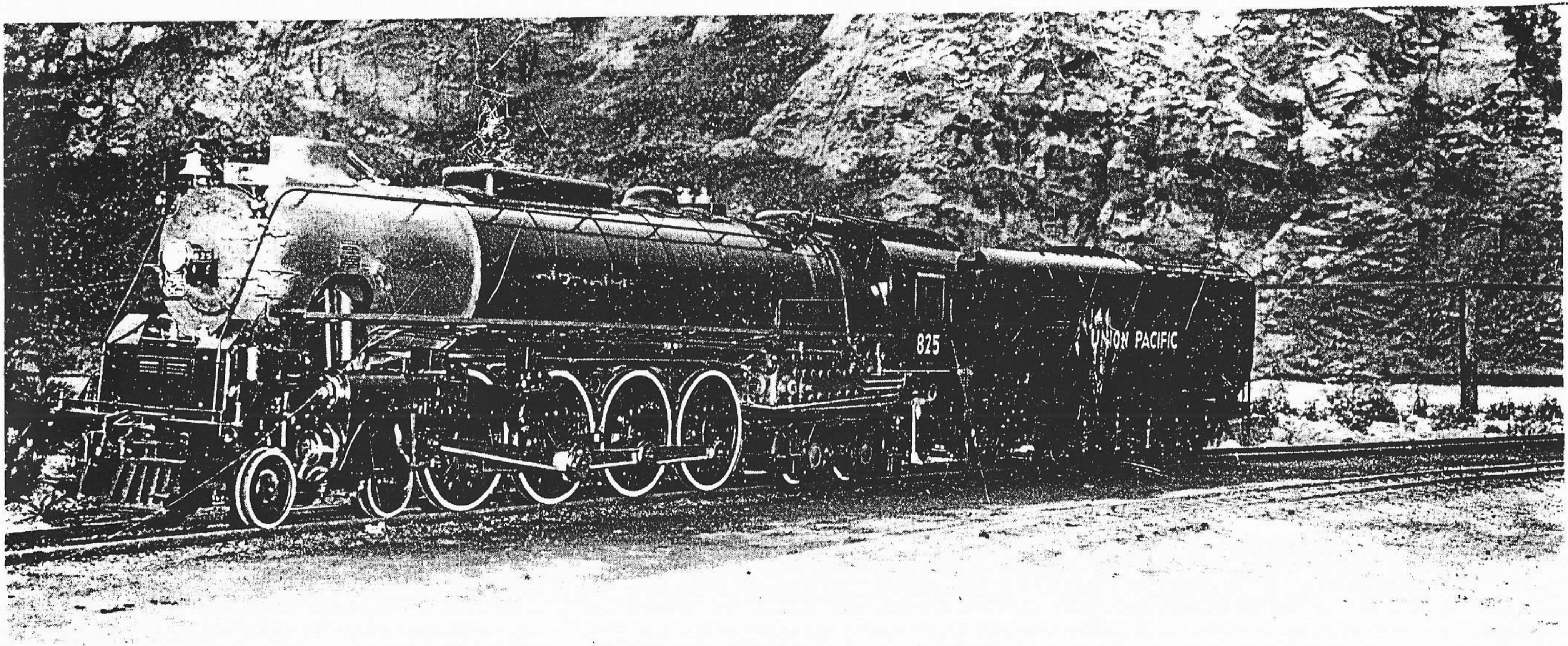
Dimensions given do not allow for variation in tapping or threading.

TABLE XIV

Approximate Weight of Various Metals

To find the weight of various metals, multiply the contents in cubic inches by the number shown below. The result will be the approximate weight in pounds.

Iron	.27777	Brass	.3112
Steel	.28332	Lead	.41015
Copper	.32118	Zinc	.25318
Tin	.26562	Aluminum	.09375



RAILROAD SUPPLY CORPORATION