



Precision Metal Washers, Gaskets and Stampings

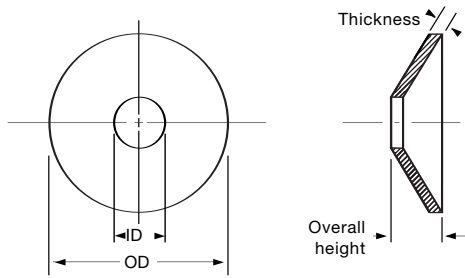
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Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-0400-2300	4	.122	.359	.032	.045
BEL-0400-1400	4	.125	.218	.010	.023
BEL-0400-1600	4	.125	.250	.020	.045
BEL-0400-1610	4	.125	.250	.013	.020
BEL-0400-2410	4	.125	.375	.007	.052
BEL-0400-4000	4	.125	.625	.062	.125
BEL-0401-0000	4	.125	1.000	.060	.180
BEL-0500-2200	5	.125	.343	.008	.015
BEL-0500-3200	5	.125	.500	.012	.068
BEL-0500-2001	5	.126	.315	.016	.024
BEL-0500-2800	5	.126	.437	.030	.048
BEL-0500-1400	5	.128	.218	.010	.022
BEL-0500-2000	5	.128	.312	.032	.065
BEL-0500-5300	5	.128	.828	.068	.144
BEL-0500-3900	5	.131	.612	.020	.046
BEL-0600-2820	6	.139	.437	.032	.110
BEL-0600-2000	6	.141	.312	.020	.042
BEL-0600-1801	6	.142	.281	.010	.024
BEL-0600-1300	6	.144	.197	.006	.025
BEL-0600-2800	6	.144	.437	.031	.171
BEL-0600-4800	6	.144	.750	.062	.109
BEL-0600-2400	6	.148	.375	.040	.055
BEL-0600-3200	6	.148	.500	.040	.070
BEL-0600-3210	6	.153	.500	.020	.045
BEL-0600-1800	6	.156	.281	.010	.026
BEL-0600-4000	6	.156	.625	.016	.040
BEL-0601-0000	6	.156	1.000	.062	.147
BEL-0600-3000	6	.158	.468	.037	.057
BEL-0600-2810	6	.159	.437	.030	.042
BEL-0600-2600	6	.160	.406	.037	.082
BEL-0600-4010	6	.160	.625	.016	.039
BEL-0600-1900	6	.161	.295	.010	.022
BEL-0800-1800	8	.165	.281	.015	.024
BEL-0800-2200	8	.167	.340	.018	.028
BEL-0800-3210	8	.167	.490	.035	.050
BEL-0800-4000	8	.167	.620	.030	.070
BEL-0800-2820	8	.168	.437	.038	.050
BEL-0800-3200	8	.168	.500	.020	.045
BEL-0800-3220	8	.168	.500	.022	.047
BEL-0800-3230	8	.168	.500	.025	.052
BEL-0800-3610	8	.168	.560	.052	.077
BEL-0800-5400	8	.168	.843	.040	.090
BEL-0800-3700	8	.169	.583	.008	.050
BEL-0800-2300	8	.172	.364	.030	.040
BEL-0800-2800	8	.173	.437	.020	.032
BEL-0800-3600	8	.175	.562	.042	.064
BEL-0800-4800	8	.175	.750	.040	.090

Tolerances

Outside Diameter	± .010
Inside Diameter	Up to/including No. 10: ± .005 Over No. 10: ± .010
Thickness	Commercial
Overall Height	+ .005 to - .015 as stamped. Some distortion may occur in heat treatment.

Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-0020-0800	0	.056	.125	.005	.010
BEL-0020-0810	0	.059	.122	.005	.013
BEL-0010-2000	0	.061	.312	.008	.018
BEL-0010-5600	0	.065	.875	.012	.082
BEL-0010-1400	0	.066	.218	.010	.032
BEL-0010-1000	0	.067	.156	.010	.024
BEL-0100-3200	1	.077	.500	.007	.027
BEL-0100-1200	1	.078	.187	.010	.020
BEL-0100-1410	1	.078	.218	.010	.050
BEL-0100-1600	1	.078	.250	.016	.047
BEL-0100-1400	1	.080	.218	.010	.072
BEL-0100-1610	1	.083	.250	.046	.077
BEL-0100-2200	1	.085	.343	.003	.015
BEL-0200-1301	2	.087	.197	.012	.018
BEL-0200-1610	2	.087	.250	.010	.050
BEL-0200-1620	2	.087	.250	.010	.040
BEL-0200-1400	2	.088	.225	.015	.043
BEL-0200-1600	2	.092	.250	.040	.060
BEL-0200-1810	2	.093	.278	.032	.048
BEL-0200-2000	2	.093	.312	.016	.061
BEL-0200-2100	2	.093	.328	.025	.050
BEL-0200-1800	2	.095	.281	.021	.040
BEL-0200-2400	2	.096	.375	.010	.062
BEL-0200-1300	2	.097	.203	.010	.035
BEL-0300-1300	3	.102	.203	.015	.045
BEL-0300-1900	3	.110	.300	.015	.062
BEL-0300-2400	3	.110	.375	.010	.045
BEL-0400-2010	4	.114	.312	.020	.037
BEL-0400-2400	4	.118	.375	.031	.051
BEL-0400-3000	4	.118	.468	.037	.055
BEL-0400-2000	4	.122	.312	.032	.050

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Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-0800-3240	8	.178	.500	.028	.059
BEL-0800-2410	8	.179	.375	.030	.040
BEL-0800-3630	8	.184	.562	.040	.085
BEL-0800-2400	8	.187	.375	.005	.030
BEL-0800-2600	8	.187	.406	.010	.037
BEL-0800-2810	8	.187	.437	.010	.020
BEL-0800-2830	8	.187	.437	.010	.042
BEL-0801-0000	8	.187	1.000	.032	.112
BEL-0801-3200	8	.187	1.500	.062	.187
BEL-0800-5300	8	.189	.828	.020	.140
BEL-1000-4010	10	.190	.625	.050	.119
BEL-1000-2510	10	.191	.390	.030	.090
BEL-1000-4400	10	.191	.680	.030	.080
BEL-1000-3220	10	.193	.497	.009	.037
BEL-1000-5700	10	.193	.884	.030	.060
BEL-1000-2800	10	.194	.437	.020	.032
BEL-1000-3610	10	.194	.557	.040	.085
BEL-1000-5500	10	.194	.856	.030	.086
BEL-1000-2410	10	.195	.375	.005	.030
BEL-1000-2431	10	.195	.370	.030	.046
BEL-1000-2432	10	.195	.375	.017	.034
BEL-1000-3603	10	.195	.559	.032	.094
BEL-1000-6000	10	.195	.934	.030	.092
BEL-1000-4820	10	.196	.750	.025	.070
BEL-1000-3221	10	.197	.500	.040	.055
BEL-1000-2520	10	.198	.366	.020	.030
BEL-1000-2830	10	.198	.437	.018	.036
BEL-1000-3000	10	.200	.466	.035	.044
BEL-1000-4000	10	.200	.625	.030	.046
BEL-1000-2430	10	.203	.375	.005	.017
BEL-1000-2610	10	.203	.406	.010	.034
BEL-1000-2820	10	.203	.437	.015	.030
BEL-1000-3200	10	.203	.500	.018	.036
BEL-1000-3210	10	.203	.500	.035	.125
BEL-1000-3600	10	.203	.562	.040	.045
BEL-1000-3660	10	.204	.561	.028	.053
BEL-1000-3640	10	.205	.562	.028	.053
BEL-1000-4800	10	.205	.750	.040	.075
BEL-1000-2700	10	.206	.428	.028	.068
BEL-1000-3650	10	.206	.562	.008	.020
BEL-1000-4830	10	.206	.747	.020	.085
BEL-1000-2400	10	.207	.375	.010	.022
BEL-1000-3800	10	.207	.588	.027	.045
BEL-1000-3690	10	.208	.562	.040	.065
BEL-1000-3602	10	.209	.559	.028	.060
BEL-1000-4810	10	.211	.750	.030	.055
BEL-1000-1800	10	.212	.281	.015	.026

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Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-1000-3680	10	.212	.562	.046	.065
BEL-1000-3620	10	.216	.562	.015	.030
BEL-1000-3670	10	.216	.562	.020	.035
BEL-1000-2500	10	.218	.390	.015	.043
BEL-1000-2600	10	.218	.406	.010	.034
BEL-1200-3610	12	.218	.562	.030	.075
BEL-1200-4830	12	.222	.750	.050	.070
BEL-1200-3200	12	.223	.500	.045	.060
BEL-1200-4000	12	.223	.620	.020	.090
BEL-1200-4010	12	.223	.625	.055	.070
BEL-1200-4200	12	.223	.656	.050	.075
BEL-1200-4810	12	.223	.750	.030	.060
BEL-1200-4840	12	.223	.750	.045	.067
BEL-1201-1600	12	.223	1.250	.060	.170
BEL-1200-5610	12	.224	.875	.060	.107
BEL-1200-4410	12	.225	.687	.054	.100
BEL-1200-4800	12	.227	.750	.075	.095
BEL-1200-4820	12	.231	.750	.060	.100
BEL-1200-3000	12	.232	.478	.016	.025
BEL-1200-3600	12	.232	.557	.060	.085
BEL-1200-4400	12	.232	.687	.050	.097
BEL-1200-5600	12	.232	.875	.060	.107
BEL-1201-3200	12	.232	1.500	.060	.155
BEL-1200-3100	12	.245	.481	.051	.125
BEL-1200-1900	12	.250	.305	.015	.035
BEL-1200-2800	12	.250	.437	.020	.052
BEL-1200-3620	12	.250	.562	.030	.050
BEL-1200-3640	12	.250	.562	.031	.081
BEL-1200-5620	12	.250	.875	.032	.187
BEL-1201-0600	12	.250	1.093	.062	.317
BEL-1201-0800	12	.250	1.125	.062	.257
BEL-1201-1610	12	.250	1.250	.025	.095
BEL-1400-5200	1/4"	.250	.812	.010	.120
BEL-1400-3000	1/4"	.252	.465	.031	.082
BEL-1400-3620	1/4"	.252	.562	.017	.035
BEL-1400-2821	1/4"	.253	.437	.018	.043
BEL-1400-2800	1/4"	.253	.437	.020	.045
BEL-1400-3600	1/4"	.253	.562	.020	.041
BEL-1400-3610	1/4"	.253	.562	.030	.050
BEL-1400-3900	1/4"	.253	.616	.020	.035
BEL-1401-1620	1/4"	.253	1.250	.060	.225
BEL-1400-3250	1/4"	.255	.500	.025	.038
BEL-1400-4040	1/4"	.255	.625	.062	.082
BEL-1400-3261	1/4"	.258	.500	.025	.046
BEL-1400-4830	1/4"	.258	.747	.025	.053
BEL-1400-5620	1/4"	.258	.875	.060	.110
BEL-1400-2820	1/4"	.260	.437	.060	.085

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Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-1400-3260	1/4"	.260	.493	.025	.065
BEL-1400-3220	1/4"	.260	.500	.020	.045
BEL-1400-3230	1/4"	.260	.500	.031	.060
BEL-1400-5630	1/4"	.260	.875	.005	.062
BEL-1400-6400	1/4"	.260	1.000	.020	.046
BEL-1401-0000	1/4"	.260	1.000	.028	.056
BEL-1401-0010	1/4"	.260	1.000	.040	.053
BEL-1401-0011	1/4"	.260	1.000	.024	.052
BEL-1400-4810	1/4"	.261	.750	.025	.060
BEL-1400-3210	1/4"	.262	.500	.010	.047
BEL-1400-2810	1/4"	.265	.437	.010	.047
BEL-1400-3200	1/4"	.265	.500	.022	.044
BEL-1400-3201	1/4"	.265	.500	.018	.034
BEL-1400-3240	1/4"	.265	.500	.045	.062
BEL-1400-4000	1/4"	.265	.625	.045	.108
BEL-1400-4800	1/4"	.265	.750	.062	.093
BEL-1400-4820	1/4"	.265	.750	.040	.109
BEL-1401-0800	1/4"	.265	1.125	.062	.140
BEL-1400-4010	1/4"	.266	.625	.050	.119
BEL-1400-4400	1/4"	.266	.688	.052	.075
BEL-1400-4020	1/4"	.268	.622	.034	.065
BEL-1400-4030	1/4"	.268	.622	.062	.100
BEL-1400-5600	1/4"	.268	.875	.025	.178
BEL-1400-4410	1/4"	.269	.682	.056	.076
BEL-1400-4411	1/4"	.269	.682	.060	.080
BEL-1600-4010	16	.270	.625	.015	.082
BEL-1600-6100	16	.271	.953	.050	.074
BEL-1601-0810	16	.273	1.123	.039	.181
BEL-1601-0000	16	.274	1.000	.040	.075
BEL-1600-3210	16	.279	.500	.018	.050
BEL-1600-3220	16	.279	.500	.018	.050
BEL-1600-3200	16	.281	.492	.010	.057
BEL-1600-4000	16	.281	.625	.032	.071
BEL-1600-4400	16	.281	.687	.055	.080
BEL-1601-1600	16	.281	1.250	.050	.205
BEL-1600-3600	16	.282	.562	.010	.030
BEL-1600-3400	16	.283	.531	.010	.032
BEL-1600-4410	16	.283	.687	.055	.080
BEL-1600-2200	16	.284	.337	.015	.037
BEL-1600-3800	16	.284	.593	.050	.075
BEL-1600-4100	16	.284	.645	.050	.100
BEL-1600-4510	16	.284	.698	.060	.112
BEL-1600-5610	16	.284	.875	.060	.107
BEL-1600-3810	16	.286	.601	.010	.060
BEL-1600-3300	16	.287	.512	.010	.050
BEL-1600-4500	16	.293	.698	.060	.117
BEL-1600-5600	16	.293	.875	.060	.107

Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-1600-5620	16	.293	.875	.062	.111
BEL-1600-3000	16	.297	.468	.022	.093
BEL-1600-3610	16	.312	.562	.040	.074
BEL-1601-0800	16	.312	1.125	.062	.250
BEL-1800-3600	5/16"	.314	.560	.031	.074
BEL-1800-4000	5/16"	.317	.625	.022	.042
BEL-1800-4030	5/16"	.317	.625	.010	.040
BEL-1800-4070	5/16"	.317	.625	.016	.036
BEL-1800-4071	5/16"	.317	.625	.030	.060
BEL-1800-4060	5/16"	.317	.625	.035	.065
BEL-1800-6000	5/16"	.317	.931	.040	.165
BEL-1800-4071	5/16"	.317	.625	.030	.060
BEL-1800-3610	5/16"	.318	.560	.027	.045
BEL-1800-3611	5/16"	.318	.560	.031	.056
BEL-1800-4831	5/16"	.320	.750	.035	.063
BEL-1800-5650	5/16"	.320	.872	.035	.052
BEL-1801-0000	5/16"	.321	1.000	.062	.085
BEL-1800-4421	5/16"	.323	.684	.093	.113
BEL-1800-3200	5/16"	.323	.500	.010	.023
BEL-1800-3800	5/16"	.323	.593	.094	.114
BEL-1800-4500	5/16"	.323	.709	.028	.049
BEL-1800-3930	5/16"	.325	.622	.032	.050
BEL-1800-4020	5/16"	.325	.625	.060	.085
BEL-1800-6010	5/16"	.325	.930	.045	.070
BEL-1800-3900	5/16"	.328	.615	.022	.030
BEL-1800-3910	5/16"	.328	.600	.022	.030
BEL-1800-4040	5/16"	.328	.614	.022	.032
BEL-1801-0820	5/16"	.329	1.122	.031	.093
BEL-1800-4800	5/16"	.330	.750	.025	.062
BEL-1800-4830	5/16"	.330	.750	.050	.087
BEL-1800-3920	5/16"	.331	.615	.022	.055
BEL-1800-4400	5/16"	.331	.684	.052	.072
BEL-1800-5200	5/16"	.333	.815	.065	.090
BEL-1800-4050	5/16"	.339	.630	.060	.082
BEL-1800-4820	5/16"	.340	.750	.098	.118
BEL-1800-5620	5/16"	.340	.875	.074	.104
BEL-1801-1610	5/16"	.340	1.250	.118	.158
BEL-1800-2800	5/16"	.341	.434	.032	.060
BEL-1800-4010	5/16"	.343	.625	.050	.100
BEL-1800-4420	5/16"	.343	.687	.062	.110
BEL-1800-5600	5/16"	.343	.875	.060	.112
BEL-1801-0810	5/16"	.343	1.125	.040	.090
BEL-1801-1600	5/16"	.343	1.250	.060	.170
BEL-1800-3230	5/16"	.345	.492	.032	.047
BEL-1800-4810	5/16"	.346	.750	.020	.072
BEL-1800-5610	5/16"	.346	.875	.062	.110
BEL-1801-0830	5/16"	.346	1.125	.062	.090

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Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-1801-0600	5/16"	.348	1.093	.062	.350
BEL-1800-3220	5/16"	.356	.495	.025	.038
BEL-1800-3210	5/16"	.359	.492	.040	.069
BEL-1800-5800	5/16"	.365	.903	.030	.081
BEL-2000-3930	3/8"	.375	.609	.031	.047
BEL-2000-5640	3/8"	.375	.875	.020	.100
BEL-2000-3920	3/8"	.378	.610	.031	.080
BEL-2000-5000	3/8"	.378	.781	.037	.065
BEL-2000-4820	3/8"	.380	.750	.060	.125
BEL-2000-4850	3/8"	.380	.750	.070	.135
BEL-2000-4870	3/8"	.380	.747	.038	.065
BEL-2000-4880	3/8"	.380	.747	.038	.080
BEL-2000-4891	3/8"	.382	.750	.037	.065
BEL-2000-5670	3/8"	.382	.872	.045	.073
BEL-2000-6010	3/8"	.382	.932	.030	.078
BEL-2001-3200	3/8"	.382	1.500	.104	.125
BEL-2000-5660	3/8"	.383	.875	.060	.110
BEL-2000-3910	3/8"	.385	.609	.028	.042
BEL-2000-4000	3/8"	.385	.625	.022	.042
BEL-2000-4830	3/8"	.385	.745	.040	.059
BEL-2000-4890	3/8"	.385	.743	.030	.083
BEL-2000-3600	3/8"	.387	.565	.031	.060
BEL-2000-4810	3/8"	.390	.750	.030	.070
BEL-2001-0410	3/8"	.390	1.060	.080	.119
BEL-2001-3000	3/8"	.390	1.472	.010	.125
BEL-2000-4892	3/8"	.393	.760	.045	.064
BEL-2000-5900	3/8"	.397	.925	.075	.105
BEL-2000-5610	3/8"	.400	.876	.062	.107
BEL-2001-1630	3/8"	.400	1.250	.040	.187
BEL-2000-4860	3/8"	.401	.747	.100	.119
BEL-2000-5010	3/8"	.402	.787	.031	.061
BEL-2000-0400	3/8"	.405	1.062	.032	.045
BEL-2000-4800	3/8"	.406	.750	.020	.045
BEL-2000-4840	3/8"	.406	.750	.050	.075
BEL-2000-5021	3/8"	.406	.780	.043	.071
BEL-2000-5610	3/8"	.406	.875	.062	.112
BEL-2000-5620	3/8"	.406	.875	.109	.124
BEL-2000-5630	3/8"	.406	.875	.089	.100
BEL-2000-5650	3/8"	.406	.875	.020	.078
BEL-2000-5910	3/8"	.406	.983	.098	.113
BEL-2001-0020	3/8"	.406	1.000	.062	.087
BEL-2001-0030	3/8"	.406	1.000	.104	.116
BEL-2001-6011	3/8"	.406	1.247	.083	.250
BEL-2001-1620	3/8"	.406	1.250	.060	.235
BEL-2001-3210	3/8"	.406	1.500	.062	.187
BEL-2001-4800	3/8"	.406	1.750	.031	.156
BEL-2001-2600	3/8"	.408	1.400	.116	.206

Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-2000-6000	3/8"	.409	.934	.098	.133
BEL-2001-0000	3/8"	.409	1.000	.060	.105
BEL-2001-1600	3/8"	.409	1.250	.074	.100
BEL-2000-5020	3/8"	.413	.783	.043	.062
BEL-2000-6011	3/8"	.413	.945	.125	.142
BEL-2000-3900	3/8"	.422	.614	.022	.055
BEL-2001-0010	3/8"	.422	1.000	.062	.162
BEL-2200-5800	7/16"	.437	.900	.090	.135
BEL-2201-0000	7/16"	.437	1.000	.062	.105
BEL-2201-1610	7/16"	.437	1.250	.062	.131
BEL-2200-5610	7/16"	.439	.875	.020	.078
BEL-2200-4810	7/16"	.440	.752	.020	.035
BEL-2200-5630	7/16"	.442	.875	.040	.065
BEL-2200-5640	7/16"	.442	.875	.040	.075
BEL-2201-0030	7/16"	.450	1.000	.062	.140
BEL-2200-4800	7/16"	.453	.750	.030	.060
BEL-2200-5210	7/16"	.453	.809	.063	.085
BEL-2200-5530	7/16"	.453	.860	.030	.060
BEL-2201-1600	7/16"	.453	1.250	.088	.168
BEL-2201-0010	7/16"	.455	1.000	.035	.102
BEL-2201-0020	7/16"	.458	1.000	.093	.162
BEL-2200-6200	7/16"	.463	.968	.018	.081
BEL-2201-3220	7/16"	.468	1.500	.134	.164
BEL-2200-5650	7/16"	.470	.872	.062	.117
BEL-2200-5200	7/16"	.471	.812	.040	.063
BEL-2201-3200	7/16"	.471	1.500	.062	.102
BEL-2200-5600	7/16"	.475	.875	.093	.118
BEL-2200-5810	7/16"	.480	.906	.049	.073
BEL-2200-5510	7/16"	.484	.859	.010	.030
BEL-2200-5500	7/16"	.491	.859	.014	.030
BEL-2200-5520	7/16"	.499	.862	.033	.042
BEL-2201-1200	7/16"	.500	1.187	.062	.152
BEL-2201-1300	7/16"	.500	1.203	.020	.082
BEL-2201-2000	7/16"	.500	1.312	.100	.128
BEL-2401-1300	1/2"	.500	1.197	.020	.066
BEL-2401-1200	1/2"	.501	1.187	.062	.132
BEL-2401-6200	1/2"	.505	.966	.050	.075
BEL-2401-0070	1/2"	.505	1.000	.024	.064
BEL-2400-5300	1/2"	.506	.809	.045	.073
BEL-2401-0050	1/2"	.506	.998	.024	.064
BEL-2401-0600	1/2"	.507	1.100	.040	.076
BEL-2401-0010	1/2"	.508	1.000	.035	.067
BEL-2401-0012	1/2"	.508	1.000	.030	.066
BEL-2400-6100	1/2"	.509	.952	.015	.055
BEL-2400-6101	1/2"	.509	.953	.018	.058
BEL-2401-0011	1/2"	.510	.993	.035	.095
BEL-2401-0080	1/2"	.510	1.000	.050	.075

Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-2401-4810	1/2"	.510	1.750	.010	.075
BEL-2401-0710	1/2"	.512	1.100	.062	.096
BEL-2400-4800	1/2"	.513	.745	.025	.130
BEL-2400-6201	1/2"	.514	.970	.020	.058
BEL-2400-4400	1/2"	.515	.687	.010	.062
BEL-2400-4810	1/2"	.515	.745	.025	.052
BEL-2400-4820	1/2"	.515	.745	.025	.043
BEL-2401-0030	1/2"	.515	1.000	.062	.125
BEL-2401-0800	1/2"	.515	1.125	.072	.150
BEL-2401-1600	1/2"	.515	1.250	.060	.096
BEL-2401-1650	1/2"	.515	1.250	.078	.137
BEL-2401-2430	1/2"	.515	1.375	.060	.095
BEL-2401-3210	1/2"	.515	1.500	.093	.250
BEL-2400-6001	1/2"	.516	.937	.047	.068
BEL-2401-1630	1/2"	.517	1.247	.062	.119
BEL-2401-0000	1/2"	.518	1.000	.035	.067
BEL-2401-3220	1/2"	.518	1.497	.112	.153
BEL-2401-3230	1/2"	.519	1.482	.037	.092
BEL-2401-1100	1/2"	.521	1.175	.095	.131
BEL-2401-0040	1/2"	.522	1.000	.035	.067
BEL-2401-0090	1/2"	.525	.997	.050	.075
BEL-2401-3200	1/2"	.530	1.500	.050	.115
BEL-2401-0810	1/2"	.531	1.125	.125	.139
BEL-2401-0840	1/2"	.531	1.125	.062	.092
BEL-2401-0820	1/2"	.531	1.125	.062	.132
BEL-2401-2420	1/2"	.531	1.375	.125	.140
BEL-2401-1620	1/2"	.532	1.250	.093	.113
BEL-2401-2400	1/2"	.532	1.375	.060	.095
BEL-2401-2410	1/2"	.532	1.375	.125	.156
BEL-2401-1640	1/2"	.534	1.247	.020	.115
BEL-2401-4000	1/2"	.534	1.625	.140	.168
BEL-2401-1610	1/2"	.536	1.250	.125	.143
BEL-2401-1670	1/2"	.536	1.250	.125	.158
BEL-2401-0200	1/2"	.538	1.031	.038	.080
BEL-2401-4800	1/2"	.540	1.750	.115	.180
BEL-2401-0700	1/2"	.546	1.109	.010	.035
BEL-2400-4200	1/2"	.549	.661	.028	.061
BEL-2401-1500	1/2"	.549	1.234	.030	.060
BEL-2401-1660	1/2"	.550	1.247	.109	.155
BEL-2400-6000	1/2"	.551	.924	.052	.083
BEL-2401-0400	1/2"	.554	1.062	.032	.064
BEL-2401-0020	1/2"	.562	1.000	.062	.132
BEL-2401-2600	1/2"	.562	1.415	.187	.222
BEL-2401-4010	1/2"	.562	1.625	.104	.134
BEL-2601-1600	9/16"	.565	1.250	.062	.134
BEL-2602-0000	9/16"	.565	2.000	.187	.312
BEL-2601-0830	9/16"	.567	1.125	.060	.085

Belleville Spring Washers

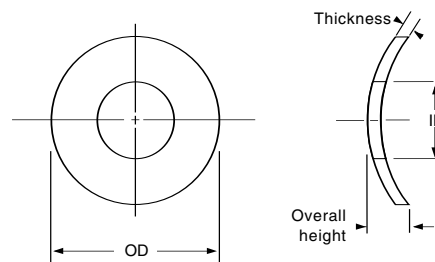
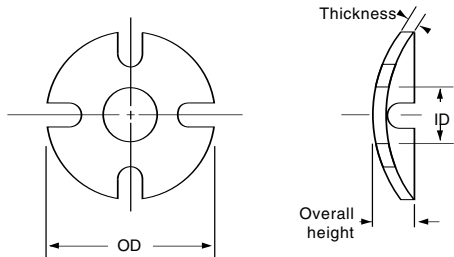
Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-2600-5800	9/16"	.570	.906	.008	.093
BEL-2600-6000	9/16"	.572	.937	.016	.036
BEL-2600-4900	9/16"	.573	.779	.015	.050
BEL-2600-5200	9/16"	.576	.812	.025	.052
BEL-2601-0600	9/16"	.576	1.100	.040	.076
BEL-2601-0400	9/16"	.580	1.059	.045	.118
BEL-2600-5500	9/16"	.596	.859	.055	.078
BEL-2600-6300	9/16"	.610	.990	.015	.035
BEL-2601-4000	9/16"	.625	1.625	.062	.205
BEL-2801-2410	5/8"	.628	1.372	.031	.093
BEL-2801-1600	5/8"	.630	1.250	.040	.082
BEL-2801-3200	5/8"	.630	1.500	.037	.100
BEL-2800-5900	5/8"	.635	.912	.031	.073
BEL-2801-2420	5/8"	.637	1.375	.078	.110
BEL-2801-0810	5/8"	.640	1.125	.028	.060
BEL-2801-0830	5/8"	.642	1.122	.028	.050
BEL-2801-0800	5/8"	.643	1.125	.028	.086
BEL-2801-2400	5/8"	.643	1.375	.050	.100
BEL-2800-4800	5/8"	.646	.750	.005	.093
BEL-2801-1610	5/8"	.653	1.250	.025	.185
BEL-2801-1620	5/8"	.653	1.250	.090	.185
BEL-2801-3100	5/8"	.655	1.490	.112	.153
BEL-2800-5200	5/8"	.656	.812	.062	.117
BEL-2801-4710	5/8"	.656	1.734	.030	.078
BEL-2801-4700	5/8"	.659	1.734	.030	.139
BEL-2801-5000	5/8"	.680	1.497	.037	.100
BEL-2801-2200	5/8"	.687	1.343	.031	.100
BEL-2801-3210	5/8"	.687	1.500	.104	.136
BEL-2801-4800	5/8"	.687	1.750	.062	.225
BEL-2801-4810	5/8"	.687	1.750	.093	.109
BEL-3002-0000	11/16"	.690	1.997	.120	.215
BEL-3001-5600	11/16"	.696	1.872	.050	.115
BEL-3000-5500	11/16"	.705	.863	.017	.037
BEL-3001-2600	11/16"	.728	1.400	.035	.085
BEL-3003-1600	11/16"	.738	3.250	.046	.140
BEL-3003-1601	11/16"	.739	3.250	.046	.155
BEL-3002-4000	11/16"	.740	2.622	.037	.125
BEL-3002-4001	11/16"	.740	2.622	.035	.120
BEL-3201-3240	3/4"	.753	1.500	.040	.093
BEL-3201-3230	3/4"	.755	1.497	.075	.145
BEL-3201-3250	3/4"	.755	1.497	.108	.137
BEL-3201-3220	3/4"	.760	1.500	.075	.105
BEL-3201-3420	3/4"	.760	1.520	.030	.072
BEL-3201-3410	3/4"	.761	1.521	.030	.092
BEL-3201-3400	3/4"	.762	1.525	.035	.080
BEL-3201-2600	3/4"	.765	1.403	.025	.070
BEL-3201-5020	3/4"	.765	1.786	.060	.120

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Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-3201-3100	3/4"	.773	1.482	.045	.095
BEL-3201-3110	3/4"	.773	1.482	.037	.092
BEL-3201-3111	3/4"	.773	1.482	.042	.092
BEL-3201-5000	3/4"	.773	1.786	.030	.066
BEL-3201-5010	3/4"	.781	1.781	.030	.076
BEL-3201-2400	3/4"	.784	1.375	.060	.090
BEL-3201-3200	3/4"	.784	1.500	.060	.090
BEL-3201-5030	3/4"	.784	1.935	.081	.135
BEL-3201-1400	3/4"	.800	1.220	.017	.045
BEL-3201-1000	3/4"	.802	1.156	.022	.062
BEL-3301-1610	13/16"	.812	1.875	.037	.100
BEL-3302-0000	13/16"	.812	2.000	.072	.132
BEL-3302-0010	13/16"	.812	2.000	.109	.234
BEL-3302-1600	13/16"	.812	2.250	.156	.202
BEL-3301-1400	13/16"	.816	1.225	.017	.045
BEL-3301-1600	13/16"	.818	1.250	.030	.095
BEL-3301-1620	13/16"	.818	1.375	.063	.105
BEL-3301-6210	13/16"	.819	1.968	.098	.152
BEL-3301-5600	13/16"	.820	1.875	.070	.195
BEL-3301-4800	13/16"	.843	1.750	.050	.125
BEL-3301-4810	13/16"	.870	1.750	.032	.080
BEL-3401-6200	7/8"	.882	1.968	.100	.165
BEL-3401-3210	7/8"	.885	1.500	.030	.076
BEL-3401-2300	7/8"	.890	1.370	.078	.115
BEL-3401-3211	7/8"	.890	1.500	.030	.081
BEL-3401-4200	7/8"	.890	1.656	.031	.125
BEL-3401-3200	7/8"	.906	1.500	.078	.098
BEL-3601-2200	1"	1.004	1.353	.025	.055
BEL-3601-2201	1"	1.004	1.353	.025	.062
BEL-3601-3600	1"	1.004	1.560	.035	.078
BEL-3601-4010	1"	1.010	1.625	.040	.095

Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
BEL-3601-4021	1"	1.010	1.625	.040	.109
BEL-3601-4000	1"	1.015	1.625	.062	.125
BEL-3601-4020	1"	1.016	1.625	.041	.078
BEL-3601-4100	1"	1.034	1.637	.119	.278
BEL-3602-4000	1"	1.034	2.622	.030	.093
BEL-3602-0600	1"	1.050	2.093	.032	.097
BEL-3602-0100	1"	1.062	2.000	.037	.100
BEL-3602-3200	1"	1.062	2.500	.125	.265
BEL-3602-0000	1"	1.080	2.000	.070	.195
BEL-3801-5600	1-1/8"	1.156	1.875	.093	.118
BEL-3801-5610	1-1/8"	1.156	1.875	.031	.118
BEL-3802-0000	1-1/8"	1.159	1.997	.086	.188
BEL-3902-3000	1"	1.225	2.475	.096	.170
BEL-4002-4800	1-1/4"	1.253	2.747	.062	.280
BEL-4001-4800	1-1/4"	1.260	1.750	.055	.087
BEL-4002-0000	1-1/4"	1.260	2.000	.037	.100
BEL-4101-5400	1-5/16"	1.315	1.840	.046	.126
BEL-4101-5600	1-5/16"	1.322	1.875	.035	.095
BEL-4101-5200	1-5/16"	1.360	1.810	.023	.048
BEL-4202-4800	1-3/8"	1.375	2.750	.122	.184
BEL-4202-3200	1-3/8"	1.393	2.497	.052	.134
BEL-4202-0300	1-3/8"	1.394	2.041	.067	.113
BEL-4202-0201	1-3/8"	1.403	2.022	.030	.075
BEL-4202-0200	1-3/8"	1.409	2.028	.024	.063
BEL-4202-4000	1-3/8"	1.437	2.625	.125	.185
BEL-4402-2300	1-1/2"	1.516	2.362	.040	.157
BEL-4502-0600	1-9/16"	1.584	2.100	.035	.090
BEL-4602-1400	1-5/8"	1.667	2.219	.035	.095
BEL-4602-4300	1-5/8"	1.680	2.625	.143	.170
BEL-4702-0700	1-11/16"	1.708	2.101	.040	.085
BEL-4702-4000	1-11/16"	1.770	2.625	.035	.098
BEL-4904-0000	1-13/16"	1.875	4.000	.109	.218
BEL-5003-1900	1-7/8"	1.900	3.300	.059	.150
BEL-5102-4000	1-15/16"	1.978	2.625	.040	.100
BEL-5203-0800	2"	2.010	3.120	.093	.220
BEL-5302-4000	2-1/16"	2.082	2.622	.040	.095
BEL-5504-0700	2-3/16"	2.200	4.100	.063	.138
BEL-5702-4700	2-5/16"	2.331	2.734	.042	.107
BEL-6103-0800	2-9/16"	2.568	3.124	.045	.113
BEL-6203-2300	2-5/8"	2.640	3.367	.040	.100
BEL-6703-4400	2-15/16"	2.962	3.688	.050	.120
BEL-7304-1300	3-5/16"	3.356	4.195	.051	.126



Tolerances	
Outside Diameter	$\pm .010$
Inside Diameter	Up to/including No. 10 : $\pm .005$ Over No.10: $\pm .010$
Thickness	Commercial
Overall Height	+ .005 to - .015 as stamped. Some distortion may occur in heat treatment.

Tolerances	
Outside Diameter	$\pm .010$
Inside Diameter	Up to/including No. 10: $\pm .005$ Over No. 10: $\pm .010$
Thickness	Commercial
Overall Height	$\pm .010$ as stamped. Some distortion may occur in heat treatment.

Slotted Belleville Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	Number of Slots
SBL-0200-1800	2	.093	.281	.010	.042	4
SBL-0400-2200	4	.122	.342	.025	.060	4
SBL-0400-2201	4	.125	.343	.015	.057	4
SBL-0500-2600	5	.125	.400	.006	.055	3
SBL-0600-3600	6	.156	.468	.026	.078	4
SBL-0800-3200	8	.188	.490	.007	.035	6
SBL-1000-4010	10	.195	.625	.032	.093	4
SBL-1000-4810	10	.199	.750	.032	.109	4
SBL-1000-4000	10	.203	.625	.032	.093	4
SBL-1000-4800	10	.203	.750	.020	.092	4
SBL-1000-3600	10	.210	.562	.032	.092	4
SBL-1400-5300	1/4"	.255	.812	.030	.125	6
SBL-1400-5301	1/4"	.255	.812	.045	.145	6
SBL-1801-2100	5/16"	.328	1.750	.050	.156	6
SBL-1801-1400	5/16"	.343	1.218	.038	.200	4
SBL-2001-1000	3/8"	.375	1.153	.040	.173	4
SBL-2001-1600	3/8"	.406	1.250	.083	.235	6
SBL-2000-4800	3/8"	.410	.750	.022	.080	8
SBL-2201-1200	7/16"	.447	1.187	.032	.185	4
SBL-2401-1000	1/2"	.503	1.153	.040	.173	4

Cylindrically Curved Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-0000-0800	None	.000	.123	.003	.031
CYL-0020-2300	None	.055	.359	.002	.078
CYL-0010-0800	None	.063	.130	.005	.013
CYL-0010-1600	None	.065	.248	.003	.040
CYL-0100-1000	1	.074	.156	.012	.035
CYL-0100-0800	1	.078	.128	.005	.017
CYL-0100-1010	1	.078	.157	.003	.023
CYL-0100-1011	1	.078	.157	.005	.023
CYL-0200-0900	2	.086	.137	.010	.025
CYL-0200-1620	2	.087	.250	.010	.050
CYL-0200-1000	2	.088	.162	.004	.028
CYL-0200-1210	2	.090	.186	.010	.036
CYL-0200-2400	2	.092	.375	.010	.062
CYL-0200-1200	2	.096	.187	.010	.025
CYL-0200-1400	2	.096	.218	.006	.046
CYL-0200-1610	2	.096	.250	.008	.055
CYL-0200-2800	2	.096	.437	.010	.100
CYL-0200-4000	2	.096	.625	.010	.093
CYL-0200-1600	2	.098	.250	.005	.040
CYL-0300-1610	3	.100	.250	.005	.040
CYL-0300-1400	3	.111	.218	.003	.025
CYL-0300-2800	3	.111	.437	.003	.093
CYL-0400-2410	4	.112	.375	.005	.090
CYL-0400-1600	4	.114	.250	.010	.045
CYL-0400-2400	4	.114	.375	.006	.078
CYL-0400-1200	4	.116	.180	.006	.040
CYL-0400-2430	4	.122	.378	.008	.055
CYL-0400-3400	4	.124	.539	.011	.115
CYL-0400-1400	4	.125	.216	.016	.033

Cylindrically Curved Spring Washers

Cylindrically Curved Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-0400-2600	4	.125	.406	.015	.062
CYL-0500-1200	5	.126	.187	.010	.025
CYL-0500-1300	5	.127	.203	.008	.050
CYL-0500-2600	5	.127	.406	.006	.055
CYL-0500-3200	5	.127	.500	.012	.068
CYL-0500-1820	5	.128	.281	.005	.062
CYL-0500-2410	5	.128	.375	.015	.035
CYL-0500-3000	5	.128	.468	.005	.060
CYL-0500-4400	5	.128	.687	.010	.062
CYL-0500-4800	5	.128	.747	.003	.028
CYL-0500-1620	5	.129	.250	.008	.045
CYL-0500-1400	5	.130	.219	.006	.031
CYL-0500-1900	5	.130	.305	.016	.082
CYL-0500-1631	5	.131	.250	.003	.030
CYL-0500-1630	5	.131	.250	.006	.045
CYL-0500-2430	5	.131	.378	.004	.060
CYL-0500-3600	5	.132	.562	.006	.130
CYL-0500-2000	5	.133	.312	.005	.062
CYL-0500-2400	5	.133	.375	.020	.062
CYL-0500-1830	5	.134	.281	.010	.030
CYL-0500-1800	5	.135	.281	.005	.067
CYL-0500-1810	5	.135	.281	.005	.056
CYL-0500-1602	5	.136	.250	.016	.043
CYL-0500-1600	5	.136	.250	.016	.044
CYL-0500-1601	5	.136	.250	.017	.044
CYL-0500-2010	5	.138	.312	.010	.093
CYL-0500-2420	5	.138	.375	.005	.085
CYL-0600-2430	6	.139	.375	.005	.062
CYL-0600-1600	6	.140	.250	.010	.060
CYL-0600-2470	6	.140	.375	.010	.053
CYL-0600-1800	6	.146	.281	.013	.040
CYL-0600-2450	6	.147	.378	.016	.070
CYL-0600-2000	6	.153	.309	.015	.060
CYL-0600-1601	6	.155	.250	.006	.035
CYL-0600-2410	6	.158	.375	.015	.035
CYL-0600-2440	6	.158	.375	.010	.040
CYL-0600-2471	6	.158	.378	.030	.085
CYL-0600-2300	6	.159	.366	.015	.035
CYL-0600-2800	6	.159	.437	.006	.053
CYL-0600-2420	6	.160	.375	.012	.052
CYL-0600-2460	6	.160	.375	.022	.032
CYL-0600-2400	6	.161	.375	.012	.052
CYL-0800-2310	8	.163	.372	.008	.063
CYL-0800-2010	8	.167	.312	.005	.030
CYL-0800-2300	8	.167	.360	.008	.062
CYL-0800-1801	8	.168	.280	.010	.046
CYL-0800-2450	8	.168	.372	.008	.062

Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-0800-2800	8	.169	.437	.005	.093
CYL-0800-2400	8	.170	.380	.003	.070
CYL-0800-1610	8	.171	.250	.015	.040
CYL-0800-3600	8	.171	.562	.015	.085
CYL-0800-3700	8	.171	.583	.008	.109
CYL-0800-1510	8	.172	.240	.005	.060
CYL-0800-2210	8	.173	.343	.005	.045
CYL-0800-1500	8	.174	.240	.010	.035
CYL-0800-1520	8	.174	.240	.010	.040
CYL-0800-2000	8	.174	.312	.018	.045
CYL-0800-2500	8	.176	.397	.006	.030
CYL-0800-1600	8	.181	.250	.016	.040
CYL-0800-2470	8	.184	.372	.005	.075
CYL-0800-2410	8	.186	.375	.010	.062
CYL-0800-2460	8	.187	.375	.006	.062
CYL-0800-4000	8	.187	.625	.005	.062
CYL-0800-1800	8	.189	.275	.006	.033
CYL-0800-2020	8	.189	.310	.003	.093
CYL-0800-2200	8	.189	.343	.008	.033
CYL-0800-2810	8	.189	.437	.008	.050
CYL-0800-2420	8	.190	.375	.010	.055
CYL-0800-2430	8	.190	.375	.025	.045
CYL-0800-2440	8	.190	.375	.008	.045
CYL-0800-3200	8	.190	.500	.006	.093
CYL-1000-2430	10	.191	.372	.008	.062
CYL-1000-4000	10	.191	.625	.005	.062
CYL-1000-2310	10	.193	.359	.012	.050
CYL-1000-2460	10	.193	.375	.003	.040
CYL-1000-2450	10	.193	.375	.025	.087
CYL-1000-2000	10	.195	.312	.010	.030
CYL-1000-2461	10	.195	.375	.004	.040
CYL-1000-2810	10	.195	.437	.005	.062
CYL-1000-3220	10	.195	.490	.010	.028
CYL-1000-2820	10	.197	.437	.022	.076
CYL-1000-3600	10	.197	.562	.010	.075
CYL-1000-3610	10	.197	.562	.012	.062
CYL-1000-2420	10	.198	.375	.008	.062
CYL-1001-1300	10	.198	1.203	.020	.150
CYL-1000-1900	10	.200	.300	.004	.046
CYL-1000-2200	10	.201	.343	.012	.085
CYL-1000-1700	10	.202	.265	.003	.062
CYL-1000-2010	10	.203	.312	.003	.062
CYL-1000-2400	10	.203	.375	.005	.062
CYL-1000-2800	10	.203	.437	.010	.062
CYL-1000-3251	10	.203	.500	.015	.080
CYL-1000-3230	10	.203	.500	.022	.062
CYL-1000-3240	10	.203	.500	.004	.070

Cylindrically Curved Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-1000-2440	10	.206	.372	.015	.062
CYL-1000-2830	10	.206	.425	.010	.070
CYL-1000-3200	10	.206	.492	.008	.080
CYL-1000-3210	10	.206	.500	.015	.093
CYL-1000-3250	10	.206	.500	.010	.085
CYL-1000-2410	10	.207	.375	.010	.075
CYL-1000-2300	10	.210	.366	.006	.095
CYL-1200-2800	12	.219	.437	.005	.075
CYL-1200-2600	12	.221	.406	.005	.062
CYL-1200-2620	12	.221	.406	.008	.030
CYL-1200-2020	12	.230	.314	.010	.047
CYL-1200-2630	12	.230	.406	.009	.062
CYL-1200-2410	12	.234	.375	.012	.064
CYL-1200-2810	12	.234	.437	.010	.065
CYL-1200-3200	12	.235	.500	.031	.070
CYL-1200-2610	12	.237	.401	.005	.046
CYL-1200-2400	12	.239	.375	.006	.100
CYL-1200-4000	12	.240	.625	.015	.115
CYL-1400-3240	1/4"	.250	.500	.015	.062
CYL-1400-5630	1/4"	.250	.750	.006	.072
CYL-1400-3610	1/4"	.252	.562	.015	.110
CYL-1400-2830	1/4"	.253	.437	.007	.030
CYL-1400-5610	1/4"	.253	.875	.030	.062
CYL-1400-2410	1/4"	.253	.375	.010	.050
CYL-1400-2420	1/4"	.255	.372	.015	.050
CYL-1400-2600	1/4"	.256	.406	.009	.032
CYL-1400-2900	1/4"	.256	.448	.010	.047
CYL-1400-5600	1/4"	.256	.875	.010	.045
CYL-1400-2451	1/4"	.257	.372	.006	.068
CYL-1400-2450	1/4"	.257	.372	.008	.070
CYL-1400-2610	1/4"	.257	.404	.003	.032
CYL-1400-2310	1/4"	.259	.359	.008	.070
CYL-1400-2300	1/4"	.259	.359	.010	.070
CYL-1400-5620	1/4"	.259	.872	.010	.100
CYL-1400-2800	1/4"	.260	.437	.004	.062
CYL-1400-3260	1/4"	.260	.497	.010	.090
CYL-1400-3250	1/4"	.260	.497	.015	.045
CYL-1400-2810	1/4"	.261	.437	.010	.100
CYL-1400-2840	1/4"	.261	.437	.010	.046
CYL-1400-3200	1/4"	.261	.500	.010	.058
CYL-1400-2440	1/4"	.262	.375	.013	.050
CYL-1400-2400	1/4"	.263	.375	.013	.045
CYL-1400-2430	1/4"	.263	.375	.013	.036
CYL-1400-2820	1/4"	.263	.437	.020	.045
CYL-1400-4800	1/4"	.263	.750	.040	.075
CYL-1400-2500	1/4"	.264	.390	.003	.075
CYL-1400-3100	1/4"	.265	.490	.006	.080

Cylindrically Curved Spring Washers

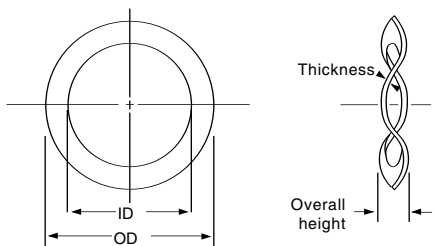
Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-1400-3110	1/4"	.265	.490	.008	.091
CYL-1400-3220	1/4"	.265	.500	.010	.070
CYL-1400-3230	1/4"	.265	.500	.010	.130
CYL-1400-4000	1/4"	.265	.625	.010	.062
CYL-1400-4010	1/4"	.265	.625	.012	.080
CYL-1401-3200	1/4"	.266	1.497	.022	.230
CYL-1400-3210	1/4"	.266	.500	.007	.062
CYL-1400-3600	1/4"	.267	.562	.008	.062
CYL-1400-4020	1/4"	.268	.622	.030	.115
CYL-1600-3220	16	.270	.500	.010	.060
CYL-1600-4030	16	.280	.625	.065	.150
CYL-1600-2500	16	.281	.400	.003	.093
CYL-1600-3200	16	.281	.492	.012	.080
CYL-1600-3230	16	.281	.500	.010	.062
CYL-1600-4000	16	.281	.625	.010	.088
CYL-1600-4800	16	.283	.750	.016	.080
CYL-1600-2400	16	.284	.375	.008	.060
CYL-1600-4020	16	.284	.622	.008	.100
CYL-1600-3000	16	.287	.467	.005	.070
CYL-1600-2821	16	.291	.438	.005	.070
CYL-1600-2800	16	.292	.437	.006	.072
CYL-1600-2810	16	.292	.437	.008	.075
CYL-1600-3210	16	.293	.500	.012	.059
CYL-1600-3240	16	.295	.500	.012	.060
CYL-1600-2910	16	.297	.453	.005	.062
CYL-1600-2600	16	.300	.406	.009	.060
CYL-1600-2820	16	.309	.440	.018	.050
CYL-1600-4010	16	.312	.625	.018	.125
CYL-1800-2900	5/16"	.312	.453	.020	.062
CYL-1800-3700	5/16"	.312	.578	.010	.093
CYL-1800-3710	5/16"	.312	.578	.016	.090
CYL-1800-3210	5/16"	.313	.502	.032	.062
CYL-1800-4020	5/16"	.314	.625	.012	.062
CYL-1800-2600	5/16"	.315	.406	.008	.100
CYL-1800-3230	5/16"	.317	.497	.018	.098
CYL-1800-4040	5/16"	.320	.625	.008	.065
CYL-1800-4400	5/16"	.323	.688	.008	.094
CYL-1800-3221	5/16"	.324	.498	.006	.080
CYL-1800-4050	5/16"	.325	.625	.006	.080
CYL-1800-4060	5/16"	.325	.625	.007	.110
CYL-1800-4070	5/16"	.325	.625	.015	.080
CYL-1800-3220	5/16"	.326	.498	.006	.099
CYL-1800-4000	5/16"	.327	.625	.010	.075
CYL-1800-5600	5/16"	.328	.875	.010	.045
CYL-1800-5610	5/16"	.328	.875	.010	.090
CYL-1800-3600	5/16"	.330	.560	.008	.088
CYL-1800-3200	5/16"	.331	.500	.010	.062

Cylindrically Curved Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-1800-4700	5/16"	.355	.734	.032	.105
CYL-1800-3900	5/16"	.358	.616	.010	.125
CYL-1800-3012	5/16"	.370	.472	.012	.096
CYL-1800-3000	5/16"	.370	.473	.007	.083
CYL-1800-3011	5/16"	.370	.475	.012	.080
CYL-1800-3010	5/16"	.370	.475	.012	.100
CYL-2000-4020	3/8"	.375	.625	.005	.062
CYL-2001-3200	3/8"	.376	1.500	.120	.170
CYL-2001-3210	3/8"	.376	1.500	.120	.164
CYL-2000-3210	3/8"	.377	.500	.009	.085
CYL-2000-3620	3/8"	.378	.562	.010	.080
CYL-2000-4000	3/8"	.380	.625	.015	.109
CYL-2000-4800	3/8"	.383	.750	.010	.140
CYL-2000-5000	3/8"	.383	.781	.013	.125
CYL-2000-3200	3/8"	.385	.500	.012	.070
CYL-2000-4010	3/8"	.390	.625	.010	.045
CYL-2000-4810	3/8"	.390	.747	.020	.145
CYL-2000-4210	3/8"	.391	.656	.025	.125
CYL-2000-3610	3/8"	.392	.562	.015	.109
CYL-2000-4030	3/8"	.393	.625	.020	.133
CYL-2000-4400	3/8"	.393	.687	.008	.135
CYL-2000-3630	3/8"	.394	.561	.006	.086
CYL-2000-3600	3/8"	.395	.562	.010	.090
CYL-2000-2700	3/8"	.395	1.421	.067	.125
CYL-2000-3900	3/8"	.400	.612	.008	.098
CYL-2000-3500	3/8"	.406	.549	.010	.100
CYL-2000-5200	3/8"	.409	.812	.010	.125
CYL-2000-4200	3/8"	.418	.660	.025	.050
CYL-2200-4810	7/16"	.440	.750	.005	.089
CYL-2200-4820	7/16"	.440	.750	.017	.140
CYL-2200-5610	7/16"	.440	.875	.025	.092
CYL-2200-5000	7/16"	.445	.781	.025	.080
CYL-2200-5620	7/16"	.450	.875	.025	.092
CYL-2200-5700	7/16"	.450	.885	.008	.155
CYL-2200-4000	7/16"	.453	.625	.010	.062
CYL-2200-4410	7/16"	.453	.688	.007	.094
CYL-2200-4600	7/16"	.460	.729	.020	.075
CYL-2200-4420	7/16"	.468	.687	.005	.130
CYL-2200-4700	7/16"	.468	.731	.005	.080
CYL-2200-5600	7/16"	.472	.875	.024	.062
CYL-2200-4400	7/16"	.487	.687	.008	.100
CYL-2400-4830	1/2"	.500	.742	.015	.115
CYL-2400-5200	1/2"	.500	.812	.032	.120
CYL-2400-5620	1/2"	.500	.875	.010	.065
CYL-2400-5650	1/2"	.500	.875	.010	.090
CYL-2400-4000	1/2"	.502	.625	.014	.109
CYL-2400-4820	1/2"	.503	.742	.015	.140

Cylindrically Curved Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height
CYL-2400-4010	1/2"	.504	.623	.008	.090
CYL-2400-4510	1/2"	.515	.719	.009	.085
CYL-2400-4700	1/2"	.516	.740	.010	.140
CYL-2400-4810	1/2"	.517	.750	.013	.090
CYL-2400-5610	1/2"	.517	.875	.010	.085
CYL-2400-4300	1/2"	.518	.671	.010	.156
CYL-2400-4400	1/2"	.518	.687	.010	.106
CYL-2400-4410	1/2"	.518	.687	.010	.045
CYL-2400-4800	1/2"	.518	.745	.015	.078
CYL-2401-0000	1/2"	.531	1.000	.012	.156
CYL-2400-4500	1/2"	.533	.703	.015	.062
CYL-2400-5600	1/2"	.536	.875	.025	.100
CYL-2400-5210	1/2"	.538	.812	.020	.100
CYL-2400-5500	1/2"	.562	.859	.008	.140
CYL-2600-5400	9/16"	.564	.843	.008	.093
CYL-2601-1200	9/16"	.578	1.187	.016	.125
CYL-2600-5200	9/16"	.579	.812	.016	.125
CYL-2600-5620	9/16"	.593	.875	.010	.125
CYL-2600-5630	9/16"	.596	.857	.020	.120
CYL-2600-5610	9/16"	.596	.873	.018	.093
CYL-2600-5500	9/16"	.598	.857	.016	.105
CYL-2600-4700	9/16"	.600	.735	.012	.095
CYL-2600-5600	9/16"	.610	.875	.013	.093
CYL-2600-5300	9/16"	.628	.826	.010	.109
CYL-2801-3200	5/8"	.630	1.500	.031	.120
CYL-2801-0000	5/8"	.641	1.000	.010	.156
CYL-2800-5600	5/8"	.656	.875	.015	.093
CYL-2801-0010	5/8"	.656	1.000	.028	.140
CYL-2801-4800	5/8"	.656	1.750	.020	.219
CYL-2800-6300	5/8"	.663	.980	.021	.118
CYL-2800-6200	5/8"	.673	.974	.014	.155
CYL-2801-3220	5/8"	.678	1.497	.031	.139
CYL-3000-5800	11/16"	.715	.914	.008	.075
CYL-3001-3200	11/16"	.718	1.500	.020	.109
CYL-3000-5500	11/16"	.749	.859	.030	.156
CYL-3001-0000	11/16"	.750	1.000	.020	.093
CYL-3201-0800	3/4"	.753	1.125	.032	.140
CYL-3201-0001	3/4"	.755	1.000	.020	.130
CYL-3200-6300	3/4"	.765	.995	.008	.080
CYL-3201-0500	3/4"	.775	1.080	.018	.125
CYL-3201-0000	3/4"	.783	1.000	.013	.093
CYL-3201-2000	3/4"	.807	1.319	.012	.149
CYL-3301-0400	13/16"	.843	1.062	.009	.100
CYL-3401-3220	7/8"	.893	1.098	.032	.125
CYL-3401-3200	7/8"	.906	1.500	.022	.125
CYL-3901-2200	1-3/16"	1.192	1.348	.032	.250



Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-1000-3100	10	.211	.482	.016	.059	3
WAV-1000-1600	10	.214	.250	.008	.040	3
WAV-1200-2000	12	.217	.312	.006	.050	3
WAV-1200-2400	12	.220	.375	.006	.075	3
WAV-1200-3100	12	.222	.482	.016	.059	3
WAV-1200-2200	12	.225	.343	.016	.065	3
WAV-1200-1920	12	.232	.300	.008	.050	2
WAV-1200-5000	12	.232	.787	.012	.108	2
WAV-1200-1800	12	.234	.280	.008	.040	2
WAV-1200-1900	12	.242	.300	.010	.040	2
WAV-1200-1910	12	.242	.300	.010	.040	3
WAV-1400-2430	1/4"	.250	.375	.005	.025	3
WAV-1400-2431	1/4"	.251	.375	.006	.025	3
WAV-1400-2410	1/4"	.252	.375	.010	.050	3
WAV-1400-3600	1/4"	.253	.562	.010	.075	3
WAV-1400-2100	1/4"	.256	.328	.018	.056	3
WAV-1400-3210	1/4"	.256	.500	.015	.085	2
WAV-1400-2432	1/4"	.257	.375	.010	.050	3
WAV-1400-2810	1/4"	.257	.437	.008	.062	2
WAV-1400-2830	1/4"	.258	.437	.005	.055	4
WAV-1400-2800	1/4"	.259	.437	.010	.062	2
WAV-1400-3230	1/4"	.259	.500	.040	.078	2
WAV-1400-3220	1/4"	.261	.500	.010	.055	3
WAV-1400-2900	1/4"	.262	.466	.020	.085	2
WAV-1400-3000	1/4"	.262	.473	.025	.075	2
WAV-1400-3200	1/4"	.262	.500	.012	.080	3
WAV-1400-3231	1/4"	.262	.500	.014	.082	3
WAV-1400-2200	1/4"	.264	.343	.010	.038	6
WAV-1400-2300	1/4"	.265	.367	.004	.033	3
WAV-1400-2400	1/4"	.265	.375	.010	.046	4
WAV-1400-2420	1/4"	.265	.375	.006	.025	3
WAV-1401-0800	1/4"	.265	1.125	.032	.170	3
WAV-1400-2600	1/4"	.267	.406	.014	.021	3
WAV-1400-2110	1/4"	.270	.335	.012	.070	3
WAV-1400-2901	1/4"	.270	.453	.005	.060	4
WAV-1400-2210	1/4"	.273	.331	.012	.070	3
WAV-1600-3100	16	.283	.484	.020	.090	3
WAV-1600-6000	16	.284	.934	.015	.098	4
WAV-1600-2910	16	.285	.448	.010	.050	3
WAV-1600-3110	16	.285	.492	.008	.062	3
WAV-1600-2400	16	.288	.370	.003	.020	3
WAV-1600-3400	16	.293	.531	.010	.075	3
WAV-1600-3410	16	.293	.537	.010	.075	3
WAV-1800-3230	5/16"	.315	.492	.008	.025	3
WAV-1800-2800	5/16"	.320	.437	.006	.030	3
WAV-1800-2840	5/16"	.320	.434	.015	.070	3
WAV-1800-3100	5/16"	.320	.481	.012	.065	4
WAV-1800-3310	5/16"	.320	.515	.008	.050	3
WAV-1800-3120	5/16"	.321	.487	.015	.052	3
WAV-1800-3200	5/16"	.321	.492	.007	.035	3
WAV-1800-2820	5/16"	.327	.437	.010	.055	3

Tolerances

Outside Diameter	±.010
Inside Diameter	Up to/including No. 10 : ±.005 Over No.10: ± .010
Thickness	Commercial
Overall Height	± .010 as stamped. Some distortion may occur in heat treatment.

Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-0100-1200	1	.076	.187	.005	.022	3
WAV-0200-1300	2	.093	.203	.004	.030	3
WAV-0300-1200	3	.095	.187	.005	.022	3
WAV-0300-1500	3	.106	.240	.006	.037	3
WAV-0400-1300	4	.120	.210	.005	.018	3
WAV-0500-1300	5	.125	.203	.004	.010	3
WAV-0500-1600	5	.125	.250	.005	.025	3
WAV-0500-1610	5	.125	.250	.003	.025	3
WAV-0500-2400	5	.127	.375	.005	.025	4
WAV-0500-1620	5	.130	.250	.003	.025	3
WAV-0600-2400	6	.159	.375	.012	.045	3
WAV-0800-3000	8	.166	.490	.016	.059	3
WAV-0800-2000	8	.168	.309	.011	.031	3
WAV-0800-2400	8	.169	.375	.016	.042	3
WAV-0800-3200	8	.171	.500	.016	.057	3
WAV-0800-2200	8	.178	.343	.010	.031	3
WAV-0800-1610	8	.180	.250	.016	.040	3
WAV-0800-1700	8	.180	.265	.020	.070	3
WAV-0800-2600	8	.180	.400	.010	.060	3
WAV-0800-4000	8	.182	.625	.006	.055	3
WAV-0800-1620	8	.185	.250	.008	.045	3
WAV-0800-1800	8	.187	.281	.006	.030	3
WAV-0800-1500	8	.191	.250	.008	.038	2
WAV-1000-1500	10	.194	.240	.004	.026	3
WAV-1000-1620	10	.194	.245	.002	.017	3
WAV-1000-2400	10	.202	.380	.006	.040	3
WAV-1000-2401	10	.202	.380	.020	.061	2
WAV-1000-1710	10	.205	.275	.010	.036	2
WAV-1000-2300	10	.205	.359	.004	.055	4
WAV-1000-2800	10	.206	.437	.015	.062	3
WAV-1000-1700	10	.209	.268	.006	.035	2
WAV-1000-2000	10	.210	.312	.010	.040	3
WAV-1000-2810	10	.210	.437	.015	.050	4

Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-1800-2411	5/16"	.327	.370	.004	.015	3
WAV-1800-2400	5/16"	.328	.372	.003	.018	3
WAV-1800-4100	5/16"	.328	.640	.014	.090	3
WAV-1800-4400	5/16"	.328	.673	.010	.062	3
WAV-1800-3300	5/16"	.331	.515	.004	.090	4
WAV-1800-3610	5/16"	.331	.559	.010	.062	3
WAV-1800-3600	5/16"	.333	.557	.015	.080	3
WAV-1800-2410	5/16"	.335	.370	.003	.015	3
WAV-1800-3602	5/16"	.340	.575	.032	.088	2
WAV-1800-5300	5/16"	.346	.828	.040	.115	2
WAV-1800-3000	5/16"	.347	.468	.005	.060	4
WAV-1800-2900	5/16"	.348	.454	.010	.035	3
WAV-1800-2810	5/16"	.348	.433	.006	.025	3
WAV-1800-3800	5/16"	.349	.588	.006	.034	3
WAV-1800-3010	5/16"	.352	.472	.005	.016	6
WAV-1800-2910	5/16"	.354	.450	.006	.065	3
WAV-1800-3020	5/16"	.357	.472	.005	.058	3
WAV-1800-2920	5/16"	.358	.465	.006	.070	3
WAV-1800-2921	5/16"	.358	.465	.007	.071	3
WAV-1800-3240	5/16"	.358	.500	.010	.055	3
WAV-1800-3250	5/16"	.360	.505	.015	.079	3
WAV-1800-3270	5/16"	.360	.497	.008	.055	3
WAV-1800-3400	5/16"	.360	.530	.012	.065	4
WAV-1800-3210	5/16"	.366	.492	.004	.014	3
WAV-1800-4500	5/16"	.370	.703	.040	.100	2
WAV-1800-3110	5/16"	.375	.491	.010	.079	6
WAV-1800-3220	5/16"	.375	.492	.005	.075	3
WAV-2000-6000	3/8"	.378	.934	.015	.067	3
WAV-2000-3520	3/8"	.380	.541	.007	.035	3
WAV-2000-3400	3/8"	.381	.531	.010	.035	3
WAV-2000-4010	3/8"	.384	.625	.007	.078	3
WAV-2000-4810	3/8"	.385	.750	.017	.093	3
WAV-2000-3210	3/8"	.386	.495	.005	.026	3
WAV-2000-4012	3/8"	.387	.630	.031	.099	2
WAV-2000-3900	3/8"	.389	.600	.010	.055	3
WAV-2000-4200	3/8"	.390	.656	.008	.080	3
WAV-2000-4400	3/8"	.390	.687	.006	.080	4
WAV-2000-4820	3/8"	.390	.750	.015	.080	3
WAV-2000-4000	3/8"	.392	.625	.015	.080	3
WAV-2000-3100	3/8"	.393	.497	.003	.050	3
WAV-2000-3200	3/8"	.393	.500	.007	.060	3
WAV-2000-3242	3/8"	.393	.500	.010	.060	3
WAV-2000-3700	3/8"	.393	.578	.006	.080	4
WAV-2000-4210	3/8"	.393	.653	.005	.099	3
WAV-2000-4310	3/8"	.397	.681	.005	.055	3
WAV-2000-3710	3/8"	.400	.570	.010	.050	3
WAV-2000-3500	3/8"	.402	.550	.006	.055	3
WAV-2000-3230	3/8"	.404	.495	.005	.020	3
WAV-2000-3241	3/8"	.404	.495	.007	.036	3
WAV-2000-3510	3/8"	.404	.544	.006	.061	4
WAV-2001-0000	3/8"	.405	1.000	.018	.125	4

Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-2000-3300	3/8"	.406	.520	.012	.045	4
WAV-2000-3410	3/8"	.406	.529	.010	.048	2
WAV-2000-3530	3/8"	.406	.550	.009	.080	2
WAV-2000-5100	3/8"	.406	.796	.015	.080	3
WAV-2000-4300	3/8"	.409	.671	.012	.062	3
WAV-2000-3220	3/8"	.410	.495	.005	.030	3
WAV-2000-3910	3/8"	.413	.600	.010	.055	3
WAV-2000-4011	3/8"	.415	.625	.008	.185	2
WAV-2000-3920	3/8"	.430	.610	.009	.085	2
WAV-2000-3240	3/8"	.431	.502	.007	.046	3
WAV-2000-4100	3/8"	.437	.640	.005	.040	3
WAV-2200-3200	7/16"	.443	.495	.009	.046	3
WAV-2200-3210	7/16"	.445	.495	.005	.023	3
WAV-2200-3700	7/16"	.450	.578	.015	.047	3
WAV-2200-4800	7/16"	.453	.750	.015	.080	3
WAV-2200-4020	7/16"	.457	.622	.010	.082	3
WAV-2200-3710	7/16"	.460	.570	.010	.050	3
WAV-2200-4400	7/16"	.463	.680	.013	.075	4
WAV-2200-5400	7/16"	.468	.875	.005	.125	3
WAV-2200-3500	7/16"	.470	.543	.008	.062	3
WAV-2200-4000	7/16"	.486	.618	.012	.040	3
WAV-2200-4810	7/16"	.487	.750	.007	.068	3
WAV-2400-4010	1/2"	.500	.625	.008	.040	3
WAV-2400-4000	1/2"	.505	.621	.004	.020	4
WAV-2400-4020	1/2"	.505	.621	.004	.050	3
WAV-2400-4030	1/2"	.506	.616	.007	.030	3
WAV-2401-0100	1/2"	.506	1.015	.010	.125	3
WAV-2400-4820	1/2"	.508	.750	.010	.062	4
WAV-2400-4200	1/2"	.510	.656	.020	.078	4
WAV-2400-4210	1/2"	.510	.656	.006	.070	4
WAV-2401-0010	1/2"	.510	1.000	.006	.080	3
WAV-2400-4810	1/2"	.511	.750	.017	.090	3
WAV-2400-5200	1/2"	.513	.812	.015	.080	3
WAV-2400-4040	1/2"	.514	.621	.005	.021	4
WAV-2400-4220	1/2"	.514	.655	.020	.073	4
WAV-2400-4400	1/2"	.515	.680	.016	.045	3
WAV-2400-5600	1/2"	.515	.862	.010	.070	3
WAV-2400-5610	1/2"	.515	.862	.010	.092	3
WAV-2400-5620	1/2"	.515	.859	.010	.093	3
WAV-2400-4700	1/2"	.516	.734	.006	.080	4
WAV-2400-4830	1/2"	.518	.748	.010	.062	3
WAV-2400-4800	1/2"	.519	.750	.015	.080	3
WAV-2400-3900	1/2"	.528	.616	.007	.030	3
WAV-2400-5100	1/2"	.530	.796	.015	.080	3
WAV-2400-4710	1/2"	.531	.734	.009	.050	3
WAV-2400-4840	1/2"	.531	.745	.010	.122	3
WAV-2400-4720	1/2"	.531	.734	.009	.080	3
WAV-2400-6000	1/2"	.532	.937	.015	.062	3
WAV-2400-5000	1/2"	.535	.778	.008	.132	3
WAV-2401-0000	1/2"	.535	1.000	.006	.110	3
WAV-2401-0020	1/2"	.537	1.000	.010	.110	3

Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-2400-5621	1/2"	.562	.872	.017	.077	3
WAV-2600-5600	9/16"	.568	.875	.015	.080	3
WAV-2600-4830	9/16"	.570	.750	.010	.100	3
WAV-2600-4810	9/16"	.578	.745	.008	.028	3
WAV-2600-5110	9/16"	.578	.796	.006	.090	3
WAV-2600-3900	9/16"	.583	.617	.007	.025	3
WAV-2600-5100	9/16"	.583	.802	.008	.070	3
WAV-2600-5900	9/16"	.597	.921	.010	.062	4
WAV-2600-4831	9/16"	.600	.745	.010	.125	3
WAV-2600-4800	9/16"	.600	.745	.013	.120	3
WAV-2600-4820	9/16"	.606	.745	.008	.028	3
WAV-2600-5300	9/16"	.622	.828	.008	.043	3
WAV-2801-0300	5/8"	.625	1.054	.008	.206	3
WAV-2800-5000	5/8"	.627	.781	.020	.080	3
WAV-2800-5310	5/8"	.628	.826	.010	.109	3
WAV-2800-5320	5/8"	.631	.828	.015	.077	4
WAV-2800-5321	5/8"	.634	.828	.008	.090	3
WAV-2800-5300	5/8"	.634	.828	.007	.090	3
WAV-2800-5200	5/8"	.635	.816	.008	.145	2
WAV-2800-6300	5/8"	.637	.984	.008	.066	3
WAV-2800-5510	5/8"	.642	.859	.008	.080	4
WAV-2801-0000	5/8"	.642	1.000	.015	.110	3
WAV-2800-4700	5/8"	.646	.734	.008	.079	3
WAV-2800-5500	5/8"	.652	.859	.010	.060	3
WAV-2800-5530	5/8"	.652	.860	.010	.065	3
WAV-2800-4811	5/8"	.655	.745	.020	.070	3
WAV-2800-4800	5/8"	.656	.750	.013	.062	4
WAV-2800-5610	5/8"	.656	.875	.010	.064	3
WAV-2800-4810	5/8"	.659	.746	.008	.024	3
WAV-2800-5400	5/8"	.664	.844	.010	.076	3
WAV-2800-4600	5/8"	.667	.718	.012	.063	4
WAV-2800-5600	5/8"	.670	.875	.018	.075	3
WAV-2801-0800	5/8"	.670	1.120	.010	.105	3
WAV-2800-5700	5/8"	.685	.890	.018	.075	3
WAV-2801-0010	5/8"	.687	1.000	.007	.090	3
WAV-3001-0000	11/16"	.688	1.000	.010	.066	3
WAV-3001-0100	11/16"	.689	1.013	.080	.147	3
WAV-3001-1600	11/16"	.693	1.224	.013	.136	3
WAV-3000-6100	11/16"	.694	.953	.015	.103	3
WAV-3001-1400	11/16"	.695	1.218	.013	.130	3
WAV-3000-5200	11/16"	.700	.809	.012	.135	3
WAV-3000-5000	11/16"	.702	.787	.008	.062	6
WAV-3000-5001	11/16"	.702	.787	.010	.064	6
WAV-3001-0700	11/16"	.703	1.115	.015	.125	3
WAV-3001-0010	11/16"	.723	1.003	.009	.120	3
WAV-3000-6200	11/16"	.723	.965	.015	.128	3
WAV-3001-0800	11/16"	.725	1.120	.010	.081	3
WAV-3200-5200	3/4"	.750	.812	.005	.059	3
WAV-3200-6211	3/4"	.750	.981	.034	.070	3
WAV-3201-0000	3/4"	.752	1.000	.016	.200	3
WAV-3201-0400	3/4"	.752	1.062	.015	.105	3

Wave Spring Washers

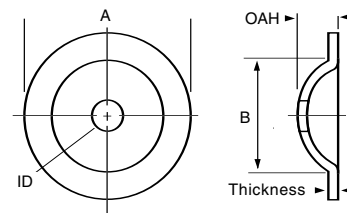
Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-3200-6210	3/4"	.755	.975	.012	.125	3
WAV-3200-6200	3/4"	.765	.966	.017	.075	3
WAV-3201-1201	3/4"	.765	1.191	.032	.086	3
WAV-3200-6300	3/4"	.766	.998	.022	.072	3
WAV-3200-5800	3/4"	.768	.910	.016	.062	3
WAV-3200-5810	3/4"	.768	.910	.016	.082	3
WAV-3201-0300	3/4"	.768	1.046	.008	.115	6
WAV-3201-0100	3/4"	.772	1.013	.013	.140	3
WAV-3201-1000	3/4"	.784	1.156	.022	.050	3
WAV-3201-0010	3/4"	.785	1.000	.016	.109	3
WAV-3201-0011	3/4"	.810	1.000	.010	.160	3
WAV-3301-0400	13/16"	.817	1.062	.012	.078	6
WAV-3301-0811	13/16"	.822	1.125	.010	.093	3
WAV-3300-5700	13/16"	.823	.884	.012	.063	4
WAV-3300-5710	13/16"	.823	.884	.012	.065	8
WAV-3300-6100	13/16"	.828	.953	.010	.097	3
WAV-3301-0610	13/16"	.828	1.098	.010	.060	3
WAV-3301-0110	13/16"	.830	1.093	.010	.062	3
WAV-3301-2010	13/16"	.839	1.321	.012	.073	3
WAV-3300-6300	13/16"	.843	.990	.012	.033	3
WAV-3300-6310	13/16"	.843	.990	.012	.041	3
WAV-3301-0631	13/16"	.843	1.093	.005	.128	3
WAV-3301-0600	13/16"	.843	1.093	.006	.110	3
WAV-3301-2000	13/16"	.843	1.312	.006	.150	4
WAV-3301-0620	13/16"	.844	1.094	.010	.154	3
WAV-3301-0630	13/16"	.844	1.094	.006	.154	3
WAV-3301-0810	13/16"	.846	1.125	.030	.125	3
WAV-3401-1100	7/8"	.893	1.171	.008	.110	6
WAV-3401-1300	7/8"	.894	1.203	.012	.156	3
WAV-3401-1000	7/8"	.901	1.159	.015	.060	3
WAV-3401-0800	7/8"	.909	1.125	.010	.093	4
WAV-3401-0810	7/8"	.923	1.125	.008	.140	3
WAV-3501-1200	15/16"	.940	1.180	.009	.072	3
WAV-3501-1510	15/16"	.964	1.231	.015	.068	3
WAV-3501-1600	15/16"	.964	1.260	.016	.145	3
WAV-3501-1500	15/16"	.966	1.240	.014	.093	3
WAV-3501-2300	15/16"	.970	1.367	.009	.110	3
WAV-3501-1100	15/16"	.971	1.169	.020	.099	3
WAV-3501-0500	15/16"	.984	1.082	.005	.125	3
WAV-3501-1100	15/16"	1.000	1.171	.015	.078	4
WAV-3601-1000	1"	1.003	1.156	.024	.125	3
WAV-3601-1900	1"	1.015	1.296	.010	.110	6
WAV-3601-2101	1"	1.015	1.328	.012	.093	3
WAV-3601-3210	1"	1.015	1.500	.008	.045	3
WAV-3601-3220	1"	1.015	1.500	.010	.184	3
WAV-3601-3230	1"	1.015	1.497	.021	.100	3
WAV-3601-3240	1"	1.015	1.500	.015	.184	3
WAV-3601-1700	1"	1.020	1.280	.007	.120	3
WAV-3601-3200	1"	1.032	1.500	.012	.078	3
WAV-3601-1801	1"	1.034	1.263	.006	.120	3
WAV-3601-1800	1"	1.034	1.263	.007	.120	3

Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-3601-3700	1"	1.034	1.562	.022	.115	3
WAV-3601-2300	1"	1.049	1.356	.015	.099	3
WAV-3601-2100	1"	1.058	1.328	.020	.187	3
WAV-3601-3100	1"	1.062	1.477	.010	.125	3
WAV-3701-1600	1-1/16"	1.090	1.250	.030	.160	3
WAV-3701-1800	1-1/16"	1.093	1.281	.020	.082	3
WAV-3701-2820	1-1/16"	1.100	1.450	.010	.156	3
WAV-3701-2810	1-1/16"	1.105	1.451	.010	.104	3
WAV-3701-2800	1-1/16"	1.112	1.437	.018	.125	3
WAV-3801-3500	1-1/8"	1.138	1.546	.013	.102	3
WAV-3801-2800	1-1/16"	1.149	1.437	.030	.102	3
WAV-3801-5900	1-1/8"	1.150	1.925	.010	.112	3
WAV-3801-2300	1-1/8"	1.175	1.357	.015	.100	3
WAV-3801-2400	1-1/8"	1.180	1.372	.013	.195	3
WAV-3901-3100	1-3/16"	1.191	1.491	.033	.125	3
WAV-3901-3500	1-3/16"	1.203	1.546	.017	.105	3
WAV-3901-1900	1-3/16"	1.220	1.300	.025	.061	3
WAV-3901-2900	1-3/16"	1.250	1.453	.015	.090	4
WAV-4001-6200	1-1/4"	1.261	1.621	.024	.142	3
WAV-4001-2500	1-1/4"	1.273	1.395	.022	.058	4
WAV-4001-3230	1-1/4"	1.273	1.498	.022	.058	3
WAV-4001-3210	1-1/4"	1.297	1.495	.003	.095	4
WAV-4001-3220	1-1/4"	1.297	1.495	.008	.105	4
WAV-4101-3600	1-5/16"	1.320	1.562	.008	.093	6
WAV-4101-3200	1-5/16"	1.331	1.500	.007	.085	6
WAV-4201-4400	1-3/8"	1.375	1.656	.010	.029	6
WAV-4201-3400	1-3/8"	1.378	1.531	.025	.187	3
WAV-4201-3801	1-3/8"	1.391	1.593	.015	.156	3
WAV-4201-3800	1-3/8"	1.391	1.593	.030	.156	3
WAV-4201-4000	1-3/8"	1.398	1.622	.016	.242	3
WAV-4201-3500	1-3/8"	1.412	1.515	.020	.225	3
WAV-4201-3700	1-3/8"	1.430	1.577	.015	.195	3
WAV-4201-4100	1-3/8"	1.430	1.635	.015	.195	3
WAV-4201-5200	1-3/8"	1.440	1.800	.010	.250	3
WAV-4202-0800	1-3/8"	1.456	2.125	.018	.155	4
WAV-4401-4820	1-1/2"	1.510	1.747	.023	.125	3
WAV-4401-4600	1-1/2"	1.518	1.722	.020	.090	4
WAV-4401-5600	1-1/2"	1.520	1.875	.016	.080	4
WAV-4401-4810	1-1/2"	1.527	1.750	.018	.080	4
WAV-4402-0000	1-1/2"	1.534	2.000	.020	.125	3
WAV-4402-2400	1-1/2"	1.538	2.360	.015	.137	3
WAV-4402-2401	1-1/2"	1.545	2.360	.015	.156	3
WAV-4401-6100	1-1/2"	1.550	1.950	.020	.138	3
WAV-4401-4800	1-1/2"	1.597	1.747	.018	.187	3
WAV-4401-4821	1-1/2"	1.597	1.747	.025	.187	3
WAV-4601-5010	1-5/8"	1.625	1.779	.018	.187	3
WAV-4601-6300	1-5/8"	1.643	2.000	.020	.120	3
WAV-4601-5000	1-5/8"	1.675	1.779	.020	.060	8
WAV-4701-5300	1-11/16"	1.706	1.825	.050	.156	3
WAV-4702-0600	1-11/16"	1.750	2.100	.015	.266	3
WAV-4702-1000	1-11/16"	1.750	2.160	.014	.266	3

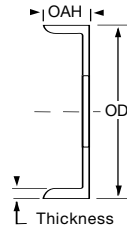
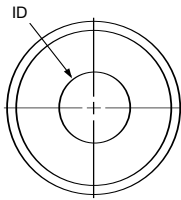
Wave Spring Washers

Part No.	Hole Size	ID	OD	Thickness	Overall Height	No. of Waves
WAV-4802-0000	1-3/4"	1.850	1.997	.018	.270	3
WAV-5202-2400	2"	2.018	2.375	.015	.078	4
WAV-5202-5600	2"	2.062	2.875	.015	.187	3
WAV-5202-5610	2"	2.062	2.875	.020	.192	3
WAV-5402-2800	2-1/8"	2.128	2.437	.036	.337	3
WAV-5402-2810	2-1/8"	2.128	2.437	.025	.156	3
WAV-5602-3100	2-1/4"	2.265	2.485	.018	.080	3
WAV-6003-1300	2-1/2"	2.522	3.208	.023	.245	3
WAV-6102-5100	2-9/16"	2.593	2.800	.010	.125	3
WAV-6302-4000	2-5/8"	2.640	3.125	.010	.250	3
WAV-6402-6300	2-3/4"	2.750	2.984	.025	.236	3
WAV-6403-0100	2-3/4"	2.780	3.020	.125	.166	3
WAV-6403-0900	2-3/4"	2.800	3.150	.109	.158	3
WAV-6803-0800	3"	3.000	3.130	.047	.178	3
WAV-6803-1300	3"	3.005	3.203	.031	.237	3



Spring Retainers

Part No.	ID	A Diameter Reference	B Diameter Reference	Thickness	Overall Height Reference
SPR-0000-5400	.00	.843	.531	.062	.203
SPR-0000-5401	.00	.843	.531	.062	.290
SPR-0000-5900	.00	.937	.593	.059	.250
SPR-0001-0700	.00	1.109	.531	.093	.265
SPR-0001-0701	.00	1.110	.562	.093	.231
SPR-0001-1200	.00	1.187	.625	.075	.312
SPR-0400-5900	.125	.940	.600	.060	.250
SPR-0500-4600	.135	.720	.609	.020	.080
SPR-0500-5200	.137	.820	.575	.015	.098



Cup Washers

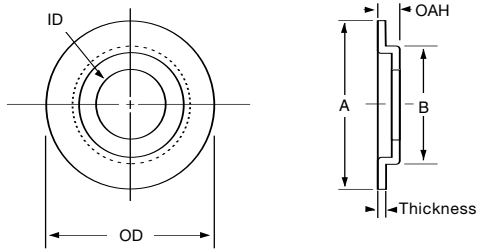
Part No.	ID	OD	Thickness	Overall Height
CUP-1400-4100	.257	.639	.030	.130
CUP-1401-3000	.259	1.468	.0625	.125
CUP-1400-5000	.259	.779	.032	.192
CUP-1400-5220	.259	.812	.038	.062
CUP-1401-1700	.263	1.190	.062	.093
CUP-1400-4400	.265	.687	.031	.125
CUP-1400-4200	.268	.653	.040	.077
CUP-1600-5600	.281	.875	.046	.062
CUP-1600-5900	.282	.918	.0478	.171
CUP-1600-3601	.283	.559	.028	.075
CUP-1600-3600	.283	.559	.028	.090
CUP-1600-2910	.312	.454	.012	.062
CUP-1600-2900	.312	.454	.012	.016
CUP-1600-4800	.312	.748	.031	.200
CUP-1800-5500	.325	.871	.093	.238
CUP-1800-4800	.328	.750	.031	.104
CUP-1800-6201	.328	.968	.032	.127
CUP-1800-6200	.328	.968	.040	.135
CUP-1800-0200	.330	1.029	.032	.125
CUP-1801-3200	.335	1.498	.064	.187
CUP-2001-0400	.375	1.059	.025	.154
CUP-2001-0420	.375	1.062	.032	.089
CUP-2001-0410	.375	1.062	.035	.155
CUP-2001-3000	.376	1.468	.0625	.125
CUP-2000-6400	.378	.998	.010	.135
CUP-2001-0000	.390	1.000	.031	.187
CUP-2000-5700	.393	.887	.027	.116
CUP-2000-4000	.400	.630	.008	.137
CUP-2001-1600	.406	1.247	.0478	.250
CUP-2001-1200	.409	1.185	.032	.094
CUP-2000-4800	.437	.750	.032	.130
CUP-2200-5800	.450	.910	.031	.118
CUP-2400-4000	.500	.630	.008	.137
CUP-2400-5400	.505	.849	.020	.145
CUP-2400-4500	.506	.700	.016	.047
CUP-2401-0100	.509	1.003	.040	.170
CUP-2402-4200	.513	2.658	.050	.171
CUP-2401-0500	.518	1.078	.025	.117
CUP-2400-6000	.518	.938	.030	.125
CUP-2401-2400	.520	1.382	.060	.150
CUP-2400-6400	.557	.9975	.062	.234
CUP-2400-5600	.562	.875	.031	.218
CUP-2400-6200	.562	.962	.028	.116
CUP-2801-0400	.640	1.062	.035	.155
CUP-2800-5800	.641	.910	.030	.070
CUP-2800-6400	.670	.997	.028	.140
CUP-2800-5400	.686	.842	.035	.095

Cup Washers

Part No.	ID	OD	Thickness	Overall Height
CUP-0000-3000	1	.462	.036	.100
CUP-0000-6100	1	.950	.032	.175
CUP-0001-0400	1	1.059	.035	.172
CUP-0001-3800	1	1.592	.029	.091
CUP-0200-1600	.0965	.247	.010	.046
CUP-0400-1500	.118	.468	.037	.055
CUP-0400-2500	.125	.391	.016	.109
CUP-0500-1300	.133	.809	.032	.094
CUP-0500-4100	.133	.636	.032	.125
CUP-0500-1900	.136	.297	.016	.062
CUP-0600-5400	.145	.840	.038	.125
CUP-0600-2800	.149	.445	.032	.125
CUP-0600-2700	.150	.420	.020	.090
CUP-0600-4600	.160	.715	.040	.100
CUP-0800-3300	.170	.515	.029	.078
CUP-0800-1800	.187	.287	.015	.040
CUP-0800-2500	.187	.390	.020	.068
CUP-0800-3310	.189	.515	.012	.140
CUP-1000-4800	.190	.748	.012	.170
CUP-1000-2300	.194	.358	.013	.093
CUP-1001-1200	.195	1.187	.062	.093
CUP-1001-1201	.200	1.187	.062	.125
CUP-1000-3200	.203	.500	.062	.125
CUP-1001-2200	.207	1.340	.024	.225
CUP-1000-3700	.212	.581	.042	.167
CUP-1200-2100	.221	.323	.015	.040
CUP-1201-2100	.239	1.326	.036	.375
CUP-1201-0400	.250	1.060	.040	.080
CUP-1201-0600	.250	1.100	.062	.156
CUP-1200-6400	.251	.997	.040	.080
CUP-1201-0410	.251	1.063	.040	.065
CUP-1201-0420	.251	1.063	.040	.080
CUP-1400-5210	.250	.812	.031	.093
CUP-1400-4700	.253	.734	.010	.040
CUP-1400-5200	.253	.812	.093	.155
CUP-1400-4000	.254	.631	.031	.125

Cup Washers

Part No.	ID	OD	Thickness	Overall Height
CUP-3000-6000	.710	.932	.018	.085
CUP-3001-0200	.732	1.025	.042	.290
CUP-3000-5900	.748	.918	.035	.095
CUP-3401-2100	.880/.885	1.318/1.324	.030	.125
CUP-3401-0700	.887	1.112	.015	.093
CUP-3601-3200	1.062	1.500	.025	.218
CUP-4001-4400	1.266	1.690	.032	.242
CUP-4101-4000	1.328	1.622	.042	.218
CUP-4701-5800	1.749	1.913	.030	.082



Back Up Washers

Part No.	ID	A Diameter Reference	B Diameter Reference	Thickness	Overall Height
BUF-0000-5500	1	.867	.590	.045	.078
BUF-0000-5600	1	.878	.590	.045	.093
BUF-0001-2500	1	1.390	.656	.044	.132
BUF-0001-3200	1	1.505	.656	.044	.132
BUF-0801-2000	.187	1.312	.781	.062	.115
BUF-1001-2000	.190	1.310	.700	.062	.115
BUF-1400-4800	.253	.750	.420	.050	.060
BUF-1400-4600	.254	.724	.550	.017	.090
BUF-1400-4601	.256	.718	.605	.015	.090
BUF-1401-2400	.256	1.372	.748	.093	.125
BUF-1401-3600	.257	1.560	1.070	.062	.093
BUF-1401-4400	.257	1.687	.816	.093	.162
BUF-1401-5600	.257	1.872	1.412	.062	.093
BUF-1402-2400	.257	2.373	1.812	.062	.093
BUF-1601-3600	.312	1.562	1.125	.062	.093
BUF-1801-3600	.323	1.562	1.125	.062	.093
BUF-1800-5500	.335	.864	.505	.020	.078
BUF-2000-4600	.373	.725	.612	.017	.090
BUF-2001-3600	.381	1.562	1.125	.062	.093
BUF-2001-5600	.381	1.875	1.437	.062	.093
BUF-2002-2400	.381	2.375	1.937	.062	.093
BUF-2002-3600	.382	2.559	1.932	.062	.093
BUF-2002-0400	.382	2.059	1.312	.062	.093
BUF-2002-3200	.390	3.497	2.250	.062	.108
BUF-2000-6400	.392	.997	.689	.025	.087
BUF-2000-4300	.426	.669	.560	.032	.062
BUF-2001-6200	.433	1.968	.787	.125	.302
BUF-2402-2400	.510	2.375	1.937	.062	.093
BUF-2401-5600	.511	1.872	1.437	.062	.093
BUF-2600-5200	.625	.805	.735	.016	.048
BUF-3702-0000	1.125	2.656	2.000	.083	.094
BUF-3902-0600	1.225	2.093	1.625	.048	.108

Flange Cup Washers

Part No.	ID	A Diameter Reference	B Diameter Reference	Thickness	Overall Height
CUF-0800-4100	.170	.640	.384	.020	.176
CUF-1001-0400	.201	1.059	.766	.062	.188
CUF-1401-0800	.260	1.125	.750	.030	.375
CUF-1600-4900	.296	.763	.479	.021	.141
CUF-1600-4800	.296	.750	.479	.021	.141
CUF-2001-0400	.389	1.062	.830	.047	.188
CUF-2201-3200	.436	1.505	1.353	.062	.282
CUF-2401-3200	.534	1.498	1.000	.031	.155
CUF-2601-0400	.571	1.059	.830	.047	.188
CUF-2600-6300	.610	.984	.816	.025	.188

Metric and Standard Finishing Washers

HK Metalcraft finishing washers for over-the-thread applications are available from stock in stainless steel. However, the sizes listed below can be produced in low carbon steel, high carbon steel and brass. HK also maintains dies for a great number of other finishing washers. Therefore, you will probably find that your special finishing washer is an HK standard.

Metric Pre-Assemblies

Part No.	ID	OD	Thickness	Overall Height	Shape
FWS-1215-CM	.143-.146	.290-.300	.015	.105-.125	
	3.63-3.71	7.37-7.62	.038	2.67-3.18	
FWS-1215-DM	.138-.141	.290-.300	.015	.105-.125	
	3.51-3.58	7.37-7.62	.038	2.67-3.18	
FWS-1115-EM	.137-.140	.352-.372	.015	.105-.125	
	3.48-3.56	8.94-9.45	.038	2.67-3.18	

Material: 1010, 1050 steel, 410 stainless steel. Countersink: 90/92 degrees. Note: Other metric washers available.

Pre-Assemblies

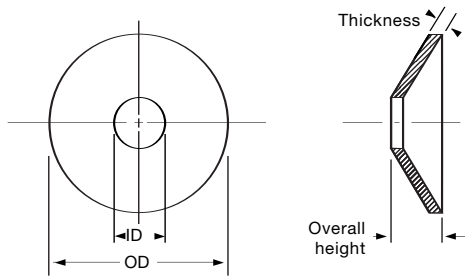
Part No.	ID	OD	Thickness	Overall Height	Shape
FWS-1215-b	.136-.139	.280-.290	.015	.105-.125	
FWS-1215-a	.142-.145	.280-.290	.015	.105-.125	
FWS-1117	.137-.140	.320-.330	.015	.105-.125	
FWS-998-b	.143-.146	.320-.330	.015	.105-.125	
FWS-998-a	.146-.149	.320-.330	.015	.095-.115	
FWS-1115-b	.135-.138	.348-.358	.015	.105-.125	
FWS-1115-c	.137-.140	.348-.358	.015	.105-.125	
FWS-1115-d	.143-.146	.343-.363	.015	.105-.125	
FWS-1115-a	.146-.149	.348-.358	.015	.105-.125	
FWS-1193	.120-.123	.490-.510	.014	.099-.130	
FWS-1000-d	.135-.138	.490-.510	.014	.099-.130	
FWS-1000	.138-.141	.490-.510	.014	.099-.130	
FWS-1012	.143-.146	.490-.510	.014	.099-.130	
FWS-993	.146-.149	.490-.510	.014	.099-.130	
FWS-1000-c	.151-.153	.490-.510	.014	.099-.130	
FWS-1000-e	.152-.156	.490-.510	.014	.099-.130	
FWS-1127	.159-.162	.490-.510	.014	.099-.130	
FWS-1000-b	.166-.169	.490-.510	.017	.110-.140	
FWS-1094-a	.153-.156	.650-.670	.015	.130-.160	
FWS-1094-d	.165-.169	.650-.670	.015	.130-.160	
FWS-1094-b	.170-.172	.650-.670	.015	.130-.160	
FWS-1094-c	.178-.180	.650-.670	.015	.130-.160	

Material: 1010 and 1050 steel. Countersink: 80/82 degrees.

Free Applications

Part No.	Screw Size	(A)	(B)	(C)	(D)	(E)	(F)	Shape
FWF-0800	8	.352	.531	.102	1/64	.028	.014	
FWF-1000	10	.425	.593	.112	1/64	.036	.018	

Dimensions listed are nominal. Countersink: 80/82 degree.



Electrical Buss Bar Belleville Washers

Part No.	ID	OD	Thickness	Overall Height
BEL-1401-0800	.265	1.125	.064	.140
BEL-2200-4800	.453	.750	.030	.060
BEL-2401-0010	.508	1.000	.036	.067
BEL-2401-1600	.515	1.250	.060	.096
BEL-2401-0810	.532	1.125	.125	.139
BEL-2401-1610	.532	1.250	.125	.143
BEL-2401-1620	.532	1.250	.093	.113
BEL-2401-2410	.532	1.375	.125	.156
BEL-2601-1600	.562	1.250	.062	.125
BEL-3601-4000	1.015	1.625	.062	.125
BEL-4502-0600	1.584	2.100	.035	.090

These parts are, or can be, made available in: 410 stainless steel, heat treated to spring temper; 17-7 ph stainless steel, heat treated to spring temper; A.I.S.A. 6150 chromium vanadium steel, heat treated to spring temper; high carbon steel, heat treated to spring temper. All of the above parts can be supplied with cadmium plate and dichromate.

Stock Dies, Materials and Finishes

Stock Dies

Standard tools on hand for over 60,000 sizes of washers in the following sizes:

Inside Diameters		Outside Diameters	
Up to 2"	every 1/64"	Up to 2"	every 1/64"
and in screw sizes No.2 thru 14		Over 2" to 4"	every 1/16"
Over 2" to 4"	every 1/16"	Over 4" to 6"	every 1/8"
Over 4" to 6"	every 1/8"	Over 6" to 8"	every 1/4"
Over 6" to 8"	every 1/4"		

Tolerances on Special Washers

Inside Diameters			Outside Diameters	
Up to 1"	—	+ .003 - .000	Up to 1"	+ .000 - .003
Over 1" to 2"	—	+ .005 - .000	Over 1" to 2"	+ .000 - .005
Over 2" to 3"	—	+ .008 - .000	Over 2" to 3"	+ .000 - .008
Over 3"	—	+ 1/64" - 1/64"	Over 3"	+ 1/64" - 1/64"

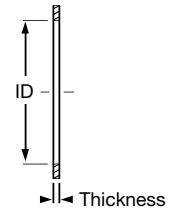
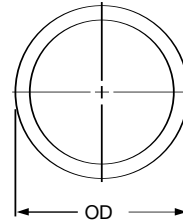
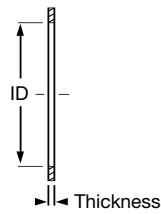
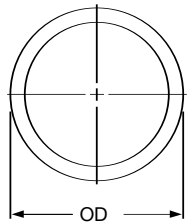
Materials

HK Metalcraft washers are available in the following materials:

Aluminum	High Carbon Steel	Phosphor Bronze
Brass	Inconel	Silicon Bronze
Bronze	Monel	Stainless Steel
Chrome Steel	Nickel	Steel
Copper	Nylon	Tin

Finishes

HK Metalcraft washers are available with all commercial finishes, where appropriate, for the above materials.



Flat Steel Gaskets

Part No.	ID	OD	Thickness
GSF-0800-1400	.175	.225	.020
	4.45	5.72	0.51
GSF-1000-1500	.193	.245	.020
	4.90	6.22	0.51
GSF-1200-0190	.230	.290	.020
	5.84	7.37	0.51
GSF-1400-0210	.260	.325	.020
	6.61	8.26	0.51
GSF-1600-0230	.285	.365	.020
	7.24	9.27	0.51
GSF-1600-0231	.285	.365	.030
	7.24	9.27	0.76
GSF-1600-0040	.290	.353	.020
	7.37	8.97	0.51
GSF-1800-0290	.320	.459	.020
	8.13	11.66	0.51
GSF-1800-0310	.341	.490	.020
	8.66	12.45	0.51
GSF-2000-0290	.378	.459	.020
	9.60	11.66	0.51
GSF-2000-0310	.385	.490	.020
	9.78	12.45	0.51
GSF-2200-0400	.450	.616	.020
	11.43	15.65	0.51
GSF-2400-0440	.510	.684	.020
	12.95	17.37	0.51
GSF-2400-4000	.511	.619	.031
	12.97	15.72	0.79
GSF-2400-4001	.551	.693	.031
	13.99	17.59	0.79
GSF-2400-0410	.551	.644	.031
	13.99	16.35	0.79
GSF-2400-4400	.560	.684	.031
	14.22	17.37	0.79
GSF-2600-4400	.582	.687	.020
	14.78	17.45	0.51
GSF-2600-4401	.584	.690	.020
	14.83	17.53	0.51
GSF-2800-4800	.640	.760	.020
	16.26	19.30	0.51

Flat Copper Gaskets

Part No.	ID	OD	Thickness
GCF-1400-2400	.255	.375	.031
	6.47	9.52	0.79
GCF-1800-4200	.323	.669	.025
	8.20	16.99	.635
GCF-1800-4800	.340	.750	.045
	8.64	19.05	1.140
GCF-2000-3200	.372	.495	.031
	9.45	12.57	.787
GCF-2000-3800	.384	.600	.050
	9.75	15.24	1.270
GCF-2000-4300	.384	.675	.125
	9.78	17.14	3.180
GCF-2000-2900	.385	.460	.020
	9.78	11.68	.508
GCF-2000-3600	.394	.562	.045
	10.00	14.27	1.14
GCF-2000-5200	.396	.811	.025
	10.06	20.60	.635
GCF-2000-3500	.405	.541	.031
	10.29	13.74	.787
GCF-2000-4000	.406	.625	.043
	10.31	15.87	1.09
GCF-2000-5210	.406	.812	.062
	10.31	20.62	1.570
GCF-2000-3510	.422	.541	.031
	10.72	13.74	.787
GCF-2000-3700	.422	.574	.043
	10.72	14.58	1.09
GCF-2201-1600	.436	1.250	.091
	11.07	31.75	2.310
GCF-2200-3600	.437	.559	.040
	11.10	14.20	1.020
GCF-2200-3700	.437	.574	.031
	11.10	14.58	.787
GCF-2200-3701	.437	.574	.043
	11.10	14.58	1.090
GCF-2200-3702	.437	.574	.050
	11.09	14.57	1.27
GCF-2200-5700	.437	.895	.025
	11.10	22.73	.635

Note: Metric measurements appear in bold.

HK Metalcraft Manufacturing Corporation, 35 Industrial Road, P.O. Box 775, Lodi, New Jersey 07644, Telephone: (973) 471-7770 FAX: (973) 471-9666

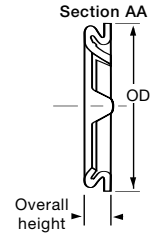
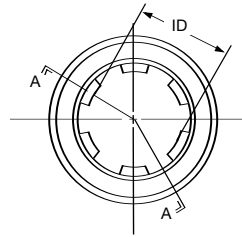
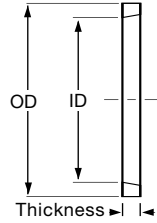
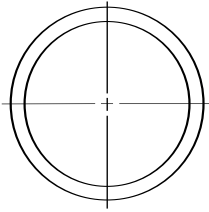
Flat Copper Gaskets

Part No.	ID	OD	Thickness
GCF-2200-4300	.445	.675	.036
	11.30	17.15	.914
GCF-2200-3500	.460	.547	.031
	11.68	13.89	.787
GCF-2201-0000	.480	1.005	.064
	12.19	25.53	1.625
GCF-2200-3601	.486	.562	.031
	12.34	14.27	.787
GCF-2400-4000	.503	.622	.062
	12.78	15.80	1.570
GCF-2401-1600	.505	1.250	.091
	12.83	31.75	2.310
GCF-2401-5200	.505	1.815	.125
	12.83	46.10	3.180
GCF-2402-1600	.505	2.250	.125
	12.83	57.15	3.180
GCF-2400-5600	.506	.875	.065
	12.85	22.22	1.650
GCF-2401-1610	.506	1.250	.065
	12.85	31.75	1.650
GCF-2400-4300	.515	.675	.031
	13.08	17.15	.787
GCF-2400-3800	.518	.590	.032
	13.16	14.98	.813
GCF-2401-0400	.531	1.062	.093
	13.49	26.97	2.360
GCF-2400-4600	.552	.715	.057
	14.02	18.16	1.450
GCF-2400-5200	.560	.812	.0620
	14.22	20.62	1.570
GCF-2400-4610	.562	.715	.031
	14.27	18.16	.787
GCF-2400-4800	.563	.750	.135
	14.30	19.05	3.430
GCF-2600-4400	.584	.685	.062
	14.83	17.40	1.570

Flat Copper Gaskets

Part No.	ID	OD	Thickness
GCF-3000-5501	.703	.859	.081
	17.86	21.82	2.06
GCF-3000-5100	.705	.801	.020
	17.91	20.35	.508
GCF-3000-6000	.710	.930	.031
	18.03	23.61	0.79
GCF-3000-6001	.710	.930	.040
	18.03	23.62	1.02
GCF-3000-6200	.718	.968	.0808
	18.24	24.59	2.050
GCF-3000-5600	.725	.875	.057
	18.41	22.21	1.45
GCF-3000-5500	.750	.867	.031
	19.05	22.02	0.79
GCF-3201-0400	.765	1.062	.045
	19.43	26.97	1.140
GCF-3201-0000	.792	1.000	.045
	20.12	25.4	1.14
GCF-3200-6000	.798	.930	.020
	20.27	23.62	.508
GCF-3200-6010	.798	.930	.031
	20.27	23.62	.787
GCF-3301-0200	.820	1.030	.032
	20.83	26.16	.810
GCF-3300-6300	.821	.990	.031
	20.85	25.15	.787
GCF-3401-0801	.900	1.125	.048
	22.85	28.56	1.22
GCF-4602-0400	1.645	2.055	.062
	41.78	52.20	1.570

Note: Metric measurements appear in bold.



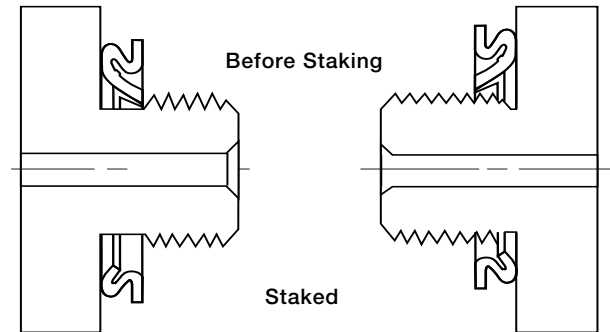
Rounded Copper Gaskets

Part No.	ID	OD	Thickness
GCR-1400-2300	.253	.367	.055/050
	6.43	9.32	1.400
GCR-2000-3200	.378	.495	.062
	9.60	12.57	1.57
GCR-2200-3700	.485	.579	.062
	12.32	14.71	1.570
GCR-2400-4400	.557	.684	.062
	14.15	17.37	1.570
GCR-3000-5600	.748	.872	.062
	19.00	22.15	1.570
GCR-3000-6000	.806	.935	.062
	20.47	23.75	1.570

Captive Gaskets (Pronged I.D.)

Part No.	ID	OD	Overall Height	Gasket Size
GSK-2200-2964	.475	.780	.080	
	12.07	19.81	2.03	12mm
GSK-2400-2960	.550	.780	.080	
	13.97	19.81	2.03	14mm
GSK-2400-2961	.550	.745	.080	
	13.97	18.92	2.03	14mm
GSK-2400-2962	.500	.780	.080	1/2"
	12.70	19.81	2.03	12.5mm

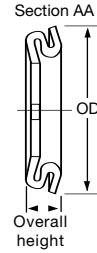
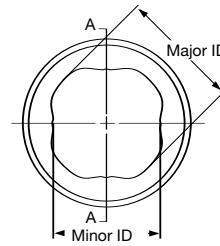
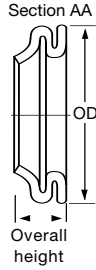
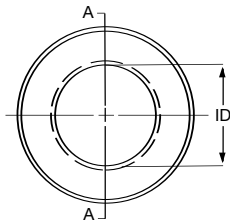
Application



Captive with undercut

Captive without undercut

Note: Metric measurements appear in bold.



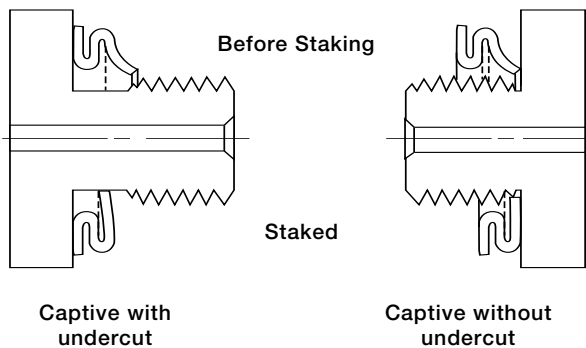
Conical Captive Gaskets

Part No.	ID	OD	Overall Height	Gasket Size
GSK-2000-4090	.397	.545	.090	7/8"
	10.08	13.84	2.29	10mm
GSK-2200-3540	.474	.630	.125	
	12.04	16.00	3.18	12mm
GSK-2200-3020	.474	.668	.140	
	12.04	16.97	3.56	12mm
GSK-2400-2990	.553	.718	.125	
	14.00	18.24	3.18	14mm
GSK-2400-1920	.555	.780	.100	
	14.09	19.81	2.54	14mm
GSK-2800-4570	.630	.815	.170	
	16.08	20.70	4.32	16mm
GSK-3000-3000	.713	.875	.135	
	18.11	22.23	3.43	18mm
GSK-3000-4230	.713	.930	.135	
	18.11	23.62	3.43	18mm
GSK-3200-4571	.755	.979	.195	
	19.18	24.87	4.95	19mm
GSK-3200-4570	.795	.976	.140	
	20.20	24.80	3.56	20mm
GSK-3400-4310	.886	1.095	.150	7/8"
	22.50	27.81	3.81	22mm

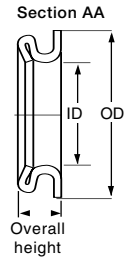
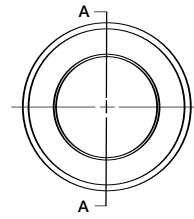
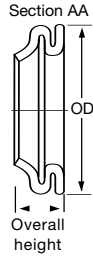
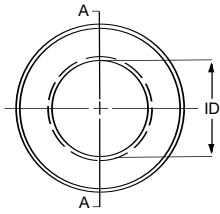
Screw-On Gaskets

Part No.	Minor ID	Major ID	OD	Overall Height	Gasket Size
GSK-2000-4110	.362	.403	.545	.055	
	9.19	10.24	13.84	1.40	10mm
GSK-2200-3820	.426	.475	.630	.070	
	10.82	12.07	16.00	1.78	12mm
GSK-2400-4331	.520	.548	.715	.070	
	13.21	13.92	18.16	1.78	14mm
GSK-3000-4430	.660	.715	.875	.075	
	16.76	18.16	22.22	1.91	18mm
GSK-3200-4600	.752	.795	.977	.094	3/4"
	19.10	20.20	24.82	2.40	19mm
GSK-3400-4780	.820	.886	1.095	.075	7/8"
	20.83	22.50	27.81	1.91	22mm

Application



Note: Metric measurements appear in bold.



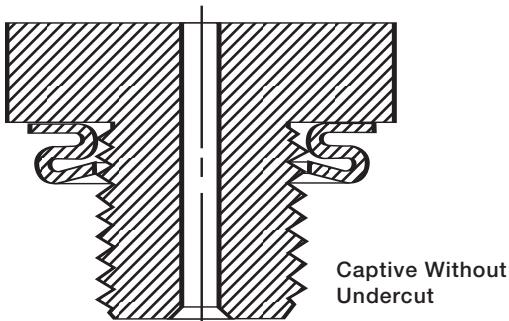
Over-The-Thread Gaskets

Part No.	ID	OD	Overall Height	Gasket Size
GSK-1600-0001	.291	.505	.080	
	7.39	12.83	2.03	7mm
GSK-2200-5440	.480	.650	.125	
	12.19	16.51	3.18	12mm
GSK-2400-4330	.557	.715	.070	
	14.15	18.16	1.78	14mm
GSK-2400-2270	.560	.785	.075	
	14.22	19.94	1.91	14mm
GSK-3000-1850	.715	.930	.070	
	18.16	23.62	.178	18mm
GSK-3000-3670	.718	.968	.083	
	18.24	24.59	2.11	18mm
GSK-3200-4601	.750	.977	.080	3/4"
	19.05	24.82	2.34	19mm
GSK-3301-4170	.835	1.095	.075	
	21.20	27.80	1.90	21mm
GSK-3401-4781	.886	1.095	.075	7/8"
	22.50	27.80	1.90	22mm

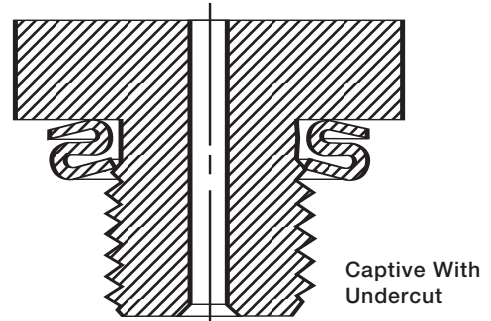
"C" Shaped Gaskets

Part No.	ID	OD	Overall Height	Gasket Size
GSK-2400-0000	.555	.722	.130	
	14.10	18.34	3.30	14mm
GSK-2400-5270	.555	.730	.145	
	14.10	18.54	3.68	14mm
GSK-3000-5700	.711	.891	.156	
	18.06	22.63	3.96	18mm

Application



Application



Note: Metric measurements appear in bold.

The Design of Spring Washers

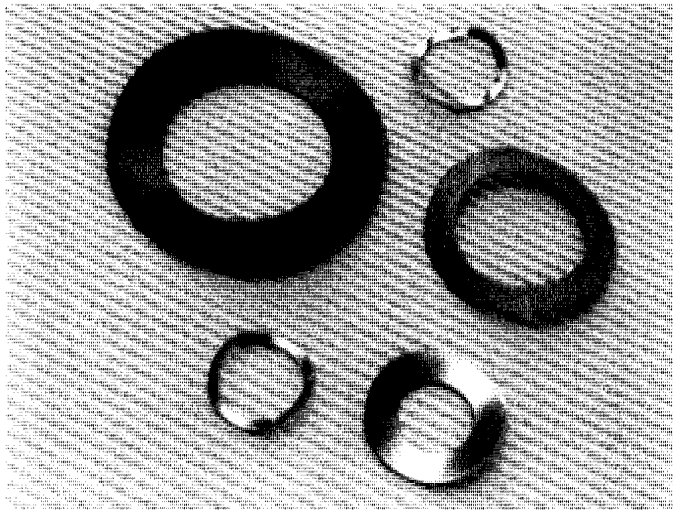


Fig. 1. Cylindrically Curved Spring washers are used where flexibility is important and loads are light. Maximum height should be less than one-half of the outside diameter.

The trend toward smaller and more compact machinery is making spring washers more popular. Their application is expected to further increase as more designers become aware of their advantages. They offer economies, occupy little space and weigh less than comparable wire springs. Although limited available deflection constitutes their main drawback, larger

deflection can be obtained by stacking them.

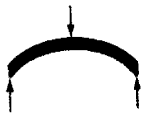
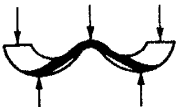
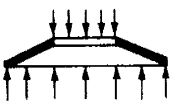
Spring washers are commonly used to apply a predetermined pressure on adjacent members. In bolted connections, they function to absorb any looseness due to vibration or temperature expansion. They also serve to eliminate side play in assemblies and are used with the bearings of a rotating shaft to control end pressure and end play. Vibration mountings often utilize such washers.

Of the many types and shapes of spring washers made, three have been developed to the point where mathematical formulas are available to accurately describe their spring characteristics. Although these three types (Cylindrically Curved, Wave and Belleville washers) have evolved independently, they cover a natural range of loading from ounces for the cylindrically curved types to tons for the Belleville. The wave washer is effective in the middle range. Various characteristics of three basic types of spring washers are given in Table 1.

If loading characteristics were the only design criterion, these three types would be sufficient to satisfy most requirements. However, the shape of spring washers can place restriction on their use. Thus, interchangeability among types may be difficult, or impossible, and special designs must be used.

Equations for the three basic types have existed for some time, but their use has been restricted due to the number of variables involved and because solutions are necessarily by trial and error.

Table 1. Characteristics of Three Basic Types of Spring Washers

Type	Light Capacity	Spring Characteristics	Nature of Spring Contact	Expansion Under Load	Maximum Deflection
Cylindrically Curved Washers	Light Loads Ounces to a hundred pounds	Spring rate approximately linear over entire deflection range	 4 Contact points (2 top, in line - 2 bottom)	Has most expansion of three basic types	1/2 of outside diameter
Wave Washers	Light to medium loads Pounds to hundreds of pounds	Spring rate approximately linear, except near flat position	 Number of contact points equals twice the number of waves	Has less expansion than Cylindrically Curved washers	Approximately 1/4 of outside diameter
Belleville Washers	Medium to heavy loads Tens of pounds to tons	Can have: 1. Approximately linear spring rate 2. Increasing spring rate 3. Decreasing spring rate 4. Zero spring rate Load capacity is erratic near the flat position	 Contact around inner and outer circumferences	Has least expansion of three basic types	(Belleville Criterion) 1/10 of rim width

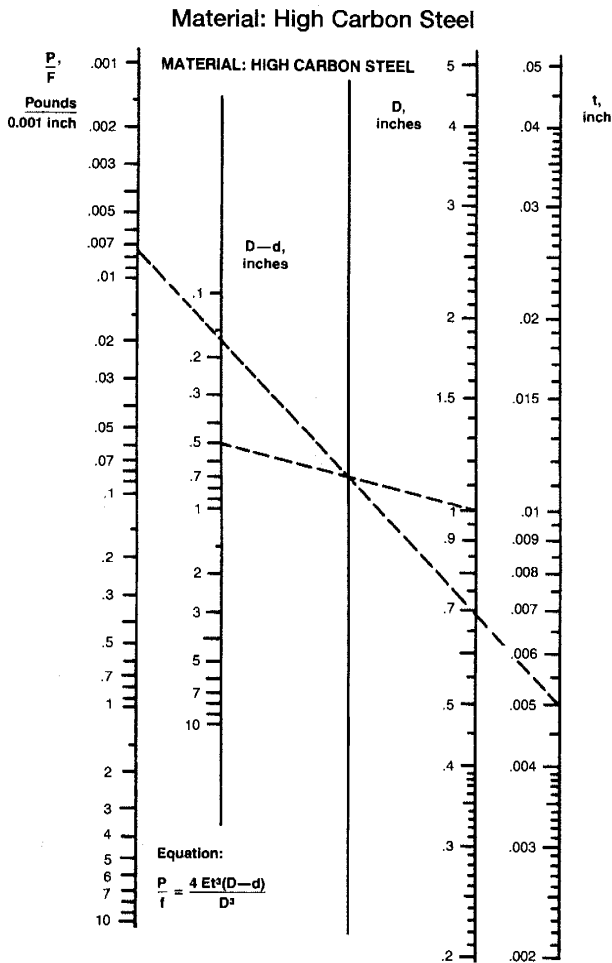


Fig. 2. Nomograph to simplify design calculations for cylindrically curved spring washers made of high-carbon steel.

Even though a satisfactory solution may be obtained, it is usually difficult to determine spring proportions that require minimum space, yet satisfy a critical combination of service conditions. Nomographs have been included in this article to help reduce design time by showing the interaction between the variables involved. Proper use of these nomographs will quickly pinpoint the correct combinations of variables for a given requirement. Nomographic solutions should be checked by the design and stress equations. The nomographs presented are based on the use of high-carbon steel and a maximum stress of 200,000 psi.

Material: High Carbon Steel
Maximum Stress: 200,000 psi

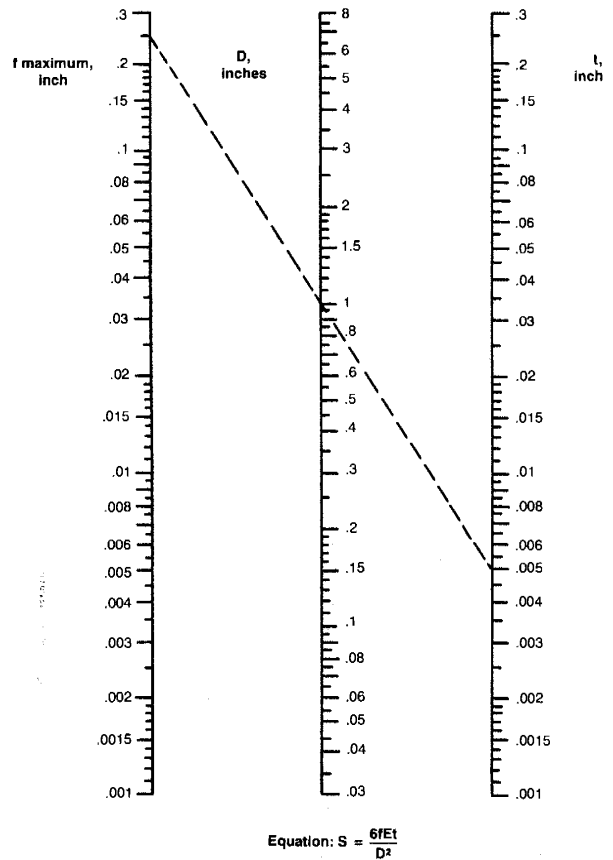


Fig. 3. Stress nomograph based on the design equations for cylindrically curved spring washers, a maximum stress of 200,000 psi, and high-carbon steel material.

They should not be used for materials which have a modulus of elasticity substantially different from 30×10^6 (and a Poisson's ratio different from 0.3 in the case of Belleville spring washers). Contrary to popular belief, the hardness of a spring washer will not affect the spring rate. It affects only the load at which permanent set takes place. Another mistaken notion is that 200,000 psi is a good maximum stress for static applications. In some cases, it is too conservative and much higher stresses could be used. For certain conical washers, stresses two or three times the accepted maximum value would be permissible.

This is due to the fact that maximum stress occurs only in a very small portion of material that is surrounding the inside diameter.

Under deflection, the highly stressed material deforms and tends to redistribute the area under maximum stress. This localized failure will not affect the height if an appreciable amount of spring washer material has not been involved in the deformation.

Material	Modulus of Elasticity E , psi	Poisson's Ratio μ
High-Carbon Steel	30×10^6	0.30
Phosphor Bronze	15×10^6	0.33
Beryllium Copper	$(16-18.5) \times 10^6$	0.30
Stainless Steel	28×10^6	0.30
Spring Brass	15×10^6	0.33
Silicon Bronze	15×10^6	0.33
Chrome Vanadium Steel	30×10^6	0.30

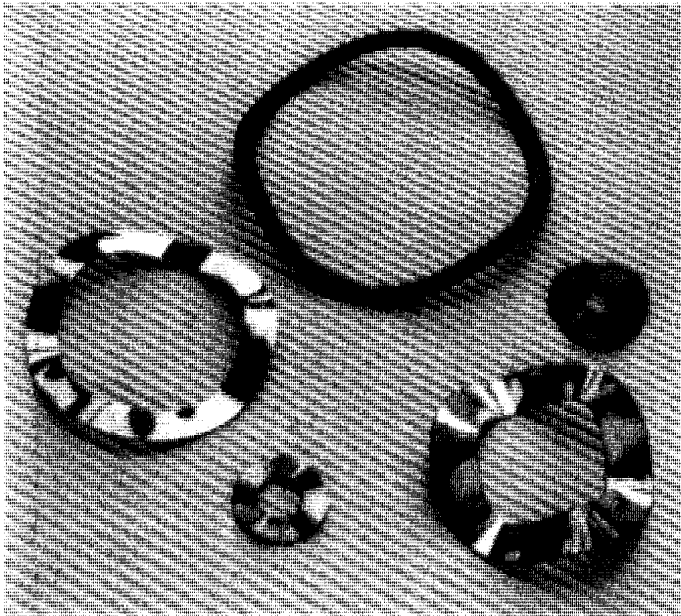


Fig. 4. Wave spring washers are effective when the load is static or the working range deflection is small, and the allowable axial space for installation is limited.

The safe stress for fatigue applications will, of course, vary with the type of service. In the case of conical washers, 200,000 psi is a typical maximum stress value used in the selection of washers that must withstand 500,000 load cycles. When the number of load cycles is to be very high, only fatigue tests on actual washers can finally determine the true working limits. Both edge rounding and shot peening have been found to be helpful in increasing the fatigue life of spring washers.

Before testing spring washers, it is always advisable to load the washer several times through the specified working deflection to eliminate any set which might take place. This procedure will help to eliminate erroneous results.

Spring washers are generally made of spring steel, but any other resilient material may be employed. Commonly used materials are listed in Table 2, page 26. When high-carbon steel is used, it is important that a plating or coating be applied to prevent corrosion. Coatings employed include: black oxide coatings; electrogalvanizing; mechanical zinc plating; phosphate coating; nickel plating; chromium plating; and aluminizing.

Hydrogen Embrittlement

Hydrogen embrittlement has plagued users and suppliers of parts having a high degree of strength and hardness. It is a common problem in the making of spring washers. Severe cracking of the washers, after relatively few load cycles and while under low intensity loads, is a typical occurrence when this condition is present. Failure may be spontaneous, due only to residual stresses. Also significant is the fact that failure often occurs after a delay until the contained hydrogen produces its destructive effect. A large amount of hydrogen may be picked up in the chemical pickling process used to clean off scale, but plating which usually follows cleaning causes the major difficulty.

Four approaches to solving this problem are:

1. To bake at sufficient temperature and, for a sufficient time immediately after the plating operation
2. To apply a vacuum-deposited plate which may or may not be subsequently electroplated
3. To electroplate a flash coat of cadmium. (A thin coat can easily be baked out in a short time. The cadmium plating acts as an effective barrier to further hydrogen penetration.)
4. To produce a porous cadmium plate by carefully controlling plating conditions. (During the baking operation, the pores will allow hydrogen to escape from the base metal.)

Cylindrically Curved Washers

The Cylindrically Curved washer, Fig. 1, page 25, is well suited for applications requiring flexibility and light loads (from ounces up to about a hundred pounds), and repeated cycles through a range of motion. Of the Cylindrically Curved, Wave and Belleville types, the Cylindrically Curved washer exhibits the most uniform

Material: High Carbon Steel

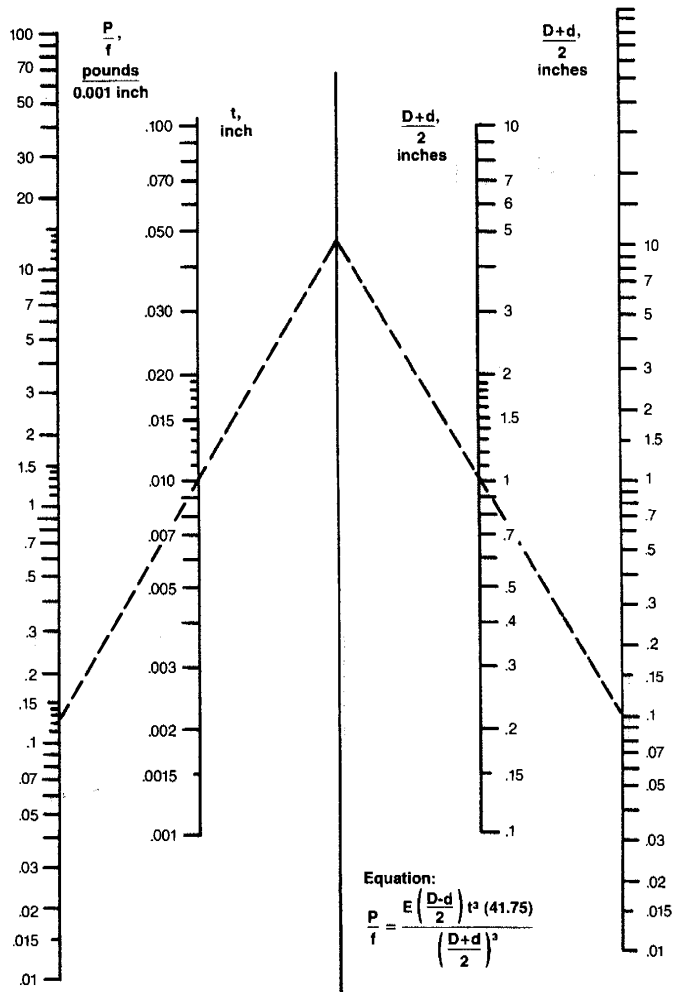
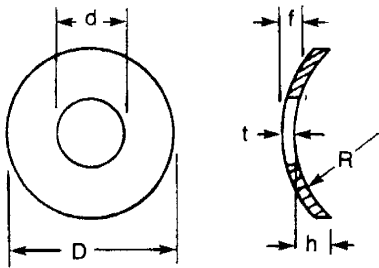


Fig. 5. Design nomograph for wave spring washers of the three-way type. Scales are based on high-carbon steel with a modulus of elasticity of 30,000,000 psi.

spring constant over the widest range of deflection. In order for this type of washer to function properly, the formed portions, which make contact, must be free to slide. Space must be provided for this expansion, and the loading surfaces must be hard enough to prevent the formed ends from digging in. The maximum height should be limited to less than one-half of the outside diameter.

Design Formulas for Cylindrically Curved Washers



$$P = \frac{4 E t^3 f (D - d)}{D^3}$$

$$S = \frac{6 f E t}{D^2}$$

$$R = \frac{(D/2)^2 + h^2}{2h}$$

$$h = R - \sqrt{R^2 - (D/2)^2}$$

$$D = 2 \sqrt{2hR - h^2}$$

Where:

- t = Stock thickness, inches
- P = Applied load, pounds
- h = Height under metal thickness, inches
- f = Deflection, inches
- d = Inside diameter, inches
- D = Outside diameter, inches
- S = Maximum induced stress, psi
- E = Modulus of elasticity, psi

The following example will illustrate the use of the design and stress nomographs shown in Figs. 2 and 3, on page 26. Based on the design equations for Cylindrically Curved washers, these nomographs are for washers made of high-carbon steel and for a maximum stress S of 200,000 psi.

Given:

- $D = 1$ inch
- $d = 0.5$ inch
- $f = 0.1$ inch
- $h = 0.187$ inch
- $P = 0.750$ pound
- $S = 200,000$ psi maximum

Find:

The thickness which will satisfy these requirements.

First, draw a line through $(D - d) = 0.5$ inch and $D = 1$ inch on the appropriate scales of the design nomograph, Fig. 2., page 26. Then draw a line through

$$\frac{P}{f} = \frac{0.750}{\left(\frac{0.1}{0.001}\right)} = \frac{0.750}{100} = 0.0075 \text{ pounds per } 0.001\text{-inch}$$

deflection and the intersection of the first line with the pivot line. This line intersects the t scale to establish a thickness of 0.005 inch. The broken line on the stress nomograph, Fig. 3, page 26, shows that the required deflection of 0.100 inch does not exceed a maximum stress of 200,000 psi and that the maximum allowable deflection is 0.250 inch.

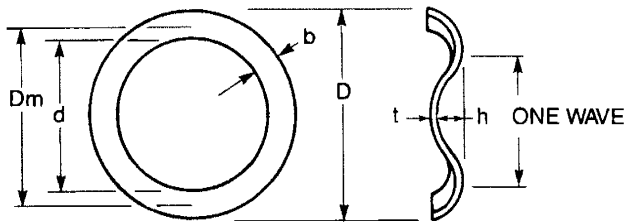
Wave Washers

When the load is static or the working range is small, and the allowable amount of axial space is limited, the use of a Wave washer, Fig. 4, page 27, is an efficient method of obtaining the required loading. Loads obtainable from Wave washers are usually in the range of a few pounds to hundreds of pounds. These springs are often used as cushion springs or cushion spacers between parts on shafts, or to take up the expected amount of variation in assembled parts. Wave washers can be made in a large range of sizes. However, when the ratio of mean diameter to radial width becomes less than 8, the load and stress calculations are not accurate. This is due to distortion of the material and the inability of the waves to recover their shape after deflection.

The uniformity of the waves is important because the true load deflection rate does not start until the waves are evenly loaded. It is for this reason that a load deflection rate should always be checked with an initial preload. Once the waves are uniformly loaded, a relatively linear spring constant will be obtained until the washer is deflected close to the flat position. The point at which the spring constant becomes nonlinear varies for different wave washers. A rule of thumb is to design the height equal to twice the required deflection.

Wave washers expand slightly upon compression and will not work properly if the outside diameter is constrained. Rough surfaces and burrs should be avoided, as they will tend to

Design Equations for Wave Washers



prevent expansion and will thus affect the load characteristics. A washer can have any number of waves from three up; however, the normal sizes usually have three, four, or six waves. By increasing the number of waves, the thickness can be reduced for a given load, but only at the expense of decreasing the allowable deflection.

$$t = \frac{0.635 (D+d) (P/bf)^{1/3}}{E^{1/3} N^{4/3}}$$

$$f = \frac{\pi^2 (D+d)^2 S}{48 E t N^2}$$

$$S = \frac{0.75 \pi P (D+d)}{N^2 t^2 (D-d)}$$

$$S = \frac{48E}{\pi^2} \frac{t f N^2}{(D+d)^2}$$

$$r = \frac{P}{f}$$

$$r = \frac{1.67 E (D-d) N^4 t^3}{(D+d)^3} \times \frac{D}{d}$$

$$P = \frac{1.67 E f N^4 t^3 (D-d)}{(D+d)^3} \times \frac{D}{d}$$

Where:

- b = Radial width of material, inches = $(D - d) / 2$
- N = Number of waves
- Dm = Mean diameter, inches = $(D + d) / 2$
- l = Spring rate, pounds/inch

Design and stress nomographs based on these equations are given in Fig. 5, page 27 and Fig. 6. They are constructed for Wave washers of the three-wave type, made of high-carbon steel, and for a maximum stress S of 200,000 psi. Use of the nomographs is illustrated by the following example.

Given:

- $D = 1.100$ inches
- $d = 0.900$ inch
- $P = 3$ pounds
- $f = 0.025$ inch

Find:

The thickness of the Wave washer which will satisfy these requirements.

On the design nomograph, draw a line through the scale points

$$\frac{D+d}{2} = 1 \text{ and } \frac{D-d}{2} = 0.1 \text{ inch,}$$

extending it to the pivot line. From the point of intersection with the pivot line, draw a line through $P/f = 3/0.025 = 120 = 0.12$ pounds per 0.001-inch deflection. This line crosses the thickness line at 0.010 inch. The stress nomograph construction shows that the maximum deflection is 0.060 inch. Hence, if $h = 2f = 0.050$ inch, the maximum design stress of 200,000 psi will not be exceeded.

Material: High Carbon Steel
Maximum Stress: 200,000 psi

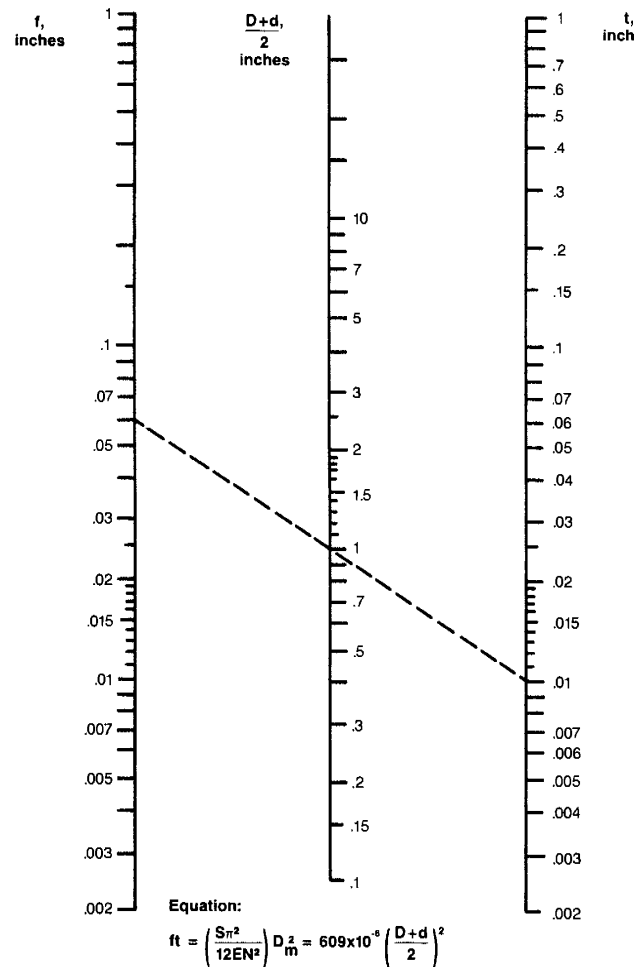


Fig. 6. Nomograph based on the stress equation for wave spring washers of the three-wave type. This representation is for high-carbon steel washers with a maximum stress of 200,000 psi.

Belleville Washers

Conical discs are widely used as compression springs to support large loads where space in the direction of loading is limited. All Belleville type washers (Fig. 7) are conical-disc springs, but not all conical-disc springs are Belleville washers. In 1867, Julien Belleville of Paris obtained a United States patent on the Belleville washer. By numerous experiments, he had determined the proportions of a Conical washer that would not take a permanent set on application, and in which the resistance is approximately proportional to the load.

Many Conical spring washers are designed with a height which will result in incomplete recovery after an initial deflection. Excessive cone heights do not add materially to the spring action, since there is a specific amount of springback available.

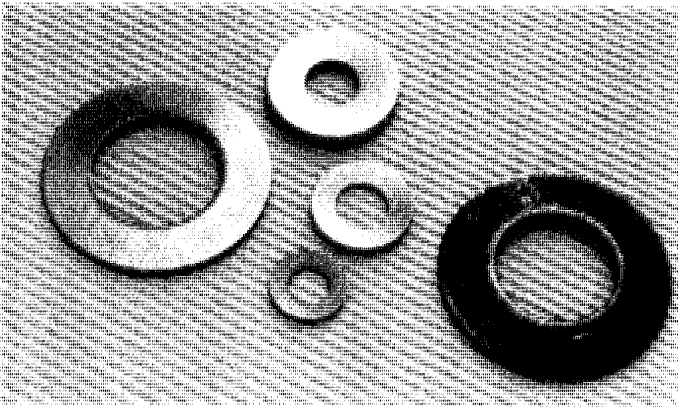


Fig. 7. Conical-disc springs are widely used to support large loads while undergoing small deflection.

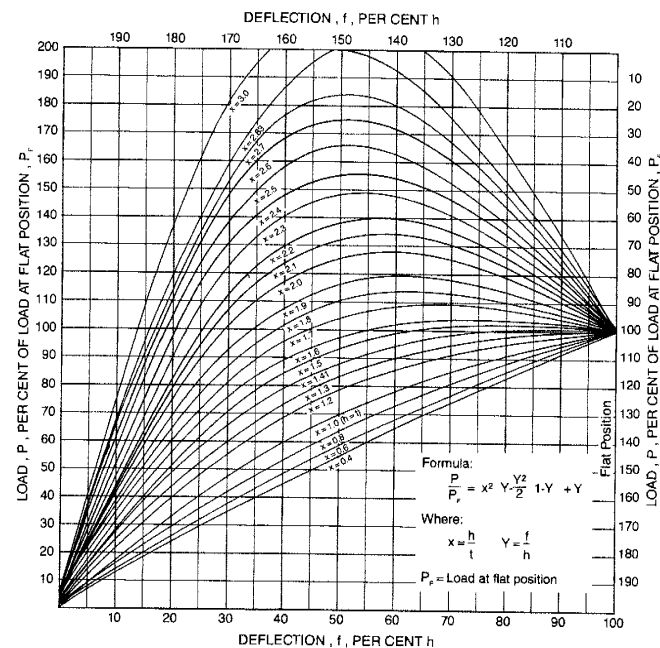


Fig. 8. Load deflection characteristics of conical-disc spring washers for various ratios (x) of free height (h) to thickness (t).

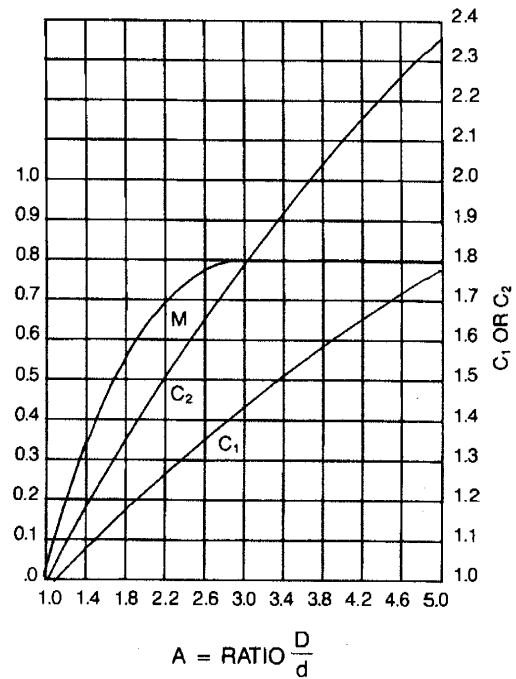


Fig. 9. Graph for determining the constants (M), (C_1), and (C_2), employed in the design equations for conical-disc washers.

However, a permanent set can result which may cause internal strains in washer failure. The true Belleville washer is an approximately linear rate spring of conical form designed to deflect from its initial height to the flat position without a loss in height caused by a permanent set due to stresses exceeding the elastic limit of the washer material. Since Belleville's time, accurate formulas have been derived not only for the case where resistance is proportional to load, but for those with nonlinear spring rates as well.

The proportions established by Julien Belleville are as follows:

- Ratio of material thickness to width of rim should be 1 to 5, and not exceed 1 to 10.
- Ratio of cone height to width of rim should not exceed 1 to 10. (This results in a maximum cone angle of about 5 1/2 degrees. Hence, for each 0.010 inch of deflection, about 0.10 inch of rim width is required.)

Other characteristics are useful in the design of conical spring washers:

- When the ratio of outside to inside diameter is in the range of 1.5 to 1.7, both the load and stiffness capacities will be maximum regardless of the value of the thickness-to-height ratio, t/h .
- Maximum flexibility will be obtained when the outside diameter D is approximately twice the inside diameter d . These are also approximately the proportions resulting in the best resiliency, or maximum ratio of energy storage to spring washer weight.

Material: High Carbon Steel

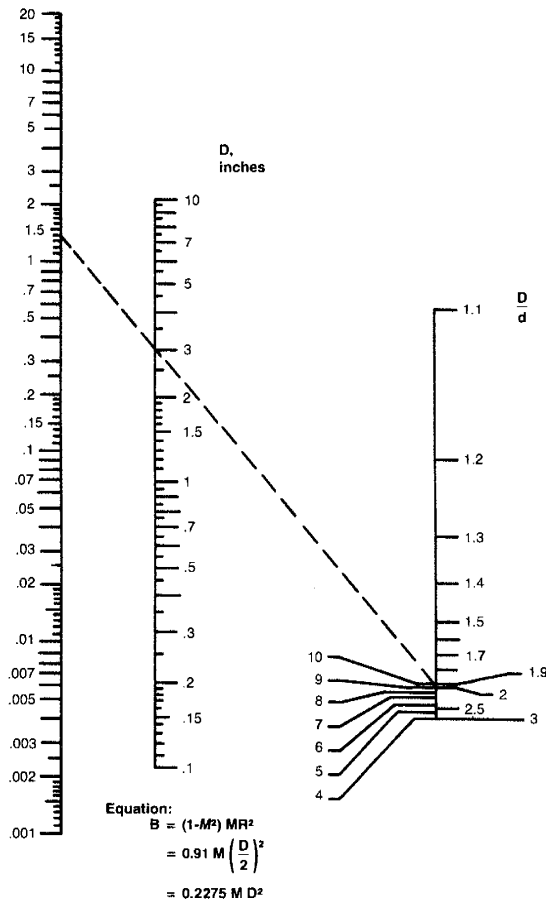


Fig. 10. Nomograph No. 1 for simplifying the design calculations for conical spring washers made of high-carbon steel. Broken line illustrates application of the nomograph in the example given.

- In bolted connections, a good design value for the load to be supported in the flat position is 50 percent of the bolt tensile strength.

When a washer has been deflected beyond 90 percent of its initial height, the design formulas become inaccurate. The actual load increases materially above the calculated load as the flat position is approached. If accurate, predetermined loads are required, the washer should be designed to give the desired load before flat position is reached.

In the case of Conical Spring washers, successful use of the stress formulas depends a great deal on the proper choice of a maximum stress. The safe stress will, of course, vary with the type of service. For applications that must withstand 500,000 cycles, 200,000 psi is a typical maximum stress for carbon-steel washers.

Special Conical Spring Washers

Conical-disc springs have a unique feature. Their stiffness (change in load per unit change in deflection) can vary over the full range of deflection. In addition, a large variety of load deflection characteristics can be obtained by changing the ratio of free height to thickness. Various possibilities are shown in the chart in Fig. 8 (page 28) and in Table 3. It can be seen from this chart that as the height-to-thickness ratio $x (= h/t)$ decreases, the load deflection curve approaches a straight line. Thus, a conical washer with an h/t ratio of 0.4 will have an almost uniform spring constant. Belleville's criteria for approximate linear springs rates apply to conical spring washers with h/t ratios of up to about 0.8.

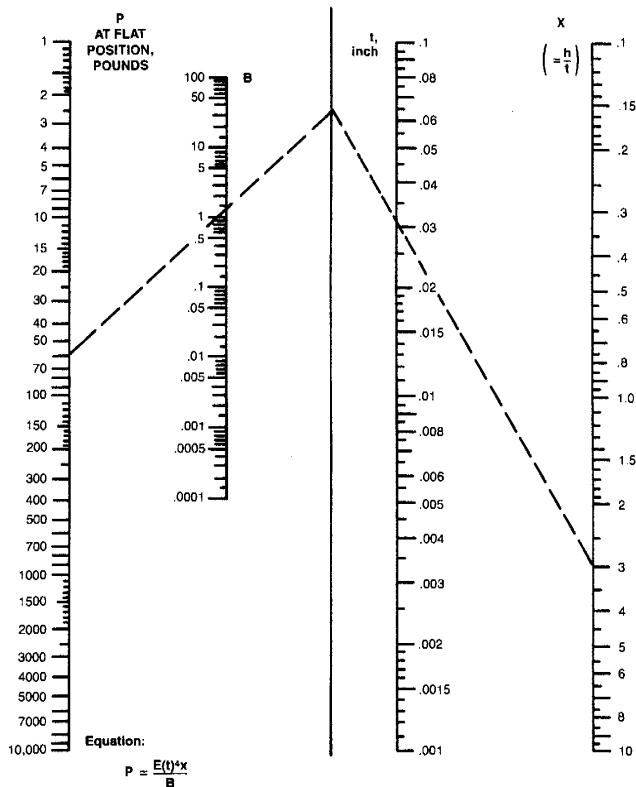
A conical washer with a height-to-thickness ratio of greater than $x = 1.41$ will support a load which reaches a maximum, decreases with further deflection, and then increases after the flat position is passed. For example, when an oil can bottom is deflected, considerable pressure must be exerted at first. But then, as the deflection continues, the pressure required decreases. It increases again after the flat position is passed. On release of the applied pressure, the bottom returns to its original position.

When the height-to-thickness ratio exceeds about 2.8, the load will become negative if the deflection can proceed past the flat position. Continued deflection will cause the spring washer to assume a stable inverted position. In other words, it will turn itself inside out. This position will be maintained until a load is

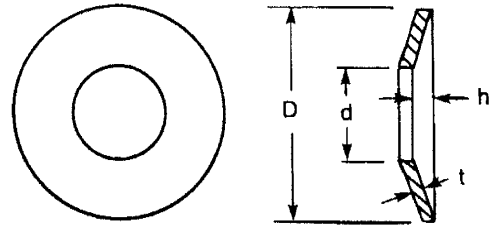
Table 3. Applications and Load Deflection Characteristics of Conical Spring Washers having various h/t Ratios

Characteristics	h/t Ratios	Application
Constant spring rate	$h/t < .4$	Where constant spring rate is required, or to obtain very high loads with small deflection.
Approximately constant spring rate (Belleville's rule apply)	$h/t < .8$	Fasteners and in stacks where approximate linear spring rate is acceptable.
Positive, decreasing spring rate	$.4 < h/t > 1.41$	Fasteners and in stacks. Higher h/t values may cause snapping if deflection can proceed past flat position.
Zero-rate condition over large deflection	$h/t = 1.5$	Taking up wear while establishing constant load. To apply gasket pressure and to provide constant pressure in special brakes.
Positive, decreasing spring rate which becomes zero, then negative before the flat position is reached	$1.4 < h/t > 2.83$	Special purpose: for fasteners not generally loaded to flat positions; and in devices where an "oil can" characteristic is desired.
Same as above, except the spring washer can remain stable on either side of the flat position	$h/t > 2.83$	Special purpose: in devices where load is required in opposite direction restore to working position.

Material: High Carbon Steel



Design Equations for Conical Spring Washers



Constants

$$M = \frac{6}{\pi \ln A} \left[\frac{(A-1)^2}{A^2} \right]$$

$$C_1 = \frac{6}{\pi \ln A} \left[\frac{A-1}{\ln A} - 1 \right]$$

$$C_2 = \frac{6}{\pi \ln A} \left[\frac{A-1}{2} \right]$$

General Equations

$$P = \frac{Ef}{(1-\mu^2)MR^2} \left[\left(h - \frac{f}{2} \right) (h-f)t + t^3 \right]$$

$$S = \frac{Ef}{(1-\mu^2)MR^2} \left[C_1 \left(h - \frac{f}{2} \right) + C_2 t \right]$$

For Conical Spring Washers Deflected to the Flat Position ($h = f$)

$$P = \frac{Eht^3}{(1-\mu^2)MR^2}$$

$$S = \frac{Eh}{(1-\mu^2)MR^2} \left(C_1 \frac{h}{2} + C_2 t \right)$$

Where:

- P = Load, pounds
- f = Deflection, inches
- t = Thickness of material, inches
- h = Free height minus thickness, inches
- D = Outside diameter, inches
- d = Inside diameter, inches
- E = Modulus of elasticity, psi
- S = Maximum stress at inside circumference, psi
- A = Ratio D/d
- R = $D/2$
- μ = Poisson's ratio

The general stress equation represents compressive stresses as long as the bracketed quantity is positive. It is possible for the term $(h - f/2)$ to become negative when f is very large, in which case the stress is tension. When this occurs the term inside the brackets should be changed to read $C_1 (h - f/2) - C_2 t$.

Fig. 11. Nomograph No. 2, which can be used in combination with Fig. 10 as an aid in determining the design of high-carbon steel conical spring washers.

applied in the opposite direction to bring it back to its initial position. Occasionally, the bottom of a damaged oil can will exhibit such a condition, and a load must be applied to the inside of the can to bring it back into working position.

Of particular interest is the constant-load or zero-rate condition which occurs over a considerable range of deflection when $h/t = 1.5$. This range has been successfully used for a novel disc brake. A conical type washer, loaded to the zero-rate condition, is used to apply braking pressure to a disc. As the brake lining wears, the spring will maintain constant pressure on the braking disc.

It should be emphasized that there are applications which do not require loading to the flat position. These spring washers should, if possible, be designed to withstand accidental flattening without permanent deformation. If spring washers with excessive heights are used, care must be taken not to deflect them past the critical point (as determined by the stress equations) at which a permanent set would occur. If large loads and/or deflection are required, conical spring washers can be combined by stacking them in various arrangements.

Conical spring washers can be produced with teeth around both the upper and lower edges. The presence of these teeth does not change the spring characteristics to any appreciable extent. However, they do penetrate the fastening surface and tend to resist any lateral shifting of the washers.

When using the design formulas, the stress should be checked after a few trial calculations. A high stress can be reduced by increasing the outside diameter or by decreasing the ratio of height to thickness. A graph for determining factors C_1 , C_2 , and M is given in Fig. 9, page 30.

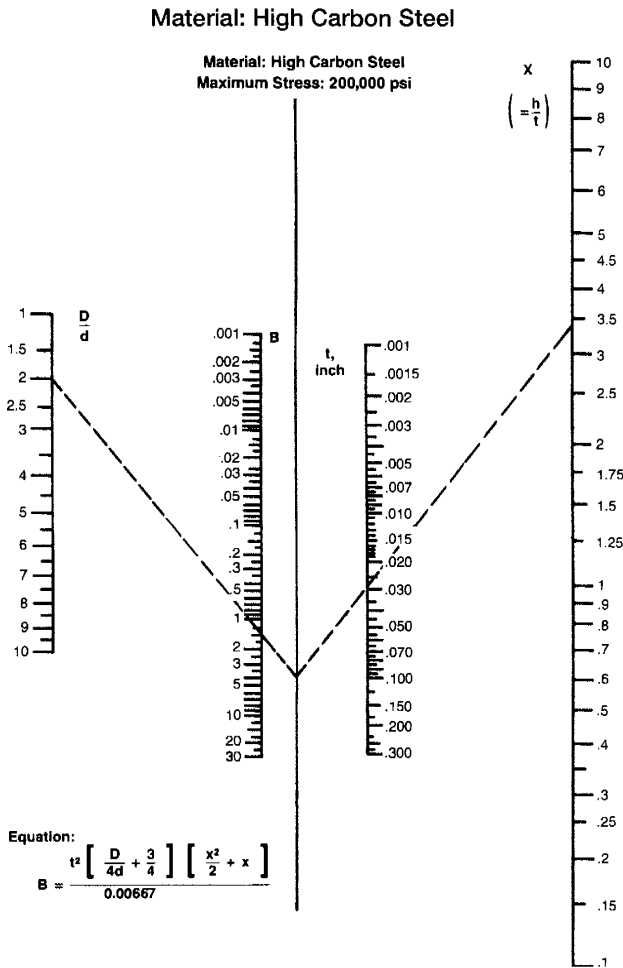
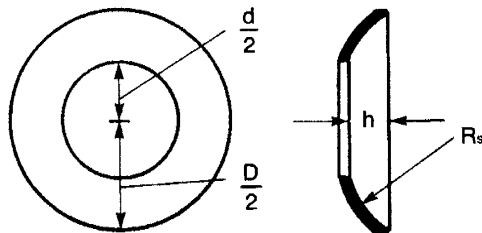


Fig. 12. Stress nomograph based on the design equations of conical spring washers, a maximum stress of 200,000 psi and high-carbon steel material.

Spherically Curved Washers



Spring washers are frequently made as segments of spheres instead of segments of cylinders. Although they are not true conical washers, they have approximately the same spring characteristics. However, the load capacity of spherically curved washers varies considerably when deflected near the flat position. The spherical shape tends to add a stiffening effect so

that, in general, spherically curved washers will have slightly higher spring rates than comparable conical washers. Knowing the inside diameter d , the outside diameter D , and the height under material thickness h , the proper forming radius R_s , can be found by the following formulas:

General Equation

$$R_s = \sqrt{\frac{(R^2 - r^2 - h^2)^2}{4h^2} + R^2}$$

where:

$$R = \frac{D}{2}$$

$$r = \frac{d}{2}$$

R_s = spherical forming radius

For Belleville Type Washers

When the height equals one-tenth of the rim width,

$$h = \frac{R - r}{10} \text{ and}$$

$$R_s = \sqrt{\frac{(0.99 R^2 - 1.01 r^2 + 0.02 Rr)^2}{0.04 (R - r)^2} + R^2}$$

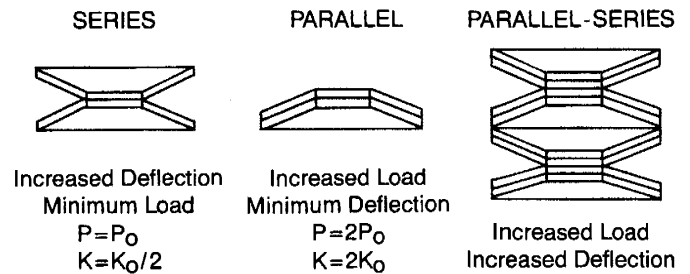


Fig. 13. Load and deflection relationships for conical spring washers stacked in series, parallel, and parallel-series combinations.

How to Use the Nomograph

Application of the nomographs presented in Figs. 10, page 31, Fig. 11, page 32, and Fig. 12 can simplify calculations when designing conical spring washers made of high-carbon steel. Scales are based on a maximum stress of 200,000 psi. Following is a typical example.

Given:

$$D = 3 \text{ inches}$$

$$d = 1.5 \text{ inches}$$

$$P = 60 \text{ pounds at the flat position}$$

$$h = f = 3/32 \text{ inches}$$

Find:

The thickness of a conical spring washer made of high-carbon steel which will satisfy these requirements.

First determine factor B , the denominator in the design equations from the conical spring design nomograph No. 1 (Fig. 10, page 31). With P at the flat position and B known, draw a line as shown to a point on the pivot line of design nomograph No. 2 (Fig. 11, page 32). Using this point as a pivot, rotate a line until $xt (=h) = 3/32$ inch. For example, at a thickness t of 0.031 inch, $x = 3$, and $xt =$ approximately $3/32$ inch.

The stress nomograph (Fig. 12, page 33) is entered using the values for D/d , B , and t to find x . As illustrated, a maximum x value of about 3.4 is obtained. Therefore, a washer with an x factor of 3 will not exceed a stress of 200,000 psi.

The chart in Fig. 8, page 30, shows how $x (=h/t)$ affects the loading characteristics. It can be used to determine the load at any deflection, once the load at the flat position is known. For example, to find what load capacity the above spring washer would have at $f = 0.0094$, convert this deflection into percent of the initial height ($0.0094/0.094 = 0.1 = 10$ percent). At the intersection of the 10 percent deflection line with the $x = 3$ curve, the load is 86.5 percent of the load in the flat position. Thus, the load at $f = 0.0094$ equals 0.865×60 pounds = 51.9 pounds. The curve shows that this spring washer at 50 percent deflection would have a load capacity of about twice the load at the flat position, and would have a negative spring rate as the flat position is approached. It would snap to flat position if loaded to maximum capacity.

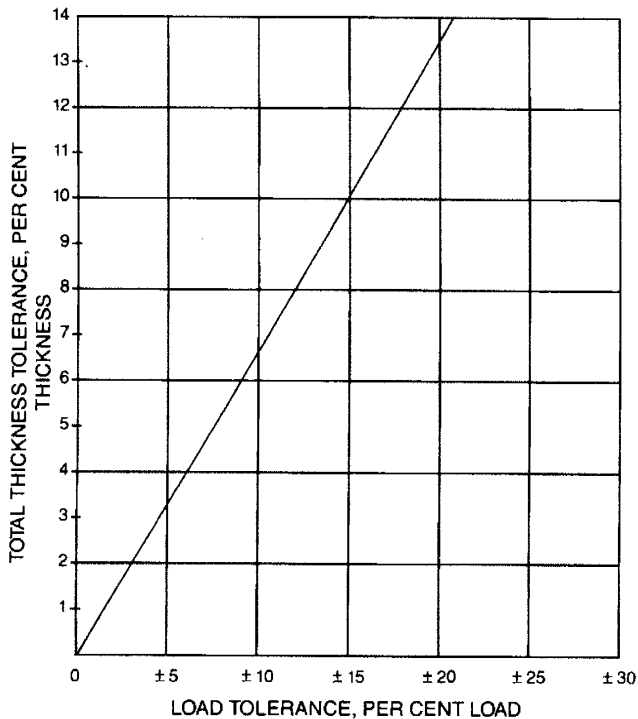


Fig. 14. Graph for use in determining the proper thickness and load tolerances for spring washers.

Multiple Conical Spring Washer Assemblies

Conical spring washers may be stacked (Fig. 13, page 33) to obtain larger load capacities and/or larger deflection. In a series stack of n washers, each washer undergoes $1/n^m$ of the total deflection, and the maximum load obtainable is equal to the maximum load from a single element. In series stacking where deflection can proceed past the flat position, the use of conical springs with an h/t (or x) value greater than 1.4, may cause snapping. For a parallel stack of springs, each washer contributes $1/n^m$ of the load capacity and all washers undergo equal deflection. By stacking in a parallel-series arrangement, higher load capacities with larger deflection can be obtained. Stacking characteristics for parallel sets combined in series are as follows:

$$P = w P_o$$

$$Y = m h$$

$$L = m (w t + h)$$

$$K = \frac{w K_o}{m}$$

P_o = Load to deflect spring to flat position, pounds

w = Number of springs in each parallel set

m = Number of parallel sets in a series

L = Free height of spring assembly, inch

Y_o = Total deflection at flat height, inch

K = Stiffness at deflection f , pounds/inch

K_o = Stiffness at flat height, pounds/inch

In stacks where a large number of springs are used, friction between elements becomes a problem and tends to produce erratic loading characteristics. However, this friction can be an advantage when used to supply a damping action for assemblies which are designed for energy absorption, as in gun recoil mechanisms.

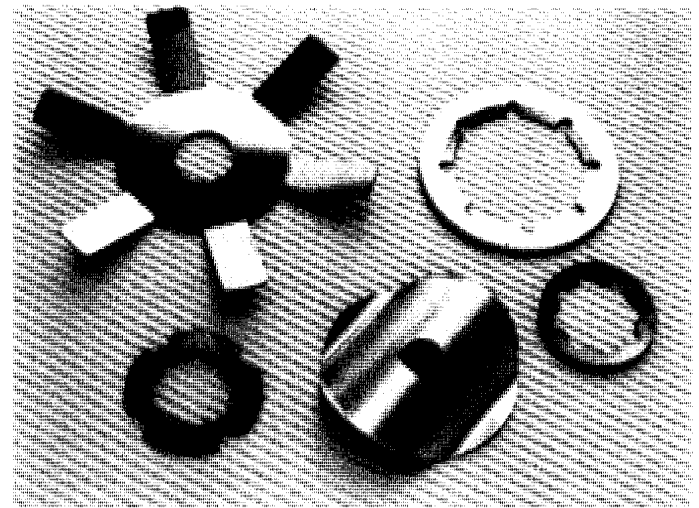


Fig. 15. Special spring washers such as these are used to provide greater deflection, special load deflection characteristics, special contact requirements, or additional functions.

Thickness and Load Tolerances

An examination of the deflection formulas will reveal that the load capacity of spring washers is dependent upon the cube of the material thickness. Thus, small changes in material thickness produce large changes in loading capacity. Much of the variation in loading among the same spring washers can be attributed to differences in material thickness.

The graph in Fig. 14, page 34 or the following equations, can be used to determine proper thickness and load tolerances.

$$\pm T_t = t \left[\sqrt[3]{1 \pm (P_t/100)} - 1 \right]$$

$$\pm P_t = 100 \left[\left(\frac{\pm T_t}{t} + 1 \right)^3 - 1 \right]$$

Where:

- t = Nominal material thickness, inch
- P_t = Load tolerance in percent of load
- T_t = Thickness tolerance, inch

By converting the tolerances on commercial stock into percent of thickness, the graph can be used to determine expected load capacity variation. If tighter load specifications are required, more costly, close-tolerance stock must be used. However, it should be kept in mind that thickness, while being the largest contributor, is only one of the variables that causes variations in load capacity.

Special Spring washers, Fig. 15, page 34, are always more expensive than the basic types and should not be employed unless specific considerations dictate otherwise. Some of the reasons for using special washers are:

- To obtain more deflection.
- To obtain special load deflection properties.
- To satisfy a specific combination of load and contact requirements.
- To provide special locking features.
- To increase the contact surface.
- To satisfy another function in combination with the spring requirements.

Typical spring washer designs are illustrated in Fig. 16. The most commonly used stamped spring washer is shown at A. This cylindrically curved type is designed to provide the greatest amount of spring action for its size and gage. A modification of the basic design A for general use is seen at B. The "V" form increases the load-carrying capacity but reduces spring resilience. Varieties A and B give the greatest deflection, but have the smallest load bearing surfaces. Spring washer C has

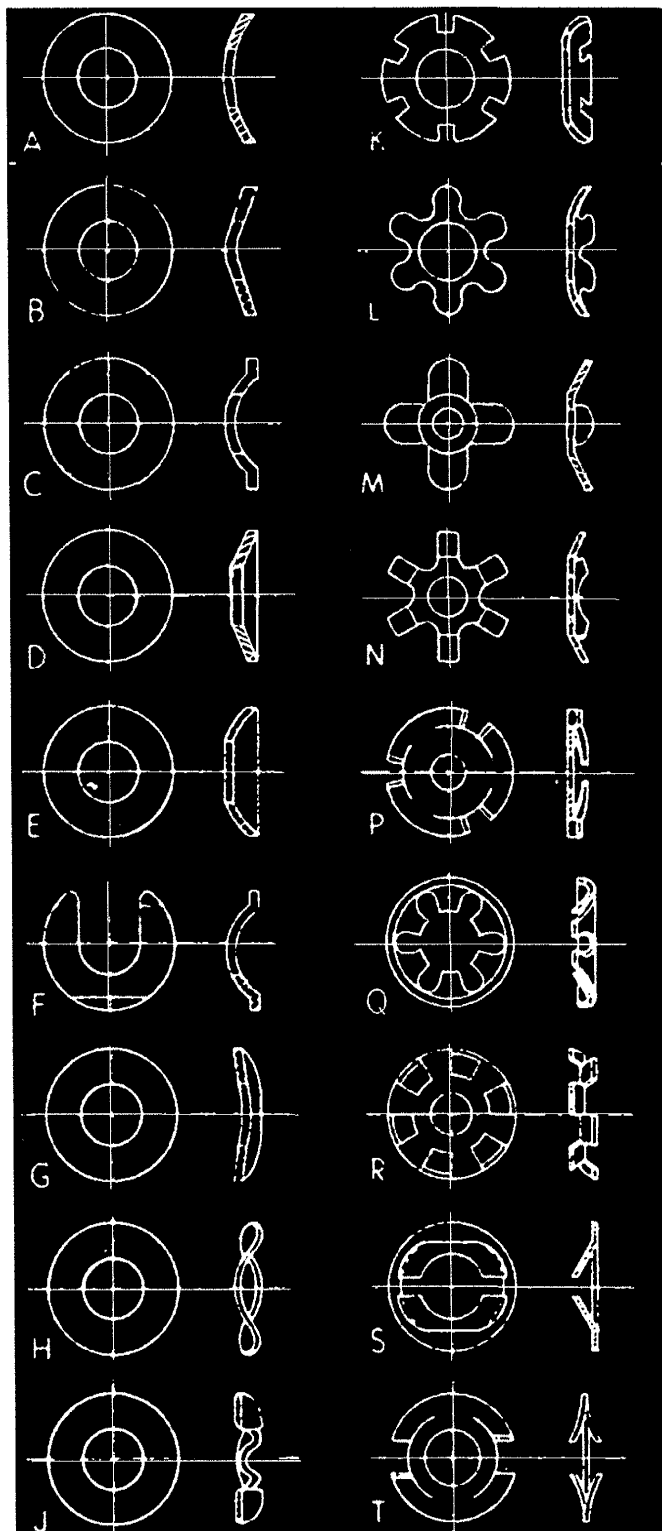


Fig. 16. Typical designs of spring washers showing the basic cylindrically curved, wave, and conical-disc types, with some of the varieties that have been developed from them.

two flat contact areas to eliminate surface scoring, when this is necessary in an application. Its characteristics are similar to design A, but it is stiffer and carries more load with the same material thickness.

The conical washer *D* and spherical washer *E* provide the greatest load-carrying capacities of any stamped spring washers of their size. They deflect less, but have stronger spring action than washers *A*, *B*, and *C*. Style *F*, a modification of variety *C*, is used as a take-up spring in applications where insertion must be made after assembly. Providing two contact areas with the assembled part, two-wave variety *G* has a greater load-carrying capability than washer *A*. Three-wave washer *H*, with three contact points per side, has greater load-carrying capacity than both varieties *A* and *G*.

Four or more waves in the rim section of washer *J* give increased load-bearing capacity when compared to matching sizes of the style *H* washer. These washers also give minimum spring movement with high spring force and permit symmetrical load distribution because of the multiple bearing surfaces. Types *K*, *L*, *M*, and *N* are modifications of spring washers *D* and *E*. Scalloping of their peripheries meets decorative requirements and provides for greater spring movement with more uniform pressure distribution.

Resilient fingers on the outer periphery of washer *P* permit application of a well balanced pressure at a relatively long distance from the center hole. It is commonly used as a ball-bearing retainer spring. Washers *Q* and *R* have modified tooth arrangements, while varieties *S* and *T* have finger arrangements which provide for maximum spring movement.

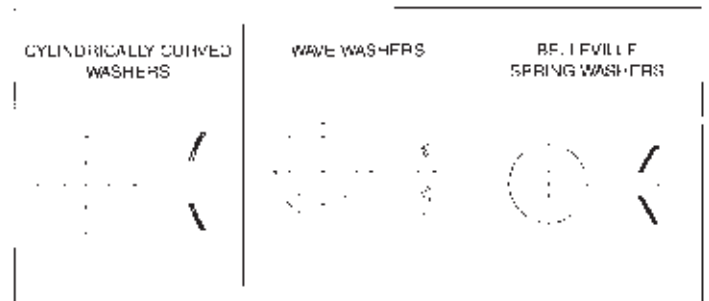
Spring Washers

Cylindrically Curved - Wave - Belleville

Spring washers are commonly used to apply a predetermined pressure on adjacent members. In bolted connections, they function to absorb any looseness due to vibration or temperature expansion. They also serve to eliminate side play in assemblies and are used with the bearings of a rotating shaft to control end pressure and end play. Vibration mountings often utilize such washers.

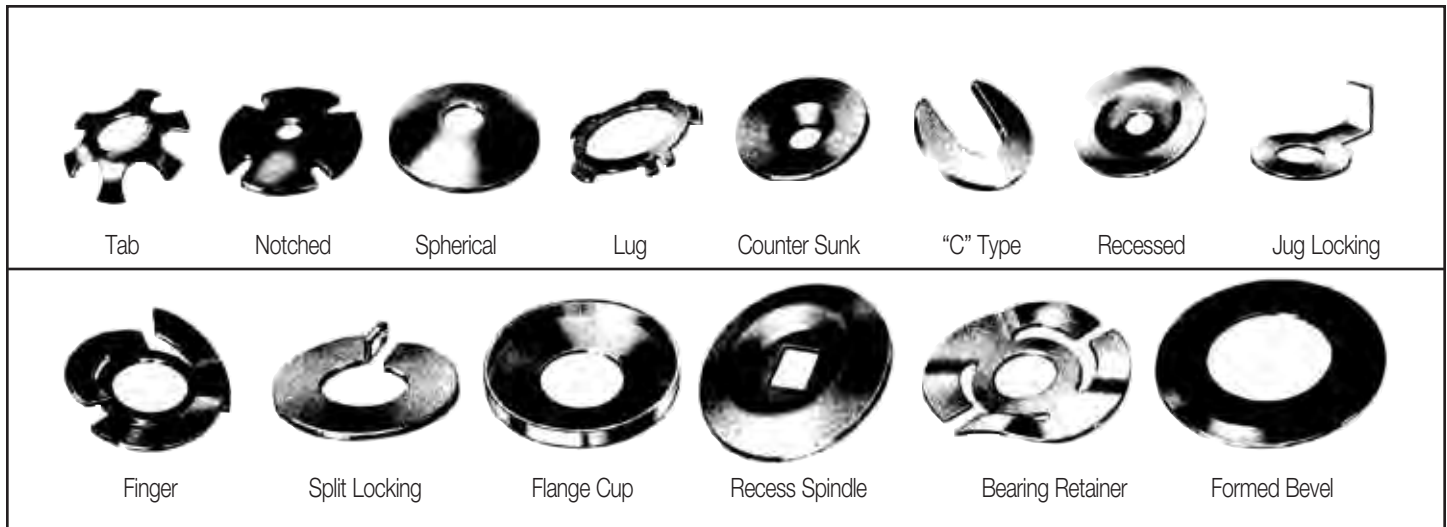
Of the many types and shapes of spring washers made, three have been developed to the point where mathematical formulas are available to accurately describe their spring characteristics. Although these three types (Cylindrically Curved, Wave and Belleville washers) have evolved independently, they cover a natural range of loading, from ounces for the cylindrically curved types to tons for the Belleville.

The trend toward smaller and more compact machinery is making spring washers more popular. Their application is expected to further increase as more designers become aware of their advantages. They offer economies, occupy little space, and weigh less than comparable wire springs.



Special Purpose Washers and Other Stamped Parts

Special purpose washers



HK Metalcraft manufactures many other types of washers than those shown. They include eccentric washers, keyway washers, oval washers and a host of others, in endless combinations.

Other stamped parts



HK Metalcraft has the facilities and equipment to handle large quantity production for a wide range of metal stampings. Tolerances and general specifications are carefully adhered to, and you can be assured of prompt deliveries.