KEYS AND KEYSEATS

ANSI Standard Keys and Keyseats.—American National Standard, B17.1 Keys and Keyseats, based on current industry practice, was approved in 1967, and reaffirmed in 1989. This standard establishes a uniform relationship between shaft sizes and key sizes for parallel and taper keys as shown in Table 1. Other data in this standard are given in Tables 2 and 3 through 7. The sizes and tolerances shown are for single key applications only.

The following definitions are given in the standard:

Key: A demountable machinery part which, when assembled into keyseats, provides a positive means for transmitting torque between the shaft and hub.

Keyseat: An axially located rectangular groove in a shaft or hub.

This standard recognizes that there are two classes of stock for parallel keys used by industry. One is a close, plus toleranced key stock and the other is a broad, negative toleranced bar stock. Based on the use of two types of stock, two classes of fit are shown:

Class 1: A clearance or metal-to-metal side fit obtained by using bar stock keys and keyseat tolerances as given in Table 4. This is a relatively free fit and applies only to parallel keys.

Class 2: A side fit, with possible interference or clearance, obtained by using key stock and keyseat tolerances as given in Table 4. This is a relatively tight fit.

Class 3: This is an interference side fit and is not tabulated in Table 4 since the degree of interference has not been standardized. However, it is suggested that the top and bottom fit range given under Class 2 in Table 4, for parallel keys be used.

Table 1. Key Size Versus Shaft Diameter *ANSI B17.1-1967 (R1998)*

Nominal Shaft Diameter		Nominal Key Size			Normal Keyseat Depth	
			Height, *H*		*H*/2	
Over	To (Incl.)	Width, *W*	Square	Rectangular	Square	Rectangular
5/16	7/16	3/32	3/32	…	3/64	…
7/16	9/16	1/8	1/8	3/32	1/16	3/64
9/16	7/8	3/16	3/16	1/8	3/32	1/16
7/8	1 1/4	1/4	1/4	3/16	1/8	3/32
1 1/4	1 3/8	5/16	5/16	1/4	5/32	1/8
1 3/8	1 3/4	3/8	3/8	1/4	3/16	1/8
1 3/4	2 1/4	1/2	1/2	3/8	1/4	3/16
2 1/4	2 3/4	5/8	5/8	7/16	5/16	7/32
2 3/4	3 1/4	3/4	3/4	1/2	3/8	1/4
3 1/4	3 3/4	7/8	7/8	5/8	7/16	5/16
3 3/4	4 1/2	1	1	3/4	1/2	3/8
4 1/2	5 1/2	1 1/4	1 1/4	7/8	5/8	7/16
5 1/2	6 1/2	1 1/2	1 1/2	1	3/4	1/2
Square Keys preferred for shaft diameters above this line; rectangular keys, below						
6 1/2	7 1/2	1 3/4	1 3/4	1 1/2[a]	7/8	3/4
7 1/2	9	2	2	1 1/2	1	3/4
9	11	2 1/2	2 1/2	1 3/4	1 1/4	7/8

[a] Some key standards show 1 1/4 inches; preferred height is 1 1/2 inches.

All dimensions are given in inches. For larger shaft sizes, see *ANSI Standard Woodruff Keys and Keyseats.*

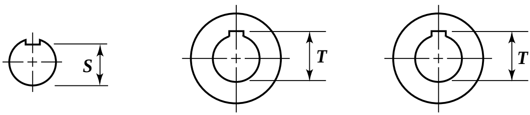
Key Size vs. Shaft Diameter: Shaft diameters are listed in Table 1 for identification of various key sizes and are not intended to establish shaft dimensions, tolerances or selections. For a stepped shaft, the size of a key is determined by the diameter of the shaft at the point of location of the key. Up through 6½-inch diameter shafts square keys are preferred; rectangular keys are preferred for larger shafts.

If special considerations dictate the use of a keyseat in the hub shallower than the preferred nominal depth shown, it is recommended that the tabulated preferred nominal standard keyseat always be used in the shaft.

Keyseat Alignment Tolerances: A tolerance of 0.010 inch, max is provided for offset (due to parallel displacement of keyseat centerline from centerline of shaft or bore) of keyseats in shaft and bore. The following tolerances for maximum lead (due to angular displacement of keyseat centerline from centerline of shaft or bore and measured at right angles to the shaft or bore centerline) of keyseats in shaft and bore are specified: 0.002 inch for keyseat length up to and including 4 inches; 0.0005 inch per inch of length for keyseat lengths above 4 inches to and including 10 inches; and 0.005 inch for keyseat lengths above 10 inches. For the effect of keyways on shaft strength, see *Effect of Keyways on Shaft Strength* on page 283.

Table 2. Depth Control Values *S* and *T* for Shaft and Hub

ANSI B17.1-1967 (R1998)



Nominal Shaft Diameter	Parallel and Taper		Parallel		Taper	
	Square	Rectangular	Square	Rectangular	Square	Rectangular
	S	*S*	*T*	*T*	*T*	*T*
1/2	0.430	0.445	0.560	0.544	0.535	0.519
9/16	0.493	0.509	0.623	0.607	0.598	0.582
5/8	0.517	0.548	0.709	0.678	0.684	0.653
11/16	0.581	0.612	0.773	0.742	0.748	0.717
3/4	0.644	0.676	0.837	0.806	0.812	0.781
13/16	0.708	0.739	0.900	0.869	0.875	0.844
7/8	0.771	0.802	0.964	0.932	0.939	0.907
15/16	0.796	0.827	1.051	1.019	1.026	0.994
1	0.859	0.890	1.114	1.083	1.089	1.058
1 1/16	0.923	0.954	1.178	1.146	1.153	1.121
1 1/8	0.986	1.017	1.241	1.210	1.216	1.185
1 3/16	1.049	1.080	1.304	1.273	1.279	1.248
1 1/4	1.112	1.144	1.367	1.336	1.342	1.311
1 5/16	1.137	1.169	1.455	1.424	1.430	1.399
1 3/8	1.201	1.232	1.518	1.487	1.493	1.462
1 7/16	1.225	1.288	1.605	1.543	1.580	1.518
1 1/2	1.289	1.351	1.669	1.606	1.644	1.581
1 9/16	1.352	1.415	1.732	1.670	1.707	1.645
1 5/8	1.416	1.478	1.796	1.733	1.771	1.708
1 11/16	1.479	1.541	1.859	1.796	1.834	1.771
1 3/4	1.542	1.605	1.922	1.860	1.897	1.835
1 13/16	1.527	1.590	2.032	1.970	2.007	1.945
1 7/8	1.591	1.654	2.096	2.034	2.071	2.009
1 15/16	1.655	1.717	2.160	2.097	2.135	2.072
2	1.718	1.781	2.223	2.161	2.198	2.136
2 1/16	1.782	1.844	2.287	2.224	2.262	2.199
2 1/8	1.845	1.908	2.350	2.288	2.325	2.263
2 3/16	1.909	1.971	2.414	2.351	2.389	2.326
2 1/4	1.972	2.034	2.477	2.414	2.452	2.389
2 5/16	1.957	2.051	2.587	2.493	2.562	2.468
2 3/8	2.021	2.114	2.651	2.557	2.626	2.532

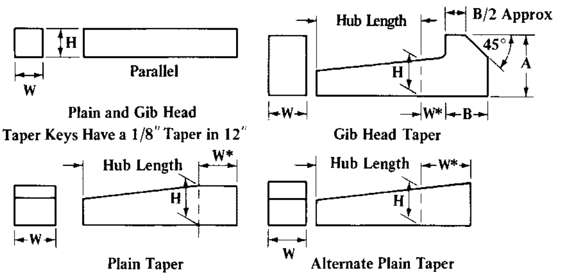
Table 2. *(Continued)* **Depth Control Values *S* and *T* for Shaft and Hub**
ANSI B17.1-1967 (R1998)

2 7/16	2.084	2.178	2.714	2.621	2.689	2.596
2 1/2	2.148	2.242	2.778	2.684	2.753	2.659
2 9/16	2.211	2.305	2.841	2.748	2.816	2.723
2 5/8	2.275	2.369	2.905	2.811	2.880	2.786
2 11/16	2.338	2.432	2.968	2.874	2.943	2.849
2 3/4	2.402	2.495	3.032	2.938	3.007	2.913
2 13/16	2.387	2.512	3.142	3.017	3.117	2.992
2 7/8	2.450	2.575	3.205	3.080	3.180	3.055
2 15/16	2.514	2.639	3.269	3.144	3.244	3.119
3	2.577	2.702	3.332	3.207	3.307	3.182
3 1/16	2.641	2.766	3.396	3.271	3.371	3.246
3 1/8	2.704	2.829	3.459	3.334	3.434	3.309
3 3/16	2.768	2.893	3.523	3.398	3.498	3.373
3 1/4	2.831	2.956	3.586	3.461	3.561	3.436
3 5/16	2.816	2.941	3.696	3.571	3.671	3.546
3 3/8	2.880	3.005	3.760	3.635	3.735	3.610
3 7/16	2.943	3.068	3.823	3.698	3.798	3.673
3 1/2	3.007	3.132	3.887	3.762	3.862	3.737
3 9/16	3.070	3.195	3.950	3.825	3.925	3.800
3 5/8	3.134	3.259	4.014	3.889	3.989	3.864
3 11/16	3.197	3.322	4.077	3.952	4.052	3.927
3 3/4	3.261	3.386	4.141	4.016	4.116	3.991
3 13/16	3.246	3.371	4.251	4.126	4.226	4.101
3 7/8	3.309	3.434	4.314	4.189	4.289	4.164
3 15/16	3.373	3.498	4.378	4.253	4.353	4.228
4	3.436	3.561	4.441	4.316	4.416	4.291
4 3/16	3.627	3.752	4.632	4.507	4.607	4.482
4 1/4	3.690	3.815	4.695	4.570	4.670	4.545
4 3/8	3.817	3.942	4.822	4.697	4.797	4.672
4 7/16	3.880	4.005	4.885	4.760	4.860	4.735
4 1/2	3.944	4.069	4.949	4.824	4.924	4.799
4 3/4	4.041	4.229	5.296	5.109	5.271	5.084
4 7/8	4.169	4.356	5.424	5.236	5.399	5.211
4 15/16	4.232	4.422	5.487	5.300	5.462	5.275
5	4.296	4.483	5.551	5.363	5.526	5.338
5 3/16	4.486	4.674	5.741	5.554	5.716	5.529
5 1/4	4.550	4.737	5.805	5.617	5.780	5.592
5 7/16	4.740	4.927	5.995	5.807	5.970	5.782
5 1/2	4.803	4.991	6.058	5.871	6.033	5.846
5 3/4	4.900	5.150	6.405	6.155	6.380	6.130
5 15/16	5.091	5.341	6.596	6.346	6.571	6.321
6	5.155	5.405	6.660	6.410	6.635	6.385
6 1/4	5.409	5.659	6.914	6.664	6.889	6.639
6 1/2	5.662	5.912	7.167	6.917	7.142	6.892
6 3/4	5.760	[a]5.885	7.515	[a]7.390	7.490	[a]7.365
7	6.014	[a]6.139	7.769	[a]7.644	7.744	[a]7.619
7 1/4	6.268	[a]6.393	8.023	[a]7.898	7.998	[a]7.873
7 1/2	6.521	[a]6.646	8.276	[a]8.151	8.251	[a]8.126
7 3/4	6.619	6.869	8.624	8.374	8.599	8.349
8	6.873	7.123	8.878	8.628	8.853	8.603
9	7.887	8.137	9.892	9.642	9.867	9.617
10	8.591	8.966	11.096	10.721	11.071	10.696
11	9.606	9.981	12.111	11.736	12.086	11.711
12	10.309	10.809	13.314	12.814	13.289	12.789
13	11.325	11.825	14.330	13.830	14.305	13.805
14	12.028	12.528	15.533	15.033	15.508	15.008
15	13.043	13.543	16.548	16.048	16.523	16.023

[a] 1 3/4 × 1 1/2 inch key.

All dimensions are given in inches. See Table 4 for tolerances.

Table 3. ANSI Standard Plain and Gib Head Keys *ANSI B17.1-1967 (R1998)*



Key			Nominal Key Size Width *W* Over	To (Incl.)	Tolerance Width, *W*		Height, *H*	
Parallel	Square	Keystock	…	1 1/4	+0.001	−0.000	+0.001	−0.000
			1 1/4	3	+0.002	−0.000	+0.002	−0.000
			3	3 1/2	+0.003	−0.000	+0.003	−0.000
		Bar Stock	…	3/4	+0.000	−0.002	+0.000	−0.002
			3/4	1 1/2	+0.000	−0.003	+0.000	−0.003
			1 1/2	2 1/2	+0.000	−0.004	+0.000	−0.004
			2 1/2	3 1/2	+0.000	−0.006	+0.000	−0.006
	Rectangular	Keystock	…	1 1/4	+0.001	−0.000	+0.005	−0.005
			1 1/4	3	+0.002	−0.000	+0.005	−0.005
			3	7	+0.003	−0.000	+0.005	−0.005
		Bar Stock	…	3/4	+0.000	−0.003	+0.000	−0.003
			3/4	1 1/2	+0.000	−0.004	+0.000	−0.004
			1 1/2	3	+0.000	−0.005	+0.000	−0.005
			3	4	+0.000	−0.006	+0.000	−0.006
			4	6	+0.000	−0.008	+0.000	−0.008
			6	7	+0.000	−0.013	+0.000	−0.013
Taper	Plain or Gib Head Square or Rectangular		…	1 1/4	+0.001	−0.000	+0.005	−0.000
			1 1/4	3	+0.002	−0.000	+0.005	−0.000
			3	7	+0.003	−0.000	+0.005	−0.000

Gib Head Nominal Dimensions													
Nominal Key Size Width, *W*	Square *H*	*A*	*B*	Rectangular *H*	*A*	*B*	Nominal Key Size Width, *W*	Square *H*	*A*	*B*	Rectangular *H*	*A*	*B*
1/8	1/8	1/4	1/4	3/32	3/16	1/8	1	1	1 5/8	1 1/8	3/4	1 1/4	7/8
3/16	3/16	5/16	5/16	1/8	1/4	1/4	1 1/4	1 1/4	2	1 7/16	7/8	1 3/8	1
1/4	1/4	7/16	3/8	3/16	5/16	5/16	1 1/2	1 1/2	2 3/8	1 3/4	1	1 5/8	1 1/8
5/16	5/16	1/2	7/16	1/4	7/16	3/8	1 3/4	1 3/4	2 3/4	2	1 1/2	2 3/8	1 3/4
3/8	3/8	5/8	1/2	1/4	7/16	3/8	2	2	3 1/2	2 1/4	1 1/2	2 3/8	1 3/4
1/2	1/2	7/8	5/8	3/8	5/8	1/2	2 1/2	2 1/2	4	3	1 3/4	2 3/4	2
5/8	5/8	1	3/4	7/16	3/4	9/16	3	3	5	3 1/2	2	3 1/2	2 1/4
3/4	3/4	1 1/4	7/8	1/2	7/8	5/8	3 1/2	3 1/2	6	4	2 1/2	4	3
7/8	7/8	1 3/8	1	5/8	1	3/4	…	…	…	…	…	…	…

All dimensions are given in inches.

*For locating position of dimension *H*. Tolerance does not apply.

For larger sizes the following relationships are suggested as guides for establishing *A* and *B*: $A = 1.8H$ and $B = 1.2H$.

Table 4. ANSI Standard Fits for Parallel and Taper Keys *ANSI B17.1-1967 (R1998)*

Type of Key	Key Width		Side Fit			Top and Bottom Fit			
			Width Tolerance			Depth Tolerance			
	Over	To (Incl.)	Key	Key-Seat	Fit Range[a]	Key	Shaft Key-Seat	Hub Key-Seat	Fit Range[a]
Class 1 Fit for Parallel Keys									
Square	…	½	+0.000	+0.002	0.004 CL	+0.000	+0.000	+0.010	0.032 CL
			−0.002	−0.000	0.000	−0.002	−0.015	−0.000	0.005 CL
	½	¾	+0.000	+0.003	0.005 CL	+0.000	+0.000	+0.010	0.032 CL
			−0.002	−0.000	0.000	−0.002	−0.015	−0.000	0.005 CL
	¾	1	+0.000	+0.003	0.006 CL	+0.000	+0.000	+0.010	0.033 CL
			−0.003	−0.000	0.000	−0.003	−0.015	−0.000	0.005 CL
	1	1½	+0.000	+0.004	0.007 CL	+0.000	+0.000	+0.010	0.033 CL
			−0.003	−0.000	0.000	−0.003	−0.015	−0.000	0.005 CL
	1½	2½	+0.000	+0.004	0.008 CL	+0.000	+0.000	+0.010	0.034 CL
			−0.004	−0.000	0.000	−0.004	−0.015	−0.000	0.005 CL
	2½	3½	+0.000	+0.004	0.010 CL	+0.000	+0.000	+0.010	0.036 CL
			−0.006	−0.000	0.000	−0.006	−0.015	−0.000	0.005 CL
Rectan-gular	…	½	+0.000	+0.002	0.005 CL	+0.000	+0.000	+0.010	0.033 CL
			−0.003	−0.000	0.000	−0.003	−0.015	−0.000	0.005 CL
	½	¾	+0.000	+0.003	0.006 CL	+0.000	+0.000	+0.010	0.033 CL
			−0.003	−0.000	0.000	−0.003	−0.015	−0.000	0.005 CL
	¾	1	+0.000	+0.003	0.007 CL	+0.000	+0.000	+0.010	0.034 CL
			−0.004	−0.000	0.000	−0.004	−0.015	−0.000	0.005 CL
	1	1½	+0.000	+0.004	0.008 CL	+0.000	+0.000	+0.010	0.034 CL
			−0.004	−0.000	0.000	−0.004	−0.015	−0.000	0.005 CL
	1½	3	+0.000	+0.004	0.009 CL	+0.000	+0.000	+0.010	0.035 CL
			−0.005	−0.000	0.000	−0.005	−0.015	−0.000	0.005 CL
	3	4	+0.000	+0.004	0.010 CL	+0.000	+0.000	+0.010	0.036 CL
			−0.006	−0.000	0.000	−0.006	−0.015	−0.000	0.005 CL
	4	6	+0.000	+0.004	0.012 CL	+0.000	+0.000	+0.010	0.038 CL
			−0.008	−0.000	0.000	−0.008	−0.015	−0.000	0.005 CL
	6	7	+0.000	+0.004	0.017 CL	+0.000	+0.000	+0.010	0.043 CL
			−0.013	−0.000	0.000	−0.013	−0.015	−0.000	0.005 CL
Class 2 Fit for Parallel and Taper Keys									
Parallel Square	…	1¼	+0.001	+0.002	0.002 CL	+0.001	+0.000	+0.010	0.030 CL
			−0.000	−0.000	0.001 INT	−0.000	−0.015	−0.000	0.004 CL
	1¼	3	+0.002	+0.002	0.002 CL	+0.002	+0.000	+0.010	0.030 CL
			−0.000	−0.000	0.002 INT	−0.000	−0.015	−0.000	0.003 CL
	3	3½	+0.003	+0.002	0.002 CL	+0.003	+0.000	+0.010	0.030 CL
			−0.000	−0.000	0.003 INT	−0.000	−0.015	−0.000	0.002 CL
Parallel Rectan-gular	…	1¼	+0.001	+0.002	0.002 CL	+0.005	+0.000	+0.010	0.035 CL
			−0.000	−0.000	0.001 INT	−0.005	−0.015	−0.000	0.000 CL
	1¼	3	+0.002	+0.002	0.002 CL	+0.005	+0.000	+0.010	0.035 CL
			−0.000	−0.000	0.002 INT	−0.005	−0.015	−0.000	0.000 CL
	3	7	+0.003	+0.002	0.002 CL	+0.005	+0.000	+0.010	0.035 CL
			−0.000	−0.000	0.003 INT	−0.005	−0.015	−0.000	0.000 CL
Taper	…	1¼	+0.001	+0.002	0.002 CL	+0.005	+0.000	+0.010	0.005 CL
			−0.000	−0.000	0.001 INT	−0.000	−0.015	−0.000	0.025 INT
	1¼	3	+0.002	+0.002	0.002 CL	+0.005	+0.000	+0.010	0.005 CL
			−0.000	−0.000	0.002 INT	−0.000	−0.015	−0.000	0.025 INT
	3	[b]	+0.003	+0.002	0.002 CL	+0.005	+0.000	+0.010	0.005 CL
			−0.000	−0.000	0.003 INT	−0.000	−0.015	−0.000	0.025 INT

[a] Limits of variation. CL = Clearance; INT = Interference.
[b] To (Incl.) 3½-inch Square and 7-inch Rectangular key widths.

All dimensions are given in inches. See also text on page 2342.

Table 5. Suggested Keyseat Fillet Radius and Key Chamfer
ANSI B17.1-1967 (R1998)

Keyseat Depth, *H*/2		Fillet Radius	45 deg. Chamfer	Keyseat Depth, *H*2		Fillet Radius	45 deg. Chamfer
Over	To (Incl.)			Over	To (Incl.)		
1⁄8	1⁄4	1⁄32	3⁄64	7⁄8	1 1⁄4	3⁄16	7⁄32
1⁄4	1⁄2	1⁄16	5⁄64	1 1⁄4	1 3⁄4	1⁄4	9⁄32
1⁄2	7⁄8	1⁄8	5⁄32	1 3⁄4	2 1⁄2	3⁄8	13⁄32

All dimensions are given in inches.

Table 6. ANSI Standard Keyseat Tolerances for Electric Motor and Generator Shaft Extensions *ANSI B17.1-1967 (R1998)*

Keyseat Width		Width Tolerance	Depth Tolerance
Over	To (Incl.)		
…	1⁄4	+0.001 –0.001	+0.000 –0.015
1⁄4	3⁄4	+0.000 –0.002	+0.000 –0.015
3⁄4	1 1⁄4	+0.000 –0.003	+0.000 –0.015

All dimensions are given in inches.

Table 7. Set Screws for Use Over Keys *ANSI B17.1-1967 (R1998)*

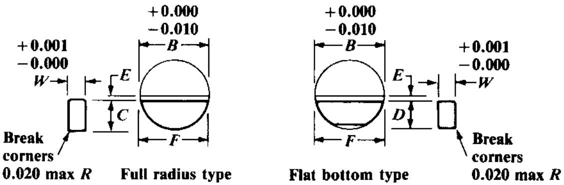
Nom. Shaft Diam.		Nom. Key Width	Set Screw Diam.	Nom. Shaft Diam.		Nom. Key Width	Set Screw Diam.
Over	To (Incl.)			Over	To (Incl.)		
5⁄16	7⁄16	3⁄32	No. 10	2 1⁄4	2 3⁄4	5⁄8	1⁄2
7⁄16	9⁄16	1⁄8	No. 10	2 3⁄4	3 1⁄4	3⁄4	5⁄8
9⁄16	7⁄8	3⁄16	1⁄4	3 1⁄4	3 3⁄4	7⁄8	3⁄4
7⁄8	1 1⁄4	1⁄4	5⁄16	3 3⁄4	4 1⁄2	1	3⁄4
1 1⁄4	1 3⁄8	5⁄16	3⁄8	4 1⁄2	5 1⁄2	1 1⁄4	7⁄8
1 3⁄8	1 3⁄4	3⁄8	3⁄8	5 1⁄2	6 1⁄2	1 1⁄2	1
1 3⁄4	2 1⁄4	1⁄2	1⁄2	…	…	…	…

All dimensions are given in inches.

These set screw diameter selections are offered as a guide but their use should be dependent upon design considerations.

ANSI Standard Woodruff Keys and Keyseats.—American National Standard B17.2 was approved in 1967, and reaffirmed in 1990. Data from this standard are shown in Tables 8, 9, and 10.

Table 8. ANSI Standard Woodruff Keys *ANSI B17.2-1967 (R1998)*

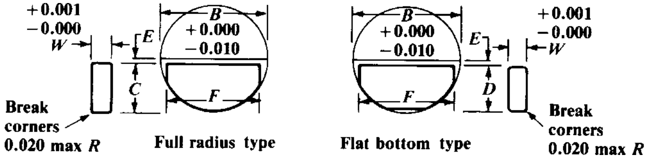


Key No.	Nominal Key Size W X B	Actual Length F +0.000 −0.010	Height of Key C Max.	C Min.	D Max.	D Min.	Distance Below Center E
202	1/16 × 1/4	0.248	0.109	0.104	0.109	0.104	1/64
202.5	1/16 × 5/16	0.311	0.140	0.135	0.140	0.135	1/64
302.5	3/32 × 5/16	0.311	0.140	0.135	0.140	0.135	1/64
203	1/16 × 3/8	0.374	0.172	0.167	0.172	0.167	1/64
303	3/32 × 3/8	0.374	0.172	0.167	0.172	0.167	1/64
403	1/8 × 3/8	0.374	0.172	0.167	0.172	0.167	1/64
204	1/16 × 1/2	0.491	0.203	0.198	0.194	0.188	3/64
304	3/32 × 1/2	0.491	0.203	0.198	0.194	0.188	3/64
404	1/8 × 1/2	0.491	0.203	0.198	0.194	0.188	3/64
305	3/32 × 5/8	0.612	0.250	0.245	0.240	0.234	1/16
405	1/8 × 5/8	0.612	0.250	0.245	0.240	0.234	1/16
505	5/32 × 5/8	0.612	0.250	0.245	0.240	0.234	1/16
605	3/16 × 5/8	0.612	0.250	0.245	0.240	0.234	1/16
406	1/8 × 3/4	0.740	0.313	0.308	0.303	0.297	1/16
506	5/32 × 3/4	0.740	0.313	0.308	0.303	0.297	1/16
606	3/16 × 3/4	0.740	0.313	0.308	0.303	0.297	1/16
806	1/4 × 3/4	0.740	0.313	0.308	0.303	0.297	1/16
507	5/32 × 7/8	0.866	0.375	0.370	0.365	0.359	1/16
607	3/16 × 7/8	0.866	0.375	0.370	0.365	0.359	1/16
707	7/32 × 7/8	0.866	0.375	0.370	0.365	0.359	1/16
807	1/4 × 7/8	0.866	0.375	0.370	0.365	0.359	1/16
608	3/16 × 1	0.992	0.438	0.433	0.428	0.422	1/16
708	7/32 × 1	0.992	0.438	0.433	0.428	0.422	1/16
808	1/4 × 1	0.992	0.438	0.433	0.428	0.422	1/16
1008	5/16 × 1	0.992	0.438	0.433	0.428	0.422	1/16
1208	3/8 × 1	0.992	0.438	0.433	0.428	0.422	1/16
609	3/16 × 1 1/8	1.114	0.484	0.479	0.475	0.469	5/64
709	7/32 × 1 1/8	1.114	0.484	0.479	0.475	0.469	5/64
809	1/4 × 1 1/8	1.114	0.484	0.479	0.475	0.469	5/64
1009	5/16 × 1 1/8	1.114	0.484	0.479	0.475	0.469	5/64
610	3/16 × 1 1/4	1.240	0.547	0.542	0.537	0.531	5/64
710	7/32 × 1 1/4	1.240	0.547	0.542	0.537	0.531	5/64
810	1/4 × 1 1/4	1.240	0.547	0.542	0.537	0.531	5/64
1010	5/16 × 1 1/4	1.240	0.547	0.542	0.537	0.531	5/64
1210	3/8 × 1 1/4	1.240	0.547	0.542	0.537	0.531	5/64
811	1/4 × 1 3/8	1.362	0.594	0.589	0.584	0.578	3/32
1011	5/16 × 1 3/8	1.362	0.594	0.589	0.584	0.578	3/32
1211	3/8 × 1 3/8	1.362	0.594	0.589	0.584	0.578	3/32
812	1/4 × 1 1/2	1.484	0.641	0.636	0.631	0.625	7/64
1012	5/16 × 1 1/2	1.484	0.641	0.636	0.631	0.625	7/64
1212	3/8 × 1 1/2	1.484	0.641	0.636	0.631	0.625	7/64

All dimensions are given in inches.

The Key numbers indicate normal key dimensions. The last two digits give the nominal diameter *B* in eighths of an inch and the digits preceding the last two give the nominal width *W* in thirty-seconds of an inch.

Table 9. ANSI Standard Woodruff Keys *ANSI B17.2-1967 (R1998)*



Key No.	Nominal Key Size $W \times B$	Actual Length F +0.000 −0.010	Height of Key C Max.	Height of Key C Min.	Height of Key D Max.	Height of Key D Min.	Distance Below Center E
617-1	$\frac{3}{16} \times 2\frac{1}{8}$	1.380	0.406	0.401	0.396	0.390	$\frac{21}{32}$
817-1	$\frac{1}{4} \times 2\frac{1}{8}$	1.380	0.406	0.401	0.396	0.390	$\frac{21}{32}$
1017-1	$\frac{5}{16} \times 2\frac{1}{8}$	1.380	0.406	0.401	0.396	0.390	$\frac{21}{32}$
1217-1	$\frac{3}{8} \times 2\frac{1}{8}$	1.380	0.406	0.401	0.396	0.390	$\frac{21}{32}$
617	$\frac{3}{16} \times 2\frac{1}{8}$	1.723	0.531	0.526	0.521	0.515	$\frac{17}{32}$
817	$\frac{1}{4} \times 2\frac{1}{8}$	1.723	0.531	0.526	0.521	0.515	$\frac{17}{32}$
1017	$\frac{5}{16} \times 2\frac{1}{8}$	1.723	0.531	0.526	0.521	0.515	$\frac{17}{32}$
1217	$\frac{3}{8} \times 2\frac{1}{8}$	1.723	0.531	0.526	0.521	0.515	$\frac{17}{32}$
822-1	$\frac{1}{4} \times 2\frac{3}{4}$	2.000	0.594	0.589	0.584	0.578	$\frac{25}{32}$
1022-1	$\frac{5}{16} \times 2\frac{3}{4}$	2.000	0.594	0.589	0.584	0.578	$\frac{25}{32}$
1222-1	$\frac{3}{8} \times 2\frac{3}{4}$	2.000	0.594	0.589	0.584	0.578	$\frac{25}{32}$
1422-1	$\frac{7}{16} \times 2\frac{3}{4}$	2.000	0.594	0.589	0.584	0.578	$\frac{25}{32}$
1622-1	$\frac{1}{2} \times 2\frac{3}{4}$	2.000	0.594	0.589	0.584	0.578	$\frac{25}{32}$
822	$\frac{1}{4} \times 2\frac{3}{4}$	2.317	0.750	0.745	0.740	0.734	$\frac{5}{8}$
1022	$\frac{5}{16} \times 2\frac{3}{4}$	2.317	0.750	0.745	0.740	0.734	$\frac{5}{8}$
1222	$\frac{3}{8} \times 2\frac{3}{4}$	2.317	0.750	0.745	0.740	0.734	$\frac{5}{8}$
1422	$\frac{7}{16} \times 2\frac{3}{4}$	2.317	0.750	0.745	0.740	0.734	$\frac{5}{8}$
1622	$\frac{1}{2} \times 2\frac{3}{4}$	2.317	0.750	0.745	0.740	0.734	$\frac{5}{8}$
1228	$\frac{3}{8} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$
1428	$\frac{7}{16} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$
1628	$\frac{1}{2} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$
1828	$\frac{9}{16} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$
2028	$\frac{5}{8} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$
2228	$\frac{11}{16} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$
2428	$\frac{3}{4} \times 3\frac{1}{2}$	2.880	0.938	0.933	0.928	0.922	$\frac{13}{16}$

All dimensions are given in inches.

The key numbers indicate nominal key dimensions. The last two digits give the nominal diameter *B* in eighths of an inch and the digits preceding the last two give the nominal width *W* in thirty-seconds of an inch.

The key numbers with the −1 designation, while representing the nominal key size have a shorter length *F* and due to a greater distance below center *E* are less in height than the keys of the same number without the −1 designation.

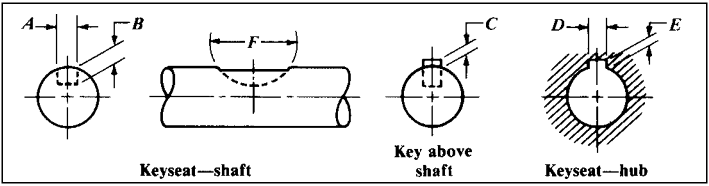


Table 10. ANSI Keyseat Dimensions for Woodruff Keys

ANSI B17.2-1967 (R1998)

Key No.	Nominal Size Key	Keyseat—Shaft					Key Above Shaft	Keyseat—Hub	
		Width *A*[a]		Depth *B*	Diameter *F*		Height *C*	Width *D*	Depth *E*
		Min.	Max.	+0.005 −0.000	Min.	Max.	+0.005 −0.005	+0.002 −0.000	+0.005 −0.000
202	1/16 × 1/4	0.0615	0.0630	0.0728	0.250	0.268	0.0312	0.0635	0.0372
202.5	1/16 × 5/16	0.0615	0.0630	0.1038	0.312	0.330	0.0312	0.0635	0.0372
302.5	3/32 × 5/16	0.0928	0.0943	0.0882	0.312	0.330	0.0469	0.0948	0.0529
203	1/16 × 3/8	0.0615	0.0630	0.1358	0.375	0.393	0.0312	0.0635	0.0372
303	3/32 × 3/8	0.0928	0.0943	0.1202	0.375	0.393	0.0469	0.0948	0.0529
403	1/8 × 3/8	0.1240	0.1255	0.1045	0.375	0.393	0.0625	0.1260	0.0685
204	1/16 × 1/2	0.0615	0.0630	0.1668	0.500	0.518	0.0312	0.0635	0.0372
304	3/32 × 1/2	0.0928	0.0943	0.1511	0.500	0.518	0.0469	0.0948	0.0529
404	1/8 × 1/2	0.1240	0.1255	0.1355	0.500	0.518	0.0625	0.1260	0.0685
305	3/32 × 5/8	0.0928	0.0943	0.1981	0.625	0.643	0.0469	0.0948	0.0529
405	1/8 × 5/8	0.1240	0.1255	0.1825	0.625	0.643	0.0625	0.1260	0.0685
505	5/32 × 5/8	0.1553	0.1568	0.1669	0.625	0.643	0.0781	0.1573	0.0841
605	3/16 × 5/8	0.1863	0.1880	0.1513	0.625	0.643	0.0937	0.1885	0.0997
406	1/8 × 3/4	0.1240	0.1255	0.2455	0.750	0.768	0.0625	0.1260	0.0685
506	5/32 × 3/4	0.1553	0.1568	0.2299	0.750	0.768	0.0781	0.1573	0.0841
606	3/16 × 3/4	0.1863	0.1880	0.2143	0.750	0.768	0.0937	0.1885	0.0997
806	1/4 × 3/4	0.2487	0.2505	0.1830	0.750	0.768	0.1250	0.2510	0.1310
507	5/32 × 7/8	0.1553	0.1568	0.2919	0.875	0.895	0.0781	0.1573	0.0841
607	3/16 × 7/8	0.1863	0.1880	0.2763	0.875	0.895	0.0937	0.1885	0.0997
707	7/32 × 7/8	0.2175	0.2193	0.2607	0.875	0.895	0.1093	0.2198	0.1153
807	1/4 × 7/8	0.2487	0.2505	0.2450	0.875	0.895	0.1250	0.2510	0.1310
608	3/16 × 1	0.1863	0.1880	0.3393	1.000	1.020	0.0937	0.1885	0.0997
708	7/32 × 1	0.2175	0.2193	0.3237	1.000	1.020	0.1093	0.2198	0.1153
808	1/4 × 1	0.2487	0.2505	0.3080	1.000	1.020	0.1250	0.2510	0.1310
1008	5/16 × 1	0.3111	0.3130	0.2768	1.000	1.020	0.1562	0.3135	0.1622
1208	3/8 × 1	0.3735	0.3755	0.2455	1.000	1.020	0.1875	0.3760	0.1935
609	3/16 × 1 1/8	0.1863	0.1880	0.3853	1.125	1.145	0.0937	0.1885	0.0997
709	7/32 × 1 1/8	0.2175	0.2193	0.3697	1.125	1.145	0.1093	0.2198	0.1153
809	1/4 × 1 1/8	0.2487	0.2505	0.3540	1.125	1.145	0.1250	0.2510	0.1310
1009	5/16 × 1 1/8	0.3111	0.3130	0.3228	1.125	1.145	0.1562	0.3135	0.1622
610	3/16 × 1 1/4	0.1863	0.1880	0.4483	1.250	1.273	0.0937	0.1885	0.0997
710	7/32 × 1 1/4	0.2175	0.2193	0.4327	1.250	1.273	0.1093	0.2198	0.1153
810	1/4 × 1 1/4	0.2487	0.2505	0.4170	1.250	1.273	0.1250	0.2510	0.1310
1010	5/16 × 1 1/4	0.3111	0.3130	0.3858	1.250	1.273	0.1562	0.3135	0.1622
1210	3/8 × 1 1/4	0.3735	0.3755	0.3545	1.250	1.273	0.1875	0.3760	0.1935
811	1/4 × 1 3/8	0.2487	0.2505	0.4640	1.375	1.398	0.1250	0.2510	0.1310
1011	5/16 × 1 3/8	0.3111	0.3130	0.4328	1.375	1.398	0.1562	0.3135	0.1622

Table 10. *(Continued)* **ANSI Keyseat Dimensions for Woodruff Keys**
ANSI B17.2-1967 (R1998)

Key No.	Nominal Size Key	Keyseat—Shaft					Key Above Shaft	Keyseat—Hub	
		Width *A*[a]		Depth *B*	Diameter *F*		Height *C*	Width *D*	Depth *E*
		Min.	Max.	+0.005 −0.000	Min.	Max.	+0.005 −0.005	+0.002 −0.000	+0.005 −0.000
1211	3/8 × 1 3/8	0.3735	0.3755	0.4015	1.375	1.398	0.1875	0.3760	0.1935
812	1/4 × 1 1/2	0.2487	0.2505	0.5110	1.500	1.523	0.1250	0.2510	0.1310
1012	5/16 × 1 1/2	0.3111	0.3130	0.4798	1.500	1.523	0.1562	0.3135	0.1622
1212	3/8 × 1 1/2	0.3735	0.3755	0.4485	1.500	1.523	0.1875	0.3760	0.1935
617-1	3/16 × 2 1/8	0.1863	0.1880	0.3073	2.125	2.160	0.0937	0.1885	0.0997
817-1	1/4 × 2 1/8	0.2487	0.2505	0.2760	2.125	2.160	0.1250	0.2510	0.1310
1017-1	5/16 × 2 1/8	0.3111	0.3130	0.2448	2.125	2.160	0.1562	0.3135	0.1622
1217-1	3/8 × 2 1/8	0.3735	0.3755	0.2135	2.125	2.160	0.1875	0.3760	0.1935
617	3/16 × 2 1/8	0.1863	0.1880	0.4323	2.125	2.160	0.0937	0.1885	0.0997
817	1/4 × 2 1/8	0.2487	0.2505	0.4010	2.125	2.160	0.1250	0.2510	0.1310
1017	5/16 × 2 1/8	0.3111	0.3130	0.3698	2.125	2.160	0.1562	0.3135	0.1622
1217	3/8 × 2 1/8	0.3735	0.3755	0.3385	2.125	2.160	0.1875	0.3760	0.1935
822-1	1/4 × 2 3/4	0.2487	0.2505	0.4640	2.750	2.785	0.1250	0.2510	0.1310
1022-1	5/16 × 2 3/4	0.3111	0.3130	0.4328	2.750	2.785	0.1562	0.3135	0.1622
1222-1	3/8 × 2 3/4	0.3735	0.3755	0.4015	2.750	2.785	0.1875	0.3760	0.1935
1422-1	7/16 × 2 3/4	0.4360	0.4380	0.3703	2.750	2.785	0.2187	0.4385	0.2247
1622-1	1/2 × 2 3/4	0.4985	0.5005	0.3390	2.750	2.785	0.2500	0.5010	0.2560
822	1/4 × 2 3/4	0.2487	0.2505	0.6200	2.750	2.785	0.1250	0.2510	0.1310
1022	5/16 × 2 3/4	0.3111	0.3130	0.5888	2.750	2.785	0.1562	0.3135	0.1622
1222	3/8 × 2 3/4	0.3735	0.3755	0.5575	2.750	2.785	0.1875	0.3760	0.1935
1422	7/16 × 2 3/4	0.4360	0.4380	0.5263	2.750	2.785	0.2187	0.4385	0.2247
1622	1/2 × 2 3/4	0.4985	0.5005	0.4950	2.750	2.785	0.2500	0.5010	0.2560
1228	3/8 × 3 1/2	0.3735	0.3755	0.7455	3.500	3.535	0.1875	0.3760	0.1935
1428	7/16 × 3 1/2	0.4360	0.4380	0.7143	3.500	3.535	0.2187	0.4385	0.2247
1628	1/2 × 3 1/2	0.4985	0.5005	0.6830	3.500	3.535	0.2500	0.5010	0.2560
1828	9/16 × 3 1/2	0.5610	0.5630	0.6518	3.500	3.535	0.2812	0.5635	0.2872
2028	5/8 × 3 1/2	0.6235	0.6255	0.6205	3.500	3.535	0.3125	0.6260	0.3185
2228	11/16 × 3 1/2	0.6860	0.6880	0.5893	3.500	3.535	0.3437	0.6885	0.3497
2428	3/4 × 3 1/2	0.7485	0.7505	0.5580	3.500	3.535	0.3750	0.7510	0.3810

[a] These Width *A* values were set with the maximum keyseat (shaft) width as that figure which will receive a key with the greatest amount of looseness consistent with assuring the key's sticking in the keyseat (shaft). Minimum keyseat width is that figure permitting the largest shaft distortion acceptable when assembling maximum key in minimum keyseat.Dimensions *A*, *B*, *C*, *D* are taken at side intersection.

All dimensions are given in inches.

The following definitions are given in this standard:

Woodruff Key: A Remountable machinery part which, when assembled into key-seats, provides a positive means for transmitting torque between the shaft and hub.

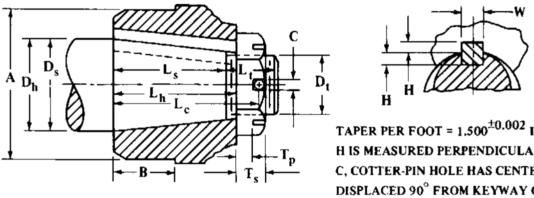
Woodruff Key Number: An identification number by which the size of key may be readily determined.

Woodruff Keyseat—Shaft: The circular pocket in which the key is retained.

Woodruff Keyseat—Hub: An axially located rectangular groove in a hub. (This has been referred to as a keyway.)

Woodruff Keyseat Milling Cutter: An arbor type or shank type milling cutter normally used for milling Woodruff keyseats in shafts.

Taper Shaft Ends with Slotted Nuts *SAE Standard*



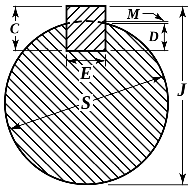
Nom. Diam.	Diam. of Shaft, D_s		Diam. of Hole, D_h		L_c	L_s	L_h	L_t	T_s	T_p	Nut Width, Flats
	Max.	Min.	Max.	Min.							
1/4	0.250	0.249	0.248	0.247	9/16	5/16	3/8	5/16	7/32	9/64	5/16
3/8	0.375	0.374	0.373	0.372	47/64	7/16	1/2	23/64	17/64	3/16	1/2
1/2	0.500	0.499	0.498	0.497	63/64	11/16	3/4	23/64	17/64	3/16	1/2
5/8	0.625	0.624	0.623	0.622	1 3/32	11/16	3/4	17/32	7/16	1/4	3/4
3/4	0.750	0.749	0.748	0.747	1 11/32	15/16	1	17/32	7/16	1/4	3/4
7/8	0.875	0.874	0.873	0.872	1 11/16	1 1/8	1 1/4	11/16	1/2	5/16	15/16
1	1.001	0.999	0.997	0.995	1 15/16	1 3/8	1 1/2	11/16	1/2	5/16	1 1/16
1 1/8	1.126	1.124	1.122	1.120	1 15/16	1 3/8	1 1/2	11/16	1/2	5/16	1 1/4
1 1/4	1.251	1.249	1.247	1.245	1 15/16	1 3/8	1 1/2	11/16	1/2	5/16	1 7/16
1 3/8	1.376	1.374	1.372	1.370	2 7/16	1 7/8	2	11/16	1/2	5/16	1 7/16
1 1/2	1.501	1.499	1.497	1.495	2 7/16	1 7/8	2	11/16	1/2	5/16	1 7/16
1 5/8	1.626	1.624	1.622	1.620	2 13/16	2 1/8	2 1/4	13/16	5/8	7/16	2 3/16
1 3/4	1.751	1.749	1.747	1.745	2 13/16	2 1/8	2 1/4	13/16	5/8	7/16	2 3/16
1 7/8	1.876	1.874	1.872	1.870	3 1/16	2 3/8	2 1/2	13/16	5/8	7/16	2 3/16
2	2.001	1.999	1.997	1.995	3 9/16	2 7/8	3	13/16	5/8	7/16	2 3/16
2 1/4	2.252	2.248	2.245	2.242	3 9/16	2 7/8	3	13/16	5/8	7/16	2 3/8
2 1/2	2.502	2.498	2.495	2.492	4 9/32	3 3/8	3 1/2	1 1/4	1	5/8	3 1/8
2 3/4	2.752	2.748	2.745	2.742	4 9/32	3 3/8	3 1/2	1 1/4	1	5/8	3 1/8
3	3.002	2.998	2.995	2.992	2 25/32	3 7/8	4	1 1/4	1	5/8	3 1/8
3 1/4	3.252	3.248	3.245	3.242	5 1/32	4 1/8	4 1/4	1 1/4	1	5/8	3 1/8
3 1/2	3.502	3.498	3.495	3.492	5 7/16	4 3/8	4 1/2	1 3/8	1 1/8	3/4	3 7/8
4	4.002	3.998	3.995	3.992	6 7/16	5 3/8	5 1/2	1 3/8	1 1/8	3/4	3 7/8

Nom. Diam.	D_t	Thds. per Inch	Keyway				Square Key		*A*	*B*	*C*
			W		*H*						
			Max.	Min.	Max.	Min.	Max.	Min.			
1/4	#10	40	0.0625	.0615	.037	.033	0.0635	0.0625	1/2	3/16	5/64
3/8	5/16	32	0.0937	.0927	.053	.049	0.0947	0.0937	11/16	1/4	5/64
1/2	5/16	32	0.1250	.1240	.069	.065	0.1260	0.1250	7/8	3/8	5/64
5/8	1/2	28	0.1562	.1552	.084	.080	0.1572	0.1562	1 1/16	3/8	1/8
3/4	1/2	28	0.1875	.1865	.100	.096	0.1885	0.1875	1 1/4	5/8	1/8
7/8	5/8	24	0.2500	.2490	.131	.127	0.2510	0.2500	1 1/2	3/4	5/32
1	3/4	20	0.2500	.2490	.131	.127	0.2510	0.2500	1 3/4	7/8	5/32
1 1/8	7/8	20	0.3125	.3115	.162	.158	0.3135	0.3125	2	7/8	5/32
1 1/4	1	20	0.3125	.3115	.162	.158	0.3135	0.3125	2 1/8	7/8	5/32
1 3/8	1	20	0.3750	.3740	.194	.190	0.3760	0.3750	2 1/4	1	5/32
1 1/2	1	20	0.3750	.3740	.194	.190	0.3760	0.3750	2 1/2	1	5/32
1 5/8	1 1/4	18	0.4375	.4365	.225	.221	0.4385	0.4375	2 3/4	1 1/4	5/32
1 3/4	1 1/4	18	0.4375	.4365	.225	.221	0.4385	0.4375	3	1 1/4	5/32
1 7/8	1 1/4	18	0.4375	.4365	.225	.221	0.4385	0.4375	3 1/8	1 1/4	5/32
2	1 1/4	18	0.5000	.4990	.256	.252	0.5010	0.5000	3 1/4	1 1/2	5/32
2 1/4	1 1/2	18	0.5625	.5610	.287	.283	0.5640	0.5625	3 1/2	1 1/2	5/32
2 1/2	2	16	0.6250	.6235	.319	.315	0.6265	0.6250	4	1 3/4	7/32
2 3/4	2	16	0.6875	.6860	.350	.346	0.6890	0.6875	4 3/8	1 3/4	7/32
3	2	16	0.7500	.7485	.381	.377	0.7515	0.7500	4 3/4	2	7/32
3 1/4	2	16	0.7500	.7485	.381	.377	0.7515	0.7500	5	2 1/8	7/32
3 1/2	2 1/2	16	0.8750	.8735	.444	.440	0.8765	0.8750	5 1/2	2 1/4	9/32
4	2 1/2	16	1.0000	.9985	.506	.502	1.0015	1.0000	6 1/4	2 3/4	9/32

All dimensions in inches except where otherwise noted.

Chamfered Keys and Filleted Keyseats.—In general practice, chamfered keys and filleted keyseats are not used. However, it is recognized that fillets in keyseats decrease stress concentration at corners. When used, fillet radii should be as large as possible without causing excessive bearing stresses due to reduced contact area between the key and its mating parts. Keys must be chamfered or rounded to clear fillet radii. Values in Table 5 assume general conditions and should be used only as a guide when critical stresses are encountered.

Table 11. Finding Depth of Keyseat and Distance from Top of Key to Bottom of Shaft



For milling keyseats, the total depth to feed cutter in from outside of shaft to bottom of keyseat is $M + D$, where D is depth of keyseat.

For checking an assembled key and shaft, caliper measurement J between top of key and bottom of shaft is used.

$$J = S - (M + D) + C$$

where C is depth of key. For Woodruff keys, dimensions C and D can be found in Tables 8 through 10. Assuming shaft diameter S is normal size, the tolerance on dimension J for Woodruff keys in keyslots are + 0.000, −0.010 inch.

Dia. of Shaft *S*. Inches	Width of Keyseat, *E*														
	1⁄16	3⁄32	1⁄8	5⁄32	3⁄16	7⁄32	1⁄4	5⁄16	3⁄8	7⁄16	1⁄2	9⁄16	5⁄8	11⁄16	3⁄4
	Dimension *M*, Inch														
0.3125	.0032	…	…	…	…	…	…	…	…	…	…	…	…	…	…
0.3437	.0029	.0065	…	…	…	…	…	…	…	…	…	…	…	…	…
0.3750	.0026	.0060	.0107	…	…	…	…	…	…	…	…	…	…	…	…
0.4060	.0024	.0055	.0099	…	…	…	…	…	…	…	…	…	…	…	…
0.4375	.0022	.0051	.0091	…	…	…	…	…	…	…	…	…	…	…	…
0.4687	.0021	.0047	.0085	.0134	…	…	…	…	…	…	…	…	…	…	…
0.5000	.0020	.0044	.0079	.0125	…	…	…	…	…	…	…	…	…	…	…
0.5625	…	.0039	.0070	.0111	.0161	…	…	…	…	…	…	…	…	…	…
0.6250	…	.0035	.0063	.0099	.0144	.0198	…	…	…	…	…	…	…	…	…
0.6875	…	.0032	.0057	.0090	.0130	.0179	.0235	…	…	…	…	…	…	…	…
0.7500	…	.0029	.0052	.0082	.0119	.0163	.0214	.0341	…	…	…	…	…	…	…
0.8125	…	.0027	.0048	.0076	.0110	.0150	.0197	.0312	…	…	…	…	…	…	…
0.8750	…	.0025	.0045	.0070	.0102	.0139	.0182	.0288	…	…	…	…	…	…	…
0.9375	…	…	.0042	.0066	.0095	.0129	.0170	.0263	.0391	…	…	…	…	…	…
1.0000	…	…	.0039	.0061	.0089	.0121	.0159	.0250	.0365	…	…	…	…	…	…
1.0625	…	…	.0037	.0058	.0083	.0114	.0149	.0235	.0342	…	…	…	…	…	…
1.1250	…	…	.0035	.0055	.0079	.0107	.0141	.0221	.0322	.0443	…	…	…	…	…
1.1875	…	…	.0033	.0052	.0074	.0102	.0133	.0209	.0304	.0418	…	…	…	…	…
1.2500	…	…	.0031	.0049	.0071	.0097	.0126	.0198	.0288	.0395	…	…	…	…	…
1.3750	…	…	…	.0045	.0064	.0088	.0115	.0180	.0261	.0357	.0471	…	…	…	…
1.5000	…	…	…	.0041	.0059	.0080	.0105	.0165	.0238	.0326	.0429	…	…	…	…
1.6250	…	…	…	.0038	.0054	.0074	.0097	.0152	.0219	.0300	.0394	.0502	…	…	…
1.7500	…	…	…	…	.0050	.0069	.0090	.0141	.0203	.0278	.0365	.0464	…	…	…
1.8750	…	…	…	…	.0047	.0064	.0084	.0131	.0189	.0259	.0340	.0432	.0536	…	…
2.0000	…	…	…	…	.0044	.0060	.0078	.0123	.0177	.0242	.0318	.0404	.0501	…	…
2.1250	…	…	…	…	…	.0056	.0074	.0116	.0167	.0228	.0298	.0379	.0470	.0572	.0684
2.2500	…	…	…	…	…	…	.0070	.0109	.0157	.0215	.0281	.0357	.0443	.0538	.0643
2.3750	…	…	…	…	…	…	…	.0103	.0149	.0203	.0266	.0338	.0419	.0509	.0608
2.5000	…	…	…	…	…	…	…	…	.0141	.0193	.0253	.0321	.0397	.0482	.0576
2.6250	…	…	…	…	…	…	…	…	.0135	.0184	.0240	.0305	.0377	.0457	.0547
2.7500	…	…	…	…	…	…	…	…	…	.0175	.0229	.0291	.0360	.0437	.0521
2.8750	…	…	…	…	…	…	…	…	…	.0168	.0219	.0278	.0344	.0417	.0498
3.0000	…	…	…	…	…	…	…	…	…	…	.0210	.0266	.0329	.0399	.0476

Depths for Milling Keyseats.—The above table has been compiled to facilitate the accurate milling of keyseats. This table gives the distance *M* (see illustration accompanying table) between the top of the shaft and a line passing through the upper corners or edges of the keyseat. Dimension *M* is calculated by the formula: $M = \frac{1}{2}(S - \sqrt{S^2 - E^2})$ where *S* is diameter of shaft, and *E* is width of keyseat. A simple approximate formula that gives *M* to within 0.001 inch is $M = E_2 \div 4S$.

Cotters.—A cotter is a form of key that is used to connect rods, etc., that are subjected either to tension or compression or both, the cotter being subjected to shearing stresses at two transverse cross-sections. When taper cotters are used for drawing and holding parts together, if the cotter is held in place by the friction between the bearing surfaces, the taper should not be too great. Ordinarily a taper varying from $\frac{1}{4}$ to $\frac{1}{2}$ inch per foot is used for plain cotters. When a set-screw or other device is used to prevent the cotter from backing out of its slot, the taper may vary from 1 $\frac{1}{2}$ to 2 inches per foot.

British Keys and Keyways

British Standard Metric Keys and Keyways.—This British Standard, BS 4235:Part 1:1972 (1986), covers square and rectangular parallel keys and keyways, and square and rectangular taper keys and keyways. Plain and gib-head taper keys are specified. There are three classes of fit for the square and rectangular parallel keys and keyways, designated free, normal, and close. A *free fit* is applied when the application requires the hub of an assembly to slide over the key; a *normal fit* is employed when the key is to be inserted in the keyway with the minimum amount of fitting, as may be required in mass-production assembly work; and a *close fit* is applied when accurate fitting of the key is required under maximum material conditions, which may involve selection of components.

The Standard does not provide for misalignment or offset greater than can be accommodated within the dimensional tolerances. If an assembly is to be heavily stressed, a check should be made to ensure that the cumulative effect of misalignment or offset, or both, does not prevent satisfactory bearing on the key. Radii and chamfers are not normally provided on keybar and keys as supplied, but they can be produced during manufacture by agreement between the user and supplier.

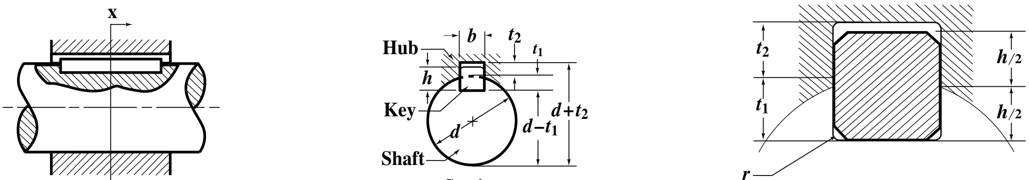
Unless otherwise specified, keys in compliance with this Standard are manufactured from steel made to BS 970 having a tensile strength of not less than 550 MN/m^2 in the finished condition. BS 970, Part 1, lists the following steels and maximum section sizes, respectively, that meet this tensile strength requirement: 070M20, 25×14 mm; 070M26, 36×20 mm; 080M30, 90×45 mm; and 080M40, 100×50 mm.

At the time of publication of this Standard, the demand for metric keys was not sufficient to enable standard ranges of lengths to be established. The lengths given in the accompanying table are those shown as standard in ISO Recommendations R773: 1969, "Rectangular or Square Parallel Keys and their Corresponding Keyways (Dimensions in Millimeters)," and R 774: 1969, "Taper Keys and their Corresponding Keyways—with or without Gib Head (Dimensions in Millimeters)."

Tables 1 through 4 on the following pages cover the dimensions and tolerances of square and rectangular keys and keyways, and square and rectangular taper keys and keyways.

Table 1. British Standard Metric Keyways for Square and Rectangular Parallel Keys *BS 4235:Part 1:1972 (1986)*

Shaft: Nonimal Diameter d: Over	Shaft: Nonimal Diameter d: Up to and Incl.	Key: Size, $b \times h$	Keyway: Width, b: Nom.	Free Fit: Shaft (H9)	Free Fit: Hub (D10)	Normal Fit: Shaft (N9)	Normal Fit: Hub (J_S9)[a]	Close Fit: Shaft and Hub (P9)	Depth: Shaft t_1: Nom.	Depth: Shaft t_1: Tol.	Depth: Hub t_2: Nom.	Depth: Hub t_2: Tol.	Radius r: Max.	Radius r: Min.
				Tolerances										
Keyways for Square Parallel Keys														
6	8	2 × 2	2	+0.025 0	+0.060 +0.020	−0.004 −0.029	+0.012 −0.012	−0.006 −0.031	1.2	+0.1 0	1	+0.1 0	0.16	0.08
8	10	3 × 3	3						1.8		1.4		0.16	0.08
10	12	4 × 4	4	+0.030 0	+0.078 +0.030	0 −0.030	+0.015 −0.015	−0.012 −0.042	2.5		1.8		0.16	0.08
12	17	5 × 5	5						3		2.3		0.25	0.16
17	22	6 × 6	6						3.5		2.8		0.25	0.16



Section x-x

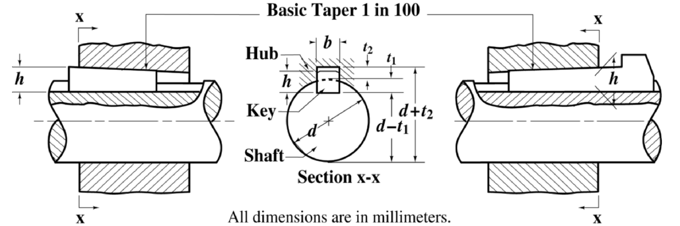
Enlarged Detail of Key and Keyways

Table 1. *(Continued)* **British Standard Metric Keyways for Square and Rectangular Parallel Keys** *BS 4235:Part 1:1972 (1986)*

Shaft		Key	Keyway											
Nonimal Diameter d			Width, b						Depth				Radius r	
		Size, $b \times h$		Free Fit		Normal Fit		Close Fit	Shaft t_1		Hub t_2			
Over	Up to and Incl.		Nom.	Shaft (H9)	Hub (D10)	Shaft (N9)	Hub (J_S9)[a]	Shaft and Hub (P9)	Nom.	Tol.	Nom.	Tol.	Max.	Min.
				Tolerances										
Keyways for Rectangular Parallel Keys														
22	30	8 × 7	8	+0.036	+0.098	0	+0.018	−0.015	4		3.3		0.25	0.16
30	38	10 × 8	10	0	+0.040	−0.036	−0.018	−0.051	5		3.3		0.40	0.25
38	44	12 × 8	12						5		3.3		0.40	0.25
44	50	14 × 9	14	+0.043	+0.120	0	+0.021	−0.018	5.5		3.8		0.40	0.25
50	58	16 × 10	16		+0.050	−0.043	−0.021	−0.061	6		4.3		0.40	0.25
58	65	18 × 11	18						7	+0.2 0	4.4	+0.2 0	0.40	0.25
65	75	20 × 12	20						7.5		4.9		0.60	0.40
75	85	22 × 14	22	+0.052	+0.149	0	+0.026	−0.022	9		5.4		0.60	0.40
85	95	25 × 14	25		+0.065	−0.052	−0.026	−0.074	9		5.4		0.60	0.40
95	110	28 × 16	28						10		6.4		0.60	0.40
110	130	32 × 18	32						11		7.4		0.60	0.40
130	150	36 × 20	36						12		8.4		1.00	0.70
150	170	40 × 22	40	+0.062	+0.180	0	+0.031	−0.026	13		9.4		1.00	0.70
170	200	45 × 25	45		−0.080	−0.062	−0.031	−0.088	15		10.4		1.00	0.70
200	230	50 × 28	50						17		11.4		1.00	0.70
230	260	56 × 32	56						20	+0.3 0	12.4	+0.3 0	1.60	1.20
260	290	63 × 32	63	+0.074	+0.220	0	+0.037	−0.032	20		12.4		1.60	1.20
290	330	70 × 36	70		+0.100	−0.074	−0.037	−0.106	22		14.4		1.60	1.20
330	380	80 × 40	80						25		15.4		2.50	2.00
380	440	90 × 45	90	+0.087	+0.260	0	+0.043	−0.037	28		17.4		2.50	2.00
440	500	100 × 50	100	0	+0.120	−0.087	−0.043	−0.124	31		19.5		2.50	2.00

[a] Tolerance limits J_S9 are quoted from BS 4500, "ISO Limits and Fits," to three significant figures.
All dimensions in millimeters.

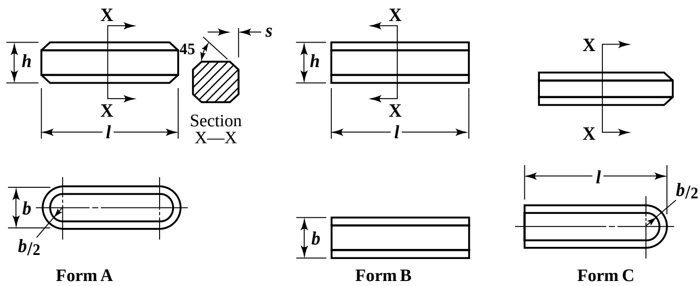
Table 2. British Standard Metric Keyways for Square and Rectangular Taper Keys, *BS 4235:Part 1:1972 (1986)*



All dimensions are in millimeters.

Shaft: Nominal Diameter *d*, Over	Shaft: Nominal Diameter *d*, Up to and Incl.	Key: Size, $b \times h$	Keyway: Width *b*, Shaft and Hub, Nom.	Keyway: Width *b*, Shaft and Hub, Tol. (D10)	Depth: Shaft t_1, Nom.	Depth: Shaft t_1, Tol.	Depth: Hub t_2, Nom.	Depth: Hub t_2, Tol.	Corner Radius of Keyway, Max.	Corner Radius of Keyway, Min.
Keyways for Square Taper Keys										
6	8	2 × 2	2	+0.060 / +0.020	1.2	+0.1 / 0	0.5	+0.1 / 0	0.16	0.08
8	10	3 × 3	3		1.8		0.9		0.16	0.08
10	12	4 × 4	4	+0.078 / +0.030	2.5		1.2		0.16	0.08
12	17	5 × 5	5		3		1.7		0.25	0.16
17	22	6 × 6	6		3.5	+0.2 / 0	2.2	+0.2 / 0	0.25	0.16
Keyways for Rectangular Taper Keys										
22	30	8 × 7	8	+0.098 / +0.040	4	+0.2 / 0	2.4	+0.2 / 0	0.25	0.16
30	38	10 × 8	10		5		2.4		0.40	0.25
38	44	12 × 8	12	+0.120 / +0.050	5		2.4		0.40	0.25
44	50	14 × 9	14		5.5		2.9		0.40	0.25
50	58	16 × 10	16		6		3.4		0.40	0.25
58	65	18 × 11	18		7		3.4		0.40	0.25
65	75	20 × 12	20	+0.149 / +0.065	7.5		3.9		0.60	0.40
75	85	22 × 14	22		9		4.4		0.60	0.40
85	95	25 × 14	25		9		4.4		0.60	0.40
95	110	28 × 16	28		10		5.4		0.60	0.40
110	130	32 × 18	32	+0.180 / +0.080	11		6.4		0.60	0.40
130	150	36 × 20	36		12	+0.3 / 0	7.1	+0.3 / 0	1.00	0.70
150	170	40 × 22	40		13		8.1		1.00	0.70
170	200	45 × 25	45		15		9.1		1.00	0.70
200	230	50 × 28	50		17		10.1		1.00	0.70
230	260	56 × 32	56	+0.220 / +0.120	20		11.1		1.60	1.20
260	290	63 × 32	63		20		11.1		1.60	1.20
290	330	70 × 36	70		22		13.1		1.60	1.20
330	380	80 × 40	80		25		14.1		2.50	2.00
380	440	90 × 45	90	+0.260 / +0.120	28		16.1		2.50	2.00
440	500	100 × 50	100		31		18.1		2.50	2.00

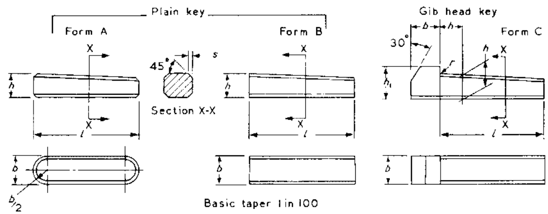
Table 3. British Standard Metric Square and Rectangular Parallel Keys.
BS 4235:Part 1:1972 (1986)



Width, *b* Nom.	Width, *b* Tol.[a]	Thickness, *h* Nom.	Thickness, *h* Tol.[a]	Chamfer, *s* Min.	Chamfer, *s* Max.	Length Range, *l* From	Length Range, *l* To
Square Parallel Keys							
2	0 / −0.025	2	0 / −0.025	0.16	0.25	6	20
3		3		0.16	0.25	6	36
4	0 / −0.030	4	0 / −0.030	0.16	0.25	8	45
5		5		0.25	0.40	10	56
6		6		0.25	0.40	14	70
Rectangular Parallel Keys							
8	0 / −0.036	7	0 / −0.090	0.25	0.40	18	90
10		8		0.40	0.60	22	110
12	0 / −0.043	8		0.40	0.60	28	140
14		9		0.40	0.60	36	160
16		10		0.40	0.60	45	180
18		11	0 / −0.110	0.40	0.60	50	200
20	0 / −0.052	12		0.60	0.80	56	220
22		14		0.60	0.80	63	250
25		14		0.60	0.80	70	280
28		16		0.60	0.80	80	320
32	0 / −0.062	18		0.60	0.80	90	360
36		20	0 / −0.130	1.00	1.20	100	400
40		22		1.00	1.20	…	…
45		25		1.00	1.20	…	…
50		28		1.00	1.20	…	…
56	0 / −0.074	32	0 / −0.160	1.60	2.00	…	…
63		32		1.60	2.00	…	…
70		36		1.60	2.00	…	…
80		40		2.50	3.00	…	…
90	0 / −0.087	45		2.50	3.00	…	…
100		50		2.50	3.00	…	…

[a] The tolerance on the width and thickness of square taper keys is h9, and on the width and thickness of rectangular keys, h9 and h11, respectively, in accordance with ISO metric limits and fits. All dimensions in millimeters.

Table 4. British Standard Metric Square and Rectangular Taper Keys
BS 4235:Part 1:1972 (1986)



Width *b*		Thickness *h*		Chamfer *s*		Length Range *l*		Gib head h_1	Radius *r*
Nom.	Tol.[a]	Nom.	Tol.[a]	Min.	Max.	From	To	Nom.	Nom.
Square Taper Keys									
2	0 −0.025	2	0 −0.025	0.16	0.25	6	20	…	…
3		3		0.16	0.25	6	36	…	…
4	0 −0.030	4	0 −0.030	0.16	0.25	8	45	7	0.25
5		5		0.25	0.40	10	56	8	0.25
6		6		0.25	0.40	14	70	10	0.25
Rectangular Taper Keys									
8	0 −0.036	7	0 −0.090	0.25	0.40	18	90	11	1.5
10		8		0.40	0.60	22	110	12	1.5
12	0 −0.043	8		0.40	0.60	28	140	12	1.5
14		9		0.40	0.60	36	160	14	1.5
16		10		0.40	0.60	45	180	16	3.2
18		11	0 −0.110	0.40	0.60	50	200	18	3.2
20	0 −0.052	12		0.60	0.80	56	220	20	3.2
22		14		0.60	0.80	63	250	22	3.2
25		14		0.60	0.80	70	280	22	3.2
28		16		0.60	0.80	80	320	25	3.2
32	0 −0.062	18		0.60	0.80	90	360	28	6.4
36		20	0 −0.130	1.00	1.20	100	400	32	6.4
40		22		1.00	1.20	…	…	36	6.4
45		25		1.00	1.20	…	…	40	6.4
50		28		1.00	1.20	…	…	45	6.4
56	0 −0.074	32	0 −0.160	1.60	2.00	…	…	50	9.5
63		32		1.60	2.00	…	…	50	9.5
70		36		1.60	2.00	…	…	56	9.5
80		40		2.50	3.00	…	…	63	9.5
90	0 −0.087	45		2.50	3.00	…	…	70	9.5
100		50		2.50	3.00	…	…	80	9.5

[a] The tolerance on the width and thickness of square taper keys is h9, and on the width and thickness of rectangular taper keys, h9 and h11 respectively, in accordance with ISO metric limits and fits. Does not apply to gib head dimensions.

British Standard Keys and Keyways: Tables 1 through 6 from BS 46:Part 1:1958 (1985) (obsolescent) provide data for rectangular parallel keys and keyways, square parallel keys and keyways, plain and gib head rectangular taper keys and key-ways, plain and gib head square taper keys and keyways, and Woodruff keys and keyways.

Parallel Keys: These keys are used for transmitting unidirectional torques in transmissions not subject to heavy starting loads and where periodic withdrawal or sliding of the hub member may be required. In many instances, particularly couplings, a gib-head cannot be accommodated, and there is insufficient room to drift out the key from behind. It is then necessary to withdraw the component over the key and a parallel key is essential. Parallel square and rectangular keys are normally side fitting with top clearance and are usually retained in the shaft rather more securely than in the hub. The rectangular key is the general-purpose key for shafts greater than 1 inch in diameter; the square key is intended for use with shafts up to and including 1-inch diameter or for shafts up to 6-inch diameter where it is desirable to have a greater key depth than is provided by rectangular keys. In stepped shafts, the larger diameters are usually required by considerations other than torque, e.g., resistance to bending. Where components such as fans, gears, impellers, etc., are attached to the larger shaft diameter, the use of a key smaller than standard for that diameter may be permissible. As this results in unequal disposition of the key in the shaft and its related hub, the dimensions *H* and *h* must be recalculated to maintain the *T*/2 relationship.

British Standard Preferred Lengths of Metric Keys *BS 4235:Part 1:1972 (1986)*

Length	Type of key				Length	Type of key			
	Sq.	Rect.	Sq. Taper	Rect. Taper		Sq.	Rect.	Sq. Taper	Rect. Taper
6	x		x		63	x	x	x	x
8	x		x		70	x	x	x	x
10	x		x		80		x		x
12	x		x		90		x		x
14	x		x		100		x		x
16	x		x		110		x		x
18	x	x	x	x	125		x		x
20	x	x	x	x	140		x		x
22	x	x	x	x	160		x		x
25	x	x	x	x	180		x		x
28	x	x	x	x	200		x		x
32	x	x	x	x	220		x		x
36	x	x	x	x	250		x		x
40	x	x	x	x	280		x		x
45	x	x	x	x	320		x		x
50	x	x	x	x	360		x		x
56	x	x	x	x	400		x		x

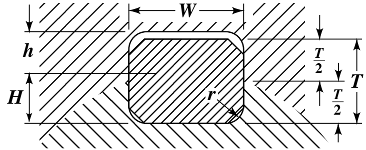
Taper Keys: These keys are used for transmitting heavy unidirectional, reversing, or vibrating torques and in applications where periodic withdrawal of the key may be necessary. Taper keys are usually top fitting, but may be top and side fitting where required, and the keyway in the hub should then have the same width value as the keyway in the shaft. Taper keys of rectangular section are used for general purposes and are of less depth than square keys; square sections are for use with shafts up to and including 1-inch diameter or for shafts up to 6-inch diameter where it is desirable to have greater key depth.

Woodruff Keys: These keys are used for light applications or the angular location of associated parts on tapered shaft ends. They are not recommended for other applications, but if so used, corner radii in the shaft and hub keyways are advisable to reduce stress concentration.

Dimensions and Tolerances for British Parallel and Taper Keys and Keyways: Dimensions and tolerances for key and keyway widths given in Tables 1, 2, 3, and 4 are based on the width of key *W* and provide a fitting allowance. The fitting allowance is designed to permit an interference between the key and the shaft keyway and a slightly easier condition between the key and the hub keyway. In shrink and heavy force fits, it may be found necessary to depart from the width and depth tolerances specified. Any variation in the width of the keyway should be such that the greatest width is at the end from which the key enters and any variation in the depth of the keyway should be such that the greatest depth is at the end from which the key enters.

Keys and keybar normally are not chamfered or radiused as supplied, but this may be done at the time of fitting. Radii and chamfers are given in Tables 1, 2, 3, and 4. Corner radii are recommended for keyways to alleviate stress concentration.

Table 1. British Standard Rectangular Parallel Keys, Keyways, and Keybars *B.S. 46: Part I: 1958*



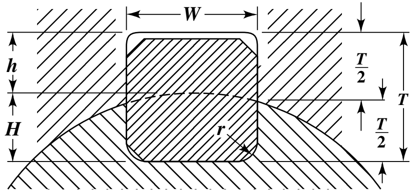
Diameter of Shaft		Key					Keyway in Shaft				Keyway in Hub				Nominal Keyway Radius, r[a]	Keybar			
Over	Up to and Including	Size W × T	Width, W		Thickness, T		Width W_s		Depth H		Width W_h		Depth h			Width W		Thickness T	
			Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		Max.	Min.	Max.	Min.
1	1¼	5/16 × ¼	0.314	0.312	0.253	0.250	0.311	0.312	0.146	0.152	0.312	0.313	0.112	0.118	0.010	0.314	0.312	0.253	0.250
1¼	1½	⅜ × ¼	0.377	0.375	0.253	0.250	0.374	0.375	0.150	0.156	0.375	0.376	0.108	0.114	0.010	0.377	0.375	0.253	0.250
1½	1¾	7/16 × 5/16	0.440	0.438	0.315	0.312	0.437	0.438	0.186	0.192	0.438	0.439	0.135	0.141	0.020	0.440	0.438	0.315	0.312
1¾	2	½ × 5/16	0.502	0.500	0.315	0.312	0.499	0.500	0.190	0.196	0.500	0.501	0.131	0.137	0.020	0.502	0.500	0.315	0.312
2	2½	⅝ × 7/16	0.627	0.625	0.441	0.438	0.624	0.625	0.260	0.266	0.625	0.626	0.185	0.191	0.020	0.627	0.625	0.441	0.438
2½	3	¾ × ½	0.752	0.750	0.503	0.500	0.749	0.750	0.299	0.305	0.750	0.751	0.209	0.215	0.020	0.752	0.750	0.503	0.500
3	3½	⅞ × ⅝	0.877	0.875	0.629	0.625	0.874	0.875	0.370	0.376	0.875	0.876	0.264	0.270	0.062	0.877	0.875	0.629	0.625
3½	4	1 × ¾	1.003	1.000	0.754	0.750	0.999	1.000	0.441	0.447	1.000	1.001	0.318	0.324	0.062	1.003	1.000	0.754	0.750
4	5	1¼ × ⅞	1.253	1.250	0.879	0.875	1.248	1.250	0.518	0.524	1.250	1.252	0.366	0.372	0.062	1.253	1.250	0.879	0.875
5	6	1½ × 1	1.504	1.500	1.006	1.000	1.498	1.500	0.599	0.605	1.500	1.502	0.412	0.418	0.062	1.504	1.500	1.006	1.000
6	7	1½ × 1¼	1.754	1.750	1.256	1.250	1.748	1.750	1.740	0.746	1.750	1.752	0.526	0.532	0.125				
7	8	2 × 1⅜	2.005	2.000	1.381	1.375	1.998	2.000	0.818	0.824	2.000	2.002	0.573	0.579	0.125				
8	9	2¼ × 1½	2.255	2.250	1.506	1.500	2.248	2.250	0.897	0.905	2.250	2.252	0.619	0.627	0.125				
9	10	2½ × 1⅝	2.505	2.500	1.631	1.625	2.498	2.500	0.975	0.983	2.500	2.502	0.666	0.674	0.187				
10	11	2¾ × 1⅞	2.755	2.750	1.881	1.875	2.748	2.750	1.114	1.122	2.750	2.752	0.777	0.785	0.187				
11	12	3 × 2	3.006	3.000	2.008	2.000	2.998	3.000	1.195	1.203	3.000	3.002	0.823	0.831	0.187				
12	13	3¼ × 2⅛	3.256	3.250	2.133	2.125	3.248	3.250	1.273	1.281	3.250	3.252	0.870	0.878	0.187				
13	14	3½ × 2⅜	3.506	3.500	2.383	2.375	3.498	3.500	1.413	1.421	3.500	3.502	0.980	0.988	0.250				
14	15	3¾ × 2½	3.756	3.750	2.508	2.500	3.748	3.750	1.492	1.502	3.750	3.752	1.026	1.036	0.250				
15	16	4 × 2⅝	4.008	4.000	2.633	2.625	3.998	4.000	1.571	1.581	4.000	4.002	1.072	1.082	0.250				
16	17	4¼ × 2⅞	4.258	4.250	2.883	2.875	4.248	4.250	1.711	1.721	4.250	4.252	1.182	1.192	0.312				
17	18	4½ × 3	4.508	4.500	3.010	3.000	4.498	4.500	1.791	1.801	4.500	4.502	1.229	1.239	0.312				
18	19	4¼ × 3⅛	4.758	4.750	3.135	3.125	4.748	4.750	1.868	1.878	4.750	4.752	1.277	1.287	0.312				
19	20	5 × 3⅜	5.008	5.000	3.385	3.375	4.998	5.000	2.010	2.020	5.000	5.002	1.385	1.395	0.312				

Bright keybar is not normally available in sections larger than the above.

All dimensions in inches.

[a] The key chamfer shall be the minimum to clear the keyway radius. Nominal values are given.

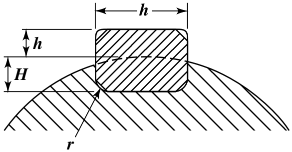
Table 2. British Standard Square Parallel Keys, Keyways, and Keybars *B.S. 46: Part I: 1958*



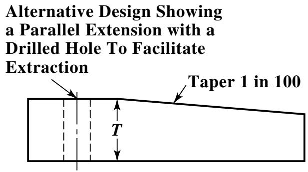
Diameter of Shaft		Key			Keyway in Shaft				Keyway in Hub				Nominal Keyway Radius, r[a]	Bright Keybar	
Over	Up to and Including	Size, $W \times T$	Width, W and Thickness, T		Width, W_s		Depth, H		Width, W_h		Depth, h			Width, W and Thickness, T	
			Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		Max.	Min.
¼	½	⅛ × ⅛	0.127	0.125	0.124	0.125	0.072	0.078	0.125	0.126	0.060	0.066	0.010	0.127	0.125
½	¾	3/16 × 3/16	0.190	0.188	0.187	0.188	0.107	0.113	0.188	0.189	0.088	0.094	0.010	0.190	0.188
¾	1	¼ × ¼	0.252	0.250	0.249	0.250	0.142	0.148	0.250	0.251	0.115	0.121	0.010	0.252	0.250
1	1¼	5/16 × 5/16	0.314	0.312	0.311	0.312	0.177	0.183	0.312	0.313	0.142	0.148	0.010	0.314	0.312
1¼	1½	⅜ × ⅜	0.377	0.375	0.374	0.375	0.213	0.219	0.375	0.376	0.169	0.175	0.010	0.377	0.375
1½	1¾	7/16 × 7/16	0.440	0.438	0.437	0.438	0.248	0.254	0.438	0.439	0.197	0.203	0.020	0.440	0.438
1¾	2	½ × ½	0.502	0.500	0.499	0.500	0.283	0.289	0.500	0.501	0.224	0.230	0.020	0.502	0.500
2	2½	⅝ × ⅝	0.627	0.625	0.624	0.625	0.354	0.360	0.625	0.626	0.278	0.284	0.020	0.627	0.625
2½	3	¾ × ¾	0.752	0.750	0.749	0.750	0.424	0.430	0.750	0.751	0.333	0.339	0.020	0.752	0.750
3	3½	⅞ × ⅞	0.877	0.875	0.874	0.875	0.495	0.501	0.875	0.876	0.387	0.393	0.062	0.877	0.875
3½	4	1 × 1	1.003	1.000	0.999	1.000	0.566	0.572	1.000	1.001	0.442	0.448	0.062	1.003	1.000
4	5	1¼ × 1¼	1.253	1.250	1.248	1.250	0.707	0.713	1.250	1.252	0.551	0.557	0.062	1.253	1.250
5	6	1½ × 1½	1.504	1.500	1.498	1.500	0.848	0.854	1.500	1.502	0.661	0.667	0.062	1.504	1.500

[a] The key chamfer shall be the minimum to clear the keyway radius. Nominal values are given. All dimensions in inches.

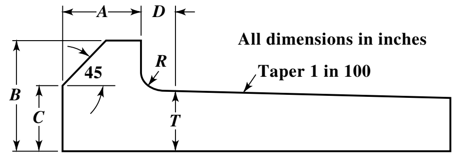
Table 3. British Standard Rectangular Taper Keys and Keyways, Gib-head and Plain *B.S. 46: Part 1: 1958*



Section at Deep End of Keyway in Hub



Plain Taper Key



Gib-Head Key

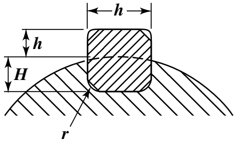
Diameter of Shaft		Key					Keyway in Shaft and Hub									Nominal Keyway Radius, r[a]	Gib-head[b]				Radius, R
Over	Up to and Including	Size, W × T	Width, W		Thickness, T		Keyway in Shaft Width, W_s		Keyway in Hub Width, W_h		Depth in Shaft, H		Depth in Hub at Deep End of Keyway, h				A	B	C	D	
			Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.							
1	1¼	5/16 × 1/4	0.314	0.312	0.254	0.249	0.311	0.312	0.312	0.313	0.146	0.152	0.090	0.096		0.010	3/8	7/16	1/4	0.3	1/16
1¼	1½	3/8 × 1/4	0.377	0.375	0.254	0.249	0.374	0.375	0.375	0.376	0.150	0.156	0.086	0.092		0.010	7/16	7/16	9/32	0.3	1/16
1½	1¾	7/16 × 5/16	0.440	0.438	0.316	0.311	0.437	0.438	0.438	0.439	0.186	0.192	0.112	0.118		0.020	1/2	9/16	5/16	0.4	1/16
1¾	2	1/2 × 5/16	0.502	0.500	0.316	0.311	0.499	0.500	0.500	0.0.501	0.190	0.196	0.108	0.114		0.020	9/16	5/8	3/8	0.4	1/16
2	2½	5/8 × 7/16	0.627	0.625	0.442	0.437	0.624	0.625	0.625	0.626	0.260	0.266	0.162	0.168		0.020	11/16	3/4	7/16	0.5	1/8
2½	3	3/4 × 1/2	0.752	0.750	0.504	0.499	0.749	0.750	0.750	0.751	0.299	0.305	0.185	0.191		0.020	13/16	7/8	17/32	0.5	1/8
3	3½	7/8 × 5/8	0.877	0.875	0.630	0.624	0.874	0.875	0.875	0.876	0.370	0.376	0.239	0.245		0.062	15/16	1	21/32	0.6	1/8
3½	4	1 × 3/4	1.003	1.000	0.755	0.749	0.999	1.000	1.000	1.001	0.441	0.447	0.293	0.299		0.062	1 1/16	1¼	23/32	0.6	1/8
4	5	1¼ × 7/8	1.253	1.250	0.880	0.874	1.248	1.250	1.250	1252	0.518	0.524	0.340	0.346		0.062	1 5/16	1½	27/32	0.7	1/4
5	6	1½ × 1	1.504	1.500	1.007	0.999	1.498	1.500	1.500	1.502	0.599	0.605	0.384	0.390		0.062	1 9/16	1 5/8	1 1/32	0.7	1/4
6	7	1¾ × 1¼	1.754	1.750	1.257	1.249	1.748	1.750	1.750	1.752	0.740	0.746	0.493	0.499		0.125	1 13/16	2	1 7/32	0.8	1/4
7	8	2 × 1 3/8	2.005	2.000	1.382	1.374	1.998	2.000	2.000	2.002	0.818	0.824	0.539	0.545		0.125	2 1/16	2¼	1 13/32	0.8	1/4
8	9	2¼ × 1½	2.255	2.250	1.509	1.499	2.248	2.250	2.250	2.252	0.897	0.905	0.581	0.589		0.125	2 5/16	2½	1 9/16	0.9	3/8
9	10	2½ × 1 5/8	2.505	2.500	1.634	1.624	2.498	2.500	2.500	2.502	0.975	0.983	0.628	0.636		0.187	2 9/16	2¾	1 11/16	0.9	3/8
10	11	2¾ × 1 7/8	2.755	2.750	1.884	1.874	2.748	2.750	2.750	2.752	1.114	1.122	0.738	0.746		0.187	2 13/16	3	1 15/16	1.0	3/8
11	12	3 × 2	3.006	3.000	2.014	1.999	2.998	3.000	3.000	3.002	1.195	1.203	0.782	0.790		0.187	3 1/16	3¼	2 1/16	1.0	3/8

[a] The key chamfer shall be the minimum to clear the keyway radius. Nominal values shall be given.

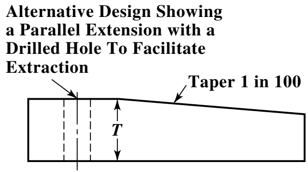
[b] Dimensions A, B, C, D, and R pertain to gib-head keys only.

All dimensions in inches.

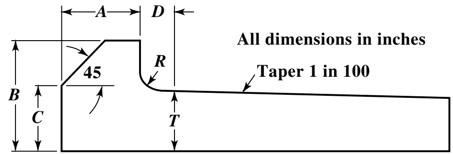
Table 4. British Standard Square Taper Keys and Keyways, Gib-head or Plain *B.S. 46: Part I: 1958*



Section at Deep End of Keyway in Hub



Plain Taper Key



Gib-Head Key

All dimensions in inches

Diameter of Shaft		Key					Keyway in Shaft and Hub								Nominal Keyway Radius, r[a]	Gib-head[b]				
Over	Up to and Including	Size $W \times T$	Width, W		Thickness, T		Keyway in Shaft Width W_s		Keyway in Hub Width W_h		Depth in Shaft, H		Depth in Hub at Deep End of Keyway, h			A	B	C	D	Radius, R
			Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.						
1/4	1/2	1/8 × 1/8	0.127	0.125	0.129	0.124	0.124	0.125	0.125	0.126	0.072	0.078	0.039	0.045	0.010	3/16	1/4	5/32	0.1	1/32
1/2	3/4	3/16 × 3/16	0.190	0.188	0.192	0.187	0.187	0.188	0.188	0.189	0.107	0.113	0.067	0.073	0.010	1/4	3/8	7/32	0.2	1/32
3/4	1	1/4 × 1/4	0.252	0.250	0.254	0.249	0.249	0.250	0.250	0.251	0.142	0.148	0.094	0.100	0.010	5/16	7/16	9/32	0.2	1/16
1	1 1/4	5/16 × 5/16	0.314	0.312	0.316	0.311	0.311	0.312	0.312	0.313	0.177	0.183	0.121	0.127	0.010	3/8	9/16	11/32	0.3	1/16
1 1/4	1 1/2	3/8 × 3/8	0.377	0.375	0.379	0.374	0.374	0.375	0.375	0.376	0.213	0.219	0.148	0.154	0.010	7/16	5/8	13/32	0.3	1/16
1 1/2	1 3/4	7/16 × 7/16	0.440	0.438	0.442	0.437	0.437	0.438	0.438	0.439	0.248	0.254	0.175	0.181	0.020	1/2	3/4	15/32	0.4	1/16
1 3/4	2	1/2 × 1/2	0.502	0.500	0.504	0.499	0.499	0.500	0.500	0.501	0.283	0.289	0.202	0.208	0.020	9/16	7/8	17/32	0.4	1/16
2	2 1/2	5/8 × 5/8	0.627	0.625	0.630	0.624	0.624	0.625	0.625	0.626	0.354	0.360	0.256	0.262	0.020	11/16	1	21/32	0.5	1/8
2 1/2	3	3/7 × 3/4	0.752	0.750	0.755	0.749	0.749	0.750	0.750	0.751	0.424	0.430	0.310	0.316	0.020	13/16	1 1/4	25/32	0.5	1/8
3	3 1/2	7/8 × 7/8	0.877	0.875	0.880	0.874	0.874	0.875	0.875	0.876	0.495	0.501	0.364	0.370	0.062	15/16	1 3/8	20/32	0.6	1/8
3 1/2	4	1 × 1	1.003	1.000	1.007	0.999	0.999	1.000	1.000	1.001	0.566	0.572	0.418	0.424	0.062	1 1/16	1 5/8	1 1/32	0.6	1/8
4	5	1 1/4 × 1 1/4	1.253	1.250	1.257	1.249	1.248	1.250	1.250	1.252	0.707	0.713	0.526	0.532	0.062	1 5/16	2	1 9/32	0.7	1/4
5	6	1 1/2 × 1 1/2	1.504	1.500	1.509	1.499	1.498	1.500	1.500	1.502	0.848	0.854	0.635	0.641	0.062	1 9/16	2 1/2	1 17/32	0.7	1/4

[a] The key chamfer shall be the minimum to clear the keyway radius. Nominal values shall be given.
[b] Dimensions A, B, C, D, and R pertain to gib-head keys only.
All dimensions in inches.

Dimensions and Tolerances of British Woodruff Keys and Keyways.—Dimensions and tolerances are shown in Table 5. An optional alternative design of the Woodruff key that differs from the normal form in its depth is given in the illustration accompanying the table. The method of designating British Woodruff Keys is the same as the American method explained in the footnote on page 2348.

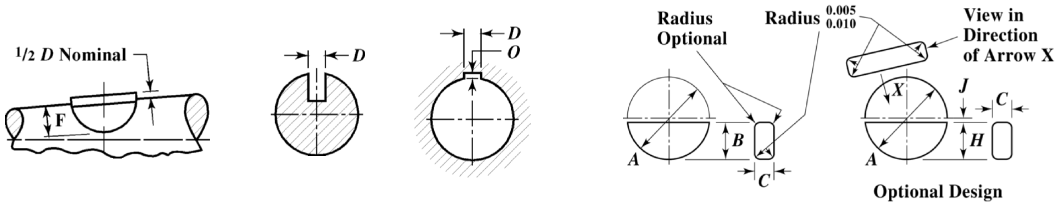


Table 5. British Standard Woodruff Keys and Keyways *BS 6: Part 1: 1958*

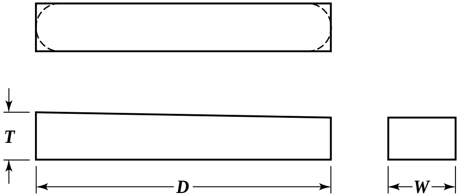
Key and Cutter No.	Key									Keyway								Optional Design		
	Nominal Fractional Size		Diameter *A*		Depth *B*		Thickness *C*		Width in Shaft, *D*		Width in Hub, *E*		Depth in Shaft, *F*		Depth in Hub at Center Line, *G*		Depth of Key, *H*		Dimension, *J*
	Width.	Dia.	Max.	Min.	Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Nom.
203	1/16	3/8	0.375	0.370	0.171	0.166	0.063	0.062	0.061	0.063	0.063	0.065	0.135	0.140	0.042	0.047	0.162	0.156	1/64
303	3/32	3/8	0.375	0.370	0.171	0.166	0.095	0.094	0.093	0.095	0.095	0.097	0.119	0.124	0.057	0.062	0.162	0.156	1/64
403	1/8	3/8	0.375	0.370	0.171	0.166	0.126	0.125	0.124	0.126	0.126	0.128	0.104	0.109	0.073	0.078	0.162	0.156	1/64
204	1/16	1/2	0.500	0.490	0.203	0.198	0.063	0.062	0.061	0.063	0.063	0.065	0.167	0.172	0.042	0.047	0.194	0.188	3/64
304	3/32	1/2	0.500	0.490	0.203	0.198	0.095	0.094	0.093	0.095	0.095	0.097	0.151	0.156	0.057	0.062	0.194	0.188	3/64
404	1/8	1/2	0.500	0.490	0.203	0.198	0.126	0.125	0.124	0.126	0.126	0.128	0.136	0.141	0.073	0.078	0.194	0.188	3/64
305	3/32	5/8	0.625	0.615	0.250	0.245	0.095	0.094	0.093	0.095	0.095	0.097	0.198	0.203	0.057	0.062	0.240	0.234	1/16
405	1/8	5/8	0.625	0.615	0.250	0.245	0.126	0.125	0.124	0.126	0.126	0.128	0.182	0.187	0.073	0.078	0.240	0.234	1/16
505	5/32	5/8	0.625	0.615	0.250	0.245	0.157	0.156	0.155	0.157	0.157	0.159	0.167	0.172	0.089	0.094	0.240	0.234	1/16
406	1/8	3/4	0.750	0.740	0.313	0.308	0.126	0.125	0.124	0.126	0.126	0.128	0.246	0.251	0.073	0.078	0.303	0.297	1/16

Table 5. *(Continued)* **British Standard Woodruff Keys and Keyways** *BS 6: Part 1: 1958*

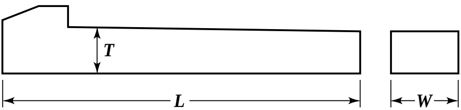
Key and Cutter No.	Key								Keyway								Optional Design		
	Nominal Fractional Size		Diameter, *A*		Depth, *B*		Thickness, *C*		Width in Shaft, *D*		Width in Hub, *E*		Depth in Shaft, *F*		Depth in Hub at Center Line, *G*		Depth of Key, *H*		Dimension, *J*
	Width.	Dia.	Max.	Min.	Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Nom.
506	5/32	3/4	0.750	0.740	0.313	0.308	0.157	0.156	0.155	0.157	0.157	0.159	0.230	0.235	0.089	0.094	0.303	0.297	1/16
606	3/16	3/4	0.750	0.740	0.313	0.308	0.189	0.188	0.187	0.189	0.189	0.191	0.214	0.219	0.104	0.109	0.303	0.297	1/16
507	5/32	7/8	0.875	0.865	0.375	0.370	0.157	0.156	0.155	0.157	0.157	0.159	0.292	0.297	0.089	0.094	0.365	0.359	1/16
607	3/16	7/8	0.875	0.865	0.375	0.370	0.189	0.188	0.187	0.189	0.189	0.191	0.276	0.281	0.104	0.109	0.365	0.359	1/16
807	1/4	7/8	0.875	0.865	0.375	0.370	0.251	0.250	0.249	0.251	0.251	0.253	0.245	0.250	0.136	0.141	0.365	0.359	1/16
608	3/16	1	1.000	0.990	0.438	0.433	0.189	0.188	0.187	0.189	0.189	0.191	0.339	0.344	0.104	0.109	0.428	0.422	1/16
808	1/4	1	1.000	0.990	0.438	0.433	0.251	0.250	0.249	0.251	0.251	0.253	0.308	0.313	0.136	0.141	0.428	0.422	1/16
1008	5/16	1	1.000	0.990	0.438	0.433	0.313	0.312	0.311	0.313	0.313	0.315	0.277	0.282	0.167	0.172	0.428	0.422	1/16
609	3/16	1 1/8	1.125	1.115	0.484	0.479	0.189	0.188	0.187	0.189	0.189	0.191	0.385	0.390	0.104	0.109	0.475	0.469	5/64
809	1/4	1 1/8	1.125	1.115	0.484	0.479	0.251	0.250	0.249	0.251	0.251	0.253	0.354	0.359	0.136	0.141	0.475	0.469	5/64
1009	5/16	1 1/8	1.125	1.115	0.484	0.479	0.313	0.312	0.311	0.313	0.313	0.315	0.323	0.328	0.167	0.172	0.475	0.469	5/64
810	1/4	1 1/4	1.250	1.240	0.547	0.542	0.251	0.250	0.249	0.251	0.251	0.253	0.417	0.422	0.136	0.141	0.537	0.531	5/64
1010	5/16	1 1/4	1.250	1.240	0.547	0.542	0.313	0.312	0.311	0.313	0.313	0.315	0.386	0.391	0.167	0.172	0.537	0.531	5/64
1210	3/8	1 1/4	1.250	1.240	0.547	0.542	0.376	0.375	0.374	0.376	0.376	0.378	0.354	0.359	0.198	0.203	0.537	0.531	5/64
1011	5/16	1 3/8	1.375	1.365	0.594	0.589	0.313	0.312	0.311	0.313	0.313	0.315	0.433	0.438	0.167	0.172	0.584	0.578	3/32
1211	3/8	1 3/8	1.375	1.365	0.594	0.589	0.376	0.375	0.374	0.376	0.376	0.378	0.402	0.407	0.198	0.203	0.584	0.578	3/32
812	1/4	1 1/2	1.500	1.490	0.641	0.636	0.251	0.250	0.249	0.251	0.251	0.253	0.511	0.516	0.136	0.141	0.631	0.625	7/64
1012	5/16	1 1/2	1.500	1.490	0.641	0.636	0.313	0.312	0.311	0.313	0.313	0.315	0.480	0.485	0.167	0.172	0.631	0.625	7/64
1212	3/8	1 1/2	1.500	1.490	0.641	0.636	0.376	0.375	0.374	0.376	0.376	0.378	0.448	0.453	0.198	0.203	0.631	0.625	7/64

All dimensions are in inches.

Table 6. British Preferred Lengths of Plain (Parallel or Taper) and Gib-head Keys, Rectangular and Square Section *BS 46:Part 1:1958 (1985) Appendix*



Plain Key Size $W \times T$	Overall Length, L														
	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5	6
1/8 × 1/8	X	X													
3/16 × 3/16	X	X	X	X	X	X									
1/4 × 1/4	X	X	X	X	X	X	X	X	X	X					
5/16 × 1/4	X	X	X	X	X	X	X	X	X	X					
5/16 × 5/16	X	X	X	X	X	X	X	X	X	X					
3/8 × 1/4		X	X	X	X	X	X	X	X	X	X	X			
3/8 × 3/8		X	X	X	X	X	X	X	X	X	X	X			
7/16 × 5/16				X	X	X	X	X	X	X	X	X			
7/16 × 7/16					X	X	X	X	X	X	X	X			
1/2 × 5/16					X	X	X	X	X	X	X	X	X	X	
1/2 × 1/2						X	X	X	X	X	X	X	X	X	
5/8 × 7/16								X	X	X	X	X	X	X	
5/8 × 5/8								X		X	X	X	X	X	X
3/4 × 1/2										X	X	X	X	X	X
3/4 × 3/4											X	X	X	X	X
7/8 × 5/8											X	X	X	X	X



Gib-head Key Size, $W \times T$	Overall Length, L																
	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8
3/16 × 3/16	X	X	X	X	X		X										
1/4 × 1/4	X	X	X	X	X	X	X	X	X								
5/16 × 1/4			X	X	X	X	X	X	X								
5/16 × 5/16			X	X	X	X	X	X	X	X							
3/8 × 1/4			X	X	X	X	X	X	X	X	X						
3/8 × 3/8			X	X	X	X	X	X	X	X	X	X	X				
7/16 × 5/16					X		X	X	X	X	X	X	X				
7/16 × 7/16					X		X	X	X	X	X	X	X				
1/2 × 5/16					X		X	X	X	X	X	X	X	X			
1/2 × 1/2					X		X	X	X	X	X	X	X	X			
5/8 × 7/16							X		X	X	X	X	X	X	X		
5/8 × 5/8									X	X	X	X	X	X	X		X
3/4 × 1/2									X	X	X	X	X	X	X	X	X
3/4 × 3/4									X		X		X		X		X
7/8 × 5/8											X		X	X	X	X	X
7/8 × 7/8													X		X		X
1 × 3/4													X		X	X	X
1 × 1													X		X		X

All dimension are in inches

Flat Belting

Flat belting was originally made from leather because it was the most durable material available and could easily be cut and joined to make a driving belt suitable for use with cylindrical or domed pulleys. This type of belting was popular because it could be used to transmit high torques over long distances and it was employed in factories to drive many small machines from a large common power source such as a steam engine. As electric motors became smaller, more efficient, and more powerful, and new types of belts and chains were made possible by modern materials and manufacturing processes, flat belts fell out of favor. Flat belts are still used for some drive purposes, but leather has been replaced by other natural and synthetic materials such as urethanes, which can be reinforced by high-strength polyamide or steel fabrics to provide properties such as resistance to stretching. The high modulus of elasticity in these flat belts eliminates the need for periodic retensioning that is usually necessary with V-belts.

Driving belts can be given a coating of an elastomer with a high coefficient of friction, to enable belts to grip pulleys without the degree of tension common with earlier materials. Urethanes are commonly used for driving belts where high resistance to abrasion is required, and will also resist attack by chemical solvents of most kinds. Flat belts having good resistance to high temperatures are also available. Typical properties of polyurethane belts include tensile strength up to 40,000 psi, depending on reinforcement type and Shore hardness of 85 to 95. Most polyurethane belts are installed under tension. The amount of the tension varies with the belt cross-section, being greater for belts of small section. Belt tension can be measured by marking lines 10 in. apart on an installed belt, then applying tension until the separation increases by the desired percentage. For 2 per cent tension, the lines on the tensioned belt would be 10.2 in. apart. Mechanical failure may result when belt tensioning is excessive, and 2 to 2.5 per cent elongation should be regarded as the limit.

Flat belts offer high load capacities and are capable of transmitting power over long distances, maintaining relative rotational direction, can operate without lubricants, and are generally inexpensive to maintain or replace when worn. Flat belt systems will operate with little maintenance and only periodic adjustment. Because they transmit motion by friction, flat belts have the ability to slip under excessive loads, providing a fail-safe action to guard against malfunctions. This advantage is offset by the problem that friction drives can both slip and creep so that they do not offer exact, consistent velocity ratios nor precision timing between input and output shafts. Flat belts can be made to any desired length, being joined by reliable chemical bonding processes.

Increasing centrifugal force has less effect on the load-carrying capacity of flat belts at high speeds than it has on V-belts, for instance. The low thickness of a flat belt, compared with a V-belt, places its center of gravity near the pulley surface. Flat belts therefore may be run at surface speeds of up to 16,000 or even 20,000 ft/min (81.28 and 101.6 m/s), although ideal speeds are in the range of 3,000 to 10,000 ft/min (15.25 to 50.8 m/s). Elastomeric drive surfaces on flat belts have eliminated the need for belt dressings that were often needed to keep leather belts in place. These surface coatings can also contain antistatic materials. Belt pulley wear and noise are low with flat belts shock and vibration are damped, and efficiency is generally greater than 98 per cent compared with 96 per cent for V-belts.

Driving belt load capacities can be calculated from torque $T = F(d/2)$ and horsepower $HP = T \times rpm/396{,}000$, where T is the torque in in.-lb, F is the force transmitted in lb, and d is the pulley diameter in in. Pulley width is usually about 10 per cent larger than the belt, and for good tracking, pulleys are often crowned by 0.012 to 0.10 in. for diameters in the range of 1.5 to 80 in.

Before a belt specification is written, the system should be checked for excessive startup and shut-down loads, which sometimes are more than 10 per cent above operating conditions. In overcoming such loads, the belt will transmit considerably more force than during normal operation. Large starting and stopping forces will also shorten belt life unless they are taken into account during the design stage.

Belt speed plays an important role in the amount of load a friction drive system can transmit. Higher speeds will require higher preloads (increased belt tension) to compensate for the higher centrifugal force. In positive drive (toothed belt) systems, higher speeds generate dynamic forces caused by unavoidable tolerance errors that may result in increased tooth or pin stresses and shorter belt life.

Pulley Diameters and Drive Ratios: Minimum pulley diameters determined by belt manufacturers are based on the minimum radius that a belt can wrap around a pulley without stressing the load-carrying members. For positive drive systems, minimum pulley diameters are also determined by the minimum number of teeth that must be engaged with the sprocket to guarantee the operating load.

Diameters of driving and driven pulleys determine the velocity ratio of the input relative to the output shaft and are derived from the following formulas: for all belt systems, velocity ratio $V = D_{pi}/D_{po}$, and for positive (toothed) drive systems, velocity ratio $V = N_i/N_o$, where D_{pi} is the pitch diameter of the driving pulley, D_{po} is the pitch diameter of the driven pulley, N_i is the number of teeth on the driving pulley, and N_o is the number of teeth on the driven pulley. For most drive systems, a velocity ratio of 8:1 is the largest that should be attempted with a single reduction drive, and 6:1 is a reasonable maximum.

Wrap Angles and Center-to-Center Distances: The radial distance for which the belt is in contact with the pulley surface, or the number of teeth in engagement for positive drive belts, is called the wrap angle. Belt and sprocket combinations should be chosen to ensure a wrap angle of about 120° around the smaller pulley. The wrap angle should not be less than 90°, especially with positive drive belts, because if too few teeth are in engagement, the belt may jump a tooth or pin and timing or synchronization may be lost.

For flat belts, the minimum allowable center-to-center distance (CD) for any belt-and-sprocket combination should be chosen to ensure a minimum wrap angle around the smaller pulley. For high-velocity systems, a good rule of thumb is a minimum CD equal to the sum of the pitch diameter of the larger sprocket and one-half the pitch diameter of the smaller sprocket. This formula ensures a minimum wrap angle of approximately 120°, which is generally sufficient for friction drives and will ensure that positive drive belts do not jump teeth.

Pulley Center Distances and Belt Lengths: Maximum center distances of pulleys should be about 15 to 20 times the pitch diameter of the smaller pulley. Greater spacing requires tight control of the belt tension because a small amount of stretch will cause a large drop in tension. Constant belt tension can be obtained by application of an adjustable tensioning pulley applied to the slack side of the belt. Friction drive systems using flat belts require much more tension than positive drive belt systems.

Belt length can be calculated from: $L = 2C + \pi(D_2 + D_1)/2 + (D_2 - D_1)^2/4C$ for friction drives, and length $L = 2C + \pi(D_2 + D_1)/2 + (D_2 + D_1)^2/4C$ for crossed belt friction belt drives, where C is the center distance, D_1 is the pitch diameter of the small pulley, and D_2 is the pitch diameter of the large pulley. For serrated belt drives, the length determined by use of these equations should be divided by the serration pitch. The belt length must then be adjusted to provide a whole number of serrations.

Calculating Diameters and Speeds of Pulleys

Pulley Diameters and Speeds.—If D = diameter of driving pulley, d = diameter of driven pulley, S = speed of driving pulley, and s = speed of driven pulley:

$$D = \frac{d \times s}{S},\qquad d = \frac{D \times S}{s},\qquad S = \frac{d \times s}{D},\qquad \text{and} \qquad s = \frac{D \times S}{d}$$

Example 1: If the diameter of the driving pulley D is 24 inches, its speed is 100 rpm, and the driven pulley is to run at 600 rpm, the diameter of the driven pulley, $d = 24 \times 100 ⁄ 600 =$ 4 inches.

Example 2: If the diameter of the driven pulley d is 36 inches, its required speed is to be 150 rpm, and the speed of the driving pulley is to be 600 rpm, the diameter of the driving pulley $D = 36 \times 150 ⁄ 600 = 9$ inches.

Example 3: If the diameter of the driven pulley d is 4 inches, its required speed is 800 rpm, and the diameter of the driving pulley D is 26 inches, the speed of the driving pulley = $4 \times 800 ⁄ 26 = 123$ rpm.

Example 4: If the diameter of the driving pulley D is 15 inches and its speed is 180 rpm, and the diameter of the driven pulley d is 9 inches, then the speed of the driven pulley = $15 \times 180 ⁄ 9 = 300$ rpm.

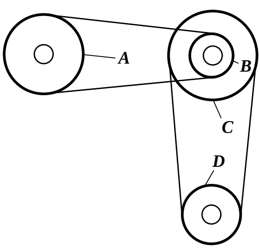
Pulley Diameters in Compound Drive.—If speeds of driving and driven pulleys, A, B, C, and D (see illustration) are known, the first step in finding their diameters is to form a fraction with the driving pulley speed as the numerator and the driven pulley speed as the, denominator, and then reduce this fraction to its lowest terms. Resolve the numerator and the denominator into two pairs of factors (a pair being one factor in the numerator and one in the denominator) and, if necessary, multiply each pair by a trial number that will give pulleys of suitable diameters.

Example: If the speed of pulley A is 260 rpm and the required speed of pulley D is 720 rpm, find the diameters of the four pulleys. Reduced to its lowest terms, the fraction 260⁄720 = 13⁄36, which represents the required speed ratio. Resolve this ratio 13⁄36 into two factors:

$$\frac{13}{36} = \frac{1 \times 13}{2 \times 18}$$

Multiply by trial numbers 12 and 1 to get:

$$\frac{(1 \times 12) \times (13 \times 1)}{(2 \times 12) \times (18 \times 1)} = \frac{12 \times 13}{24 \times 18}$$



Compound Drive with Four Pulleys.

The values 12 and 13 in the numerator represent the diameters of the *driven* pulleys, B and D, and the values 24 and 18 in the denominator represent the diameters of the *driving* pulleys, A and C, as shown in the illustration.

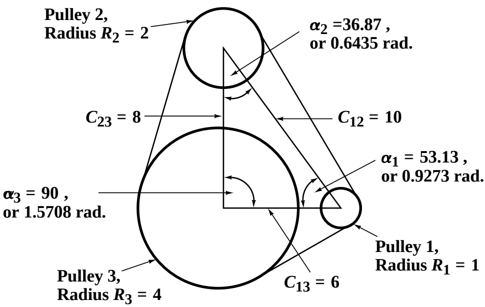
Speed of Driven Pulley in Compound Drive.—If diameters of pulleys *A*, *B*, *C*, and *D* (see illustration above), and speed of pulley *A* are known, the speed of the driven pulley *D* is found from:

$$\frac{\text{driving pulley diameter}}{\text{driven pulley diameter}} \times \frac{\text{driving pulley diameter}}{\text{driven pulley diameter}} \times \text{speed of first driving pulley}$$

Example: If the diameters of driving pulleys *A* and *C* are 18 and 24 inches, diameters of driven pulleys *B* and *D* are 12 and 13 inches, and the speed of driving pulley *A* is 260 rpm, speed of driven pulley

$$D = \frac{18 \times 24}{12 \times 13} \times 260 = 720 \text{ rpm}$$

Length of Belt Traversing Three Pulleys.—The length *L* of a belt traversing three pulleys, as shown in the diagram below, and touching them on one side only, can be found by the following formula.



Flat Belt Traversing Three Pulleys.

Referring to the diagram, R_1, R_2, and R_3 are the radii of the three pulleys; C_{12}, C_{13}, and C_{23} are the center distances; and α_1, α_2, and α_3 are the angles, in radians, of the triangle formed by the center distances. Then:

$$L = C_{12} + C_{13} + C_{23} + \frac{1}{2}\left[\frac{(R_2 - R_1)^2}{C_{12}} + \frac{(R_3 - R_1)^2}{C_{13}} + \frac{(R_3 - R_2)^2}{C_{23}}\right]$$
$$+ \pi(R_1 + R_2 + R_3) - (\alpha_1 R_1 + \alpha_2 R_2 + \alpha_3 R_3)$$

For example: assume $R_1 = 1$, $R_2 = 2$, $R_3 = 4$, $C_{12} = 10$, $C_{13} = 6$, $C_{23} = 8$, $\alpha_1 = 53.13$ degrees or 0.9273 radian, $\alpha_2 = 36.87$ degrees or 0.6435 radian, and $\alpha_3 = 90$ degrees or 1.5708 radians. Then:

$$L = 10 + 6 + 8 + \frac{1}{2}\left[\frac{(2-1)^2}{10} + \frac{(4-1)^2}{6} + \frac{(4-2)^2}{8}\right]$$
$$+ \pi(1 + 2 + 4) - 0.9273 \times 1 + 0.6435 \times 2 + 1.5708 \times 4$$
$$= 24 + 1.05 + 21.9911 - 8.4975 = 38.5436$$