



# PRODUCT APPLICATION NOTES

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## Shaft and Hub Keyway and Key Sizes

Keys connecting shafts to pulley hubs are commonly used to achieve reliable no-slip power transmission in belt drive systems. This PA Note will explain the uses of keys and keyways in pulleys and bushings, and present current industry standards for key and keyway component sizing.

### What is a Key, Keyseat, and Keyway?

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

Keyseat: An axially located rectangular groove in a shaft, hub, or bushing. This may also be referred to as shaft keyseat or hub keyseat or bushing keyseat when describing an exact application. The hub or bushing keyseat can be referred to as a keyway.

Keyway: The hub or bushing keyseat.

### Keys and Keyways: The Basics

In order to lock a hub or bushing and shaft together, and prevent the shaft from rotating in the bore, a key is commonly inserted into a keyway that is machined in both the bore and shaft. The key is responsible for preventing rotation between the shaft and the bore, and carries a portion of the torque load. Improperly fitted keys and keyways -either too tight or too loose- can result in mechanical failures. Therefore, to ensure appropriate fit, the width and height dimensions of standard key and keyways must be held to recommended tolerances. Industry standards for key sizes in various bores exist for both English and Metric systems. A common standard available from the Mechanical Power Transmission Association is MPTA-B1-2003. Another useful industry standard is ANSI Standard B17.1 for Keys and Keyseats.

### Shallow Keys

Shallow keys are sometimes used when the shaft diameter approaches the maximum bushing or hub bore range. In order to accommodate the large shaft, the bore keyway depth is reduced. The power transmission capability of this arrangement is not reduced, but may not be as robust as a standard key and keyseat. Dimensional standards for "shallow key" sizes do not exist, so manufacturers generally furnish these special keys with their pulleys or bushings.

### **Plain Bore Style Pulleys**

In larger plain bore style pulleys, a keyway must be machined into the bore with the correct tolerances. The fit between a finished pulley bore and its mating shaft must not allow relative movement when the pulley is subjected to belt tension and torque loads. This is accomplished with the use of set screws, and by controlling the fit or clearance between the bore and the mating shaft. Set screws do push shafts to one side of the bores causing eccentricity or radial run-out, resulting in belt tension excursion and vibration. In order to minimize these potentially negative results, Gates publishes recommended shaft to bore fit tolerances for a range of shaft sizes. If cyclical or pulsating loads will be transmitted, an interference type fit is required. Interference fit tolerances for a range of shaft sizes are also published by Gates. Tables containing these recommended fit tolerances are available in any of the Gates Synchronous Belt Drive Design Manuals.

In smaller minimum plain bore style pulleys, keys are not used. Set screws, along with the press fit interaction between the bore and shaft, are relied upon to secure the hub to the shaft. This type of arrangement is generally sufficient for very light loads. In these cases, designers should evaluate the design loads to be sure the set screw holding torque is sufficient.

### **Pulleys With Bushings**

In order to achieve better concentricity as well as versatility in fitting numerous standard shaft sizes, tapered bushings are commonly used in pulleys. The most common bushing types used in industrial power transmission applications are QD<sup>®</sup> (Quick Disconnect – flanged type) and TL (Taper-Lock<sup>®</sup> – flangeless type). Each system has its own merits and benefits.

In most QD type bushings, a setscrew in the flange tightens against the key to prevent key loss in applications subject to vibrating or pulsating loads, and in vertical shaft applications. Some bushing types are manufactured with an integral key that is formed as part of the bore. This also prevents potential key loss. Both types of bushings are popular in vertical shaft installations.

### **Keyless Bushings**

Besides keyed bushings, several types of keyless locking devices using a tapered wedge principle are available. These keyless bushings convert clamping action between inner and outer tapered rings into radial pressure that locks the device to the shaft and pulley. Keyless bushings exert significantly greater radial hub loads compared to conventional tapered and keyed bushings. This requires that hubs be sufficiently sized to handle the increased hoop stress loads. Keyless bushings transmit high torque loads while maintaining excellent concentricity (minimal radial run out and belt tension excursion). However, they are available in a limited number of bore sizes and tend to cost more than conventional tapered and keyed bushings.

### **Standard Key and Keyway Sizing**

Figure 1 describes the dimensions used when specifying English and Metric keys and keyways.

#### English Dimensions:

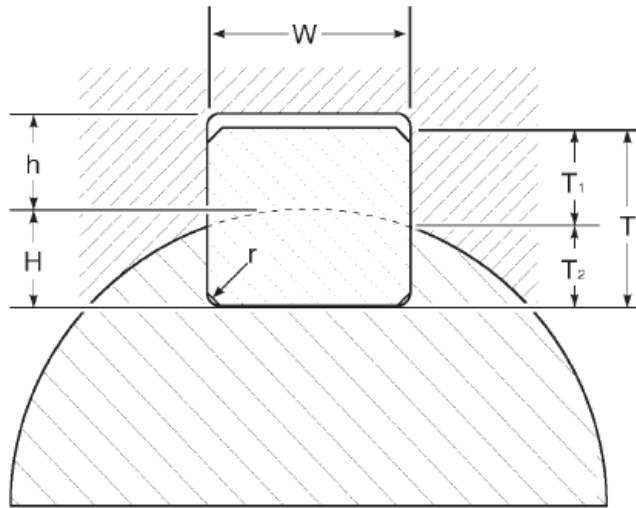
Keyway:  $W \times T_1$

Key:  $W \times T$

#### Metric Dimensions:

Keyway:  $W \times h$

Key:  $W \times T$



**Figure 1 - Keyway and Key Size Dimension Reference**

### **Specifying English Keyways**

In the English system, it is standard practice to dimension keyways. The hub keyway is dimensioned by its width and depth on the shaft – keyway sides. Referencing Figure 1, the keyway dimension is  $W \times T_1$ .

Unless otherwise specified, the shaft keyway is assumed to be standard. A list of standard keyway and corresponding key sizes for English shafts are listed below in Table 1. The common specification dimension, Keyway Size, is highlighted.

<b>English Standard Keyway and Key Sizes</b>					
<b>Shaft Diameter (in)</b>		<b>Keyway (in)*</b>		<b>Key (in)</b>	
<b>From</b>	<b>To</b>	<b>Width (W)</b>	<b>Depth (T<sub>1</sub>)</b>	<b>Width (W)</b>	<b>Depth (T)</b>
5/16	7/16	3/32	3/64	3/32	3/32
1/2	9/16	1/8	1/16	1/8	1/8
5/8	7/8	3/16	3/32	3/16	3/16
15/16	1 1/4	1/4	1/8	1/4	1/4
1 5/16	1 3/8	5/16	5/32	5/16	5/16
1 7/16	1 3/4	3/8	3/16	3/8	3/8
1 13/16	2 1/4	1/2	1/4	1/2	1/2
2 5/16	2 3/4	5/8	5/16	5/8	5/8
2 13/16	3 1/4	3/4	3/8	3/4	3/4
3 5/16	3 3/4	7/8	7/16	7/8	7/8
3 13/16	4 1/2	1	1/2	1	1
4 9/16	5 1/2	1 1/4	5/8	1 1/4	1 1/4
5 9/16	6 1/2	1 1/2	3/4	1 1/2	1 1/2
6 9/16	7 1/2	1 3/4	3/4	1 3/4	1 1/2
7 9/16	9	2	3/4	2	1 1/2

\* Common dimension specification

**Table 1 - Standard English Keyway and Key Dimensions**

### Specifying Metric Keyways

Dimensioning and specifying Metric keys and keyways varies significantly from the English system. In the Metric system it is common practice to specify the key size. Referencing Figure 1, the Metric key size is  $W \times T$ . The keyway dimensions are also different from the English system. Metric keyways are dimensioned by width and depth as measured from the radius of the shaft to the center of the keyway. See dimensions  $W$  and  $h$  in Figure 1.

Unless otherwise specified, the shaft keyway is assumed to be standard. Also,  $T_1$  and  $T_2$  are not necessarily equal. The Metric system does not refer to keyseat or keyway dimensions as does the English system. Instead, key dimensions are specified. Note that metric keys are rectangular in shape, and not square as in the English system. A list of the standard key sizes and corresponding keyways for Metric shafts are listed below in Table 2. The common specification dimension, Key Size, is highlighted.

Metric Standard Parallel Keyway and Key Sizes					
Shaft Diameter (mm)		Keyway (mm)		Key (mm)*	
From	To	Width (W)	Depth (h)	Width (W)	Depth (T)
6	8	2	1.0	2	2
9	10	3	1.4	3	3
11	12	4	1.8	4	4
13	17	5	2.3	5	5
18	22	6	2.8	6	6
23	30	8	3.3	8	7
31	38	10	3.3	10	8
39	44	12	3.3	12	8
45	50	14	3.8	14	9
51	58	16	4.3	16	10
59	65	18	4.4	18	11
66	75	20	4.9	20	12
76	86	22	5.4	22	14
86	96	25	5.4	25	14
96	110	28	6.4	28	16
111	130	32	7.4	32	18
131	150	36	8.4	36	20
151	170	40	9.4	40	22
171	200	45	10.4	45	25
201	230	50	11.4	50	28
231	260	56	12.4	56	32
261	290	63	12.4	63	32
291	330	70	14.4	70	36
331	380	80	15.4	80	40
381	440	90	17.4	90	45
441	500	100	19.5	100	50

\* Common dimension specification

**Table 2 - Standard Metric Keyway and Key Dimensions**

