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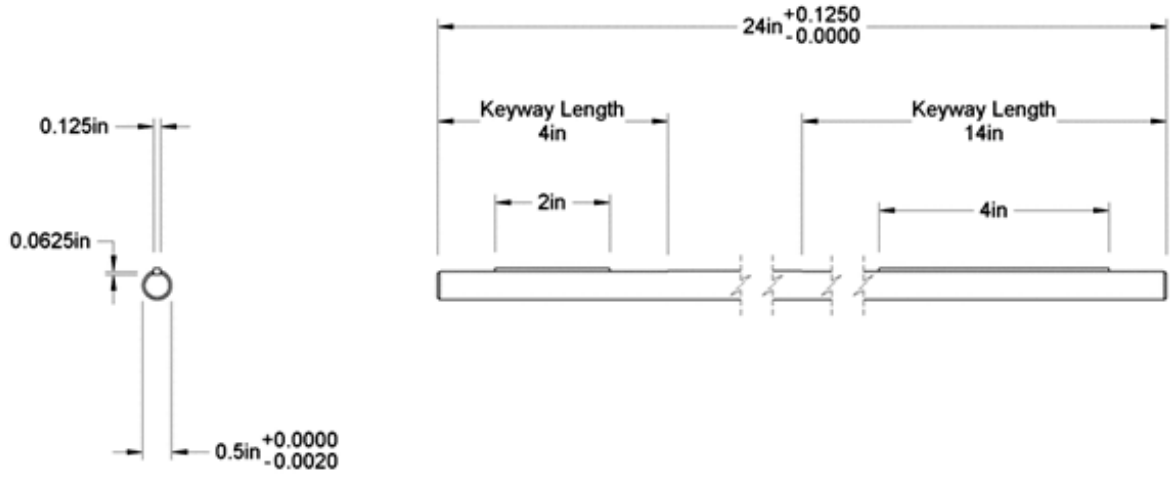
Shaft Research 2/22/2024

What Types of Rotary Shafts Exist in The Marketplace?

There are several different types of shafts available in the marketplace. Looking at McMaster Carr [1], Grainger [2], Misumi [3], and MSC [4] general use shafts generally consist of keyed shafts, keyless shafts, D-Profile shafts, grooved shafts, and hex shafts. Linear motion shafts also exist in the marketplace and are very similar to rotary shafts but have a much tighter straightness tolerance (0.002” per ft vs 0.0313” per ft) as seen on McMaster Carr’s website. By comparing the quoted hardness by McMaster to published hardness for the given materials it does not appear that the shafts get hardened. Standards relevant to shafts include ANSI B17.1-1967, ASTM A-276/479, and ASTM A291/291M-19.

Keyed Shafts

Keyed shafts are either partially or fully keyed. Fully keyed shafts have a cut keyway that runs the full length of the shaft, a partially keyed shaft only has sections of keyways cut at a single end, both ends, or at the center of the shaft. A typical example of a partially keyed shaft looks like the following:



The keyways are at the ends of each shaft with the center being left as a plain shaft. The benefit of partially keyed shafts is that the shaft accessory has a set stopping point on the shaft, it also uses less key stock when assembling. The size range offered by the analyzed suppliers appears to be 5/16” to 2-1/2” in diameter for both partially and fully keyed shafts. The length tolerances tend to vary from ±0.0313” to ±0.125”. Straightness tolerance varies from as tight as 0.005” per

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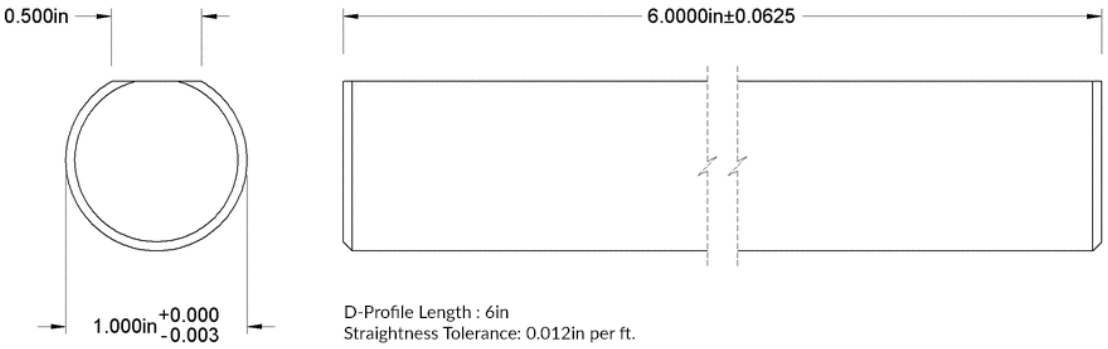
foot all the way to 0.0313" per foot. Diameter tolerance varies from ±0.005" all the way to -0.0025" +0.0000" which appears more commonly. The key stock is typically square, so the keyway depth is typically half the width for equal distribution of load between the mating parts. Keyed shafts primarily increment in diameter by 1/16" from 5/16" to 2-1/2".

Keyless Shafts

Keyless shafts are essentially ground and polished rods that have been cut to length and chamfered. They are typically for lower torque applications, accessories such as hubs, wheels, sprockets, gears, fan blades, etc. would be held in place with a press fit, set screws, shaft collars, and/or some method of clamping to the shaft. The tolerances are very similar to the keyed shafts. The diameter increments appear less regular and are closer to 1/8" compared to the 1/16" for the keyed shafts. Diameters start at 1/8" and increase all the way up to 2".

D-Profile Shafts

D profiled shafts are like keyed shafts but instead of a keyway have a flat. This flat allows for setscrews to engage and prevent sliding along the shaft. The flat and set screw allows for torque to be transmitted. Based upon McMaster's offerings the flat seems to run the length of the shaft. The tolerances are similar to those of other shafts. The diameters start at ¼" and go up to 1" in 1/8" increments. An example of a D profiled shaft looks like the following:



Grooved Shafts

Grooved shafts have thin grooves cut near the ends of the shaft for retaining rings to clip into. The retaining rings hold components such as gears or bearings in place along the shaft. They can also hold the shaft in place as it rotates. Looking at the McMaster product offering [5] as well as the Grainger product offering [6], they are only offered in 303 stainless steel in diameters from ¼" up to 1" in 1/8" increments. They appear to only be offered in 3",6" and 9"

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lengths as well. The length tolerances are very similar to the other shafts, the diameter tolerances appear to be -0.0002" to be able to precisely fit in bearings. The straightness tolerance appears to be similar to the other shafts as well. An example of a grooved shaft might look something like the following:

The grooves are typically spaced at the width of a typical bearing for the shaft size, other accessories would likely fit this spacing as well.

Hex Shafts

Due to their shape hex shafts do not need keyways as their flat edges allow for torque transmission. Since they do not need a keyway, they are very similar to the keyless shafts. They would be cut to length and chamfered sections of hex. The most involved operation that could take place is machining of the ends of the shaft. With them being simple, McMaster and Grainger as well as others seem to typically only sell hex accessories, those accessories point to a size range of 3/8"-1" hex from McMaster's offerings [7]. Tolerances would be very similar to the other shafts.

Linear Motion

Linear motion shafts are similar to keyless shafts with a much tighter tolerance (-0.001" to -.0005" in diameter and .002" per ft for straightness). They pair with linear bearings and act as linear guides. Since they typically have less bending loads places on the, some are manufactured hollow. Since the majority of these shaft need to be mounted at the ends and many have tapped or threaded ends as can be seen with Grainger's offerings [8]. Based upon McMaster's offerings [9], these shafts come in a wide range of aluminum, stainless, alloy and carbon steels. They also appear in lengths from 3" to 8' with diameters starting at ¼" and ranging all the way to 4" with Grainger and 2" with McMaster.

Ends

Many shafts have different machined ends, these ends consist of D-profile/flat, tapped, threaded, stepped, and splined. The D profiled ends are slightly less common but allow for

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attaching the shaft end to an output and for easy torque transmission. Many smaller DC motors come with similarly styled output shafts. Tapped and threaded ends are more common on keyless and linear motion shafts but are not limited to them. Stepped down ends are turned to a smaller diameter to fit in smaller accessories such as bearings, this is primarily on keyed or keyless shafts. Splined shafts have a tooth profile to transmit torque in things like heavy machinery and other high torque applications.

Coatings

Shafts are sometimes coats to provide corrosion resistance and/or wear resistance. Black oxide coatings provide mild corrosion resistance in dry environments. Chrome plating gives more corrosion resistance as well as provides wear resistance. Nitride coatings are more corrosion resistant but less wear resistant. Anodizing aluminum shaft provides additional surface hardness, wear resistance, and further corrosion resistance than aluminum already provides [1].

Materials

Aluminum shafts are inherently lightweight and naturally corrosion resistant but are lower strength. Carbon steel shafts are higher strength and have good machinability, making carbon steels great for general use shafts. Alloy steels such as 4140 or 4340 and others will support greater stress but have lower machineability. Stainless steels have natural corrosion resistance, with 303 being more machinable but 316 being the most corrosion resistant.

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References

[1] https://www.mcmaster.com/products/shafts/shafts-2~/

[2] https://www.grainger.com/category/power-transmission/rotary-shafts-accessories

[3]https://us.misumiec.com/vona2/mech/M0800000000/M0801000000/M0801010000/?searchFlow=results2category&categoryKeyword=rotary+shafts+%26+drive+shafts&curSearch=%7B%22field%22%3A%22%40search%2CseriesList.templateType%22%2C%22categoryCode%22%3A%22M0801010000%22%2C%22sort%22%3A1%2C%22allSpecFlag%22%3A0%2C%22page%22%3A1%2C%22brandModeFlag%22%3A1%2C%22pageSize%22%3A45%7D&listDisplay=mc-list

[4]https://www.mscdirect.com/browse/tn/Motion-Control-Fluid-Power/Linear-Motion/Shafting-Rails-Supports/Round-Linear-Shafting?navid=2104444

[5]https://www.mcmaster.com/products/shafts/shafts-2~/rotary-shafts-with-retaining-ring-grooves/

[6] https://www.grainger.com/product/ONDRIVES-US-Grooved-Shaft-303-Stainless-802YT6

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[8]https://www.grainger.com/category/power-transmission/linear-motion/precision-linear-shafts/linear-motion-shafts?tv_optin=true&searchQuery=linear+motion+shaft&searchBar=true&suggestConfigId=6&tier=Not+Applicable

[9] https://www.mcmaster.com/products/shafts/shafts-2~/linear-motion-shafts-5/