

CRITICAL SPEED OF A ROTATING TORQUEMETER

It is not possible to perfectly balance a rotating device. Thus, when a torque meter, or any real rotating body, is operated at relatively low speeds (see further discussion), its' imperfect balance results in its' center of mass following a small circular path. This situation will hold true as the rotational speed is increased until the **first shaft critical** is reached. At **critical speed**, large shaft deflections and excessive vibrations will occur. If the speed is increased, these vibrations will subside until a **second shaft critical** is reached when the symptoms will reappear. If operation is required at a **critical speed**, component life will be reduced and measurement accuracy degraded.

It is virtually impossible to encounter a critical speed when a Himmelstein MCRT® torque meter is operated anywhere within its published speed rating. However, when high speed versions of these torque meters are supplied - usually include strengthened rotor assemblies, modified bearings and provision for external lubrication - it is conceivable that a **critical speed** will be encountered in the operating range. This document has been prepared to assist you in evaluating the probability of such an occurrence. It also provides guidance concerning torque meter mounting and coupling selection that allows you to increase the **critical speed** of a shaft system.

The **critical speed** of a shaft system including a torque meter is related to torque meter shaft design, bearing placement, torque meter mounting, coupling characteristics and the interaction between the rest of the shaft system and the torque meter. For applications where precise **critical speed** computations are vital, consultation with the factory is necessary. However, the following equations will allow approximate calculations.

FLOATING SHAFT TORQUEMETER MOUNTING

When the torque meter is mounted as a floating shaft (see Fig. 1), the **critical speed** of the torque meter only may be approximated by:

$$N_c = \frac{1.54 \times 10^6 d^2}{(W_1 L^3)^{1/2}}$$

Where: N_c = Critical Speed (RPM)
 d = Shaft Diameter (inches)
 W_1 = Weight of torque meter (pounds)
 L = Overall length of torque meter shaft (inches)

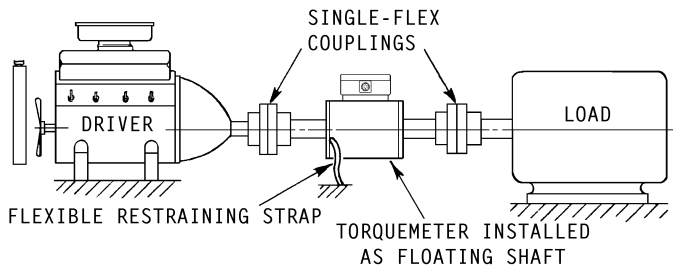


Figure 1 Floating Shaft Mount

In this arrangement, the total weight of the torque meter and the flexible couplings is supported by the input and output shaft system. As a result, the critical speed of the **complete** shaft system will probably be less than that given by the formula. Divide the calculated result by two (2) to obtain a conservative value.

FOOT MOUNTED TORQUEMETER

With a foot mounted torque meter (see Fig. 2), the **critical speed** of the torque meter may be approximated by:

$$N_c = \frac{8.28 \times 10^6 d}{L^2} \left[\frac{1}{1 + \frac{6.11 W_2}{L d^2}} \right]^{1/2}$$

Where: N_c = Critical Speed (RPM)
 d = Shaft Diameter (inches)
 L = Overall length of torque meter shaft (inches)
 W_2 = Weight of one complete coupling (pounds)

Because the double flex couplings tend to isolate the torque meter from the rest of the shaft system, this approximation is relatively accurate.

OTHER CONSIDERATIONS

When operating at high shaft speeds, adequate bearing lubrication must be provided - in most cases external lubrication may have to be furnished. Too little lubrication can result in premature bearing failure. Too much lubrication causes excessive viscous losses. Such losses will result in bearing heating and can cause torque measurement errors - the torque meter reads the running torque of the load-side bearing. The shaft system, including Flexible Couplings, must be balanced for high speed operation.

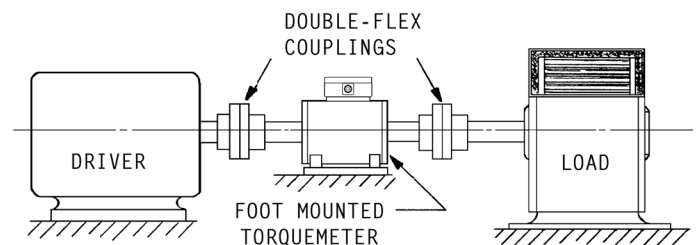


Figure 2 Rigid Stator Mount

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