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Perpendicularity Refinement

Recently a client asked me to look at a drawing that is similar to the one shown in Fig. 6-4A below. This part has three coaxial cylinders. The smallest cylinder must be coaxial to the 2.000 diameter cylinder within a cylindrical tolerance of .010 in diameter, and both cylinders are to be perpendicular to datum feature A within a cylindrical tolerance of .005 in diameter.

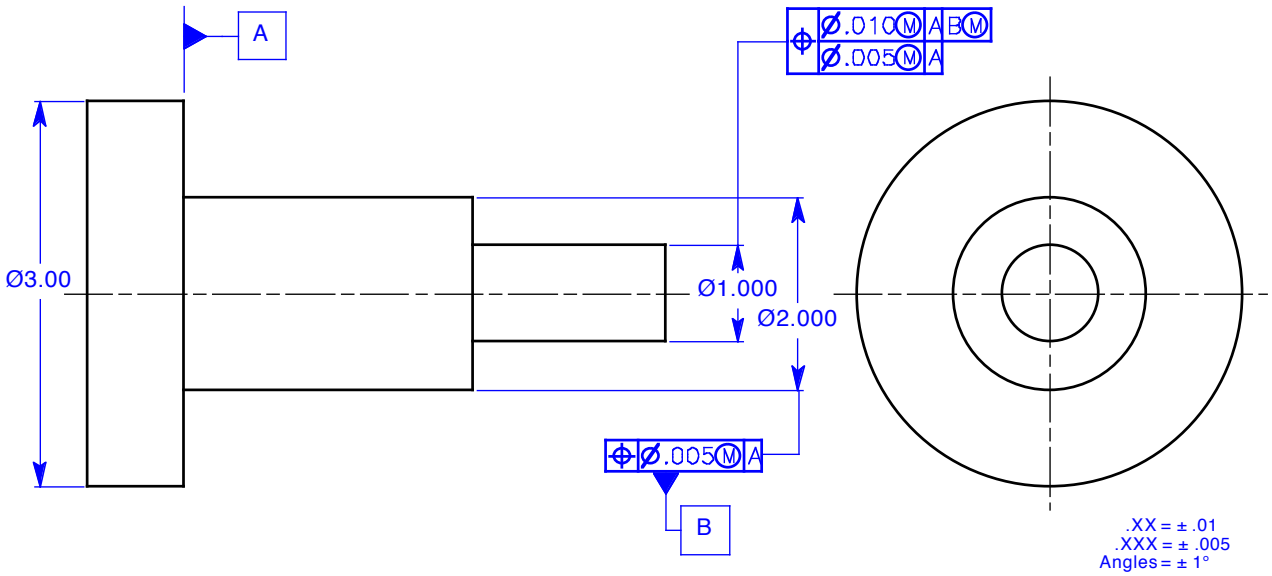

Figure 6-4A The inappropriate use of the position control to control perpendicularity

In an attempt to control the perpendicularly of the 2.000 diameter cylinder in Fig. 6-4A, the designer incorrectly toleranced it with a position control.[1] If perpendicularity is required, use the perpendicularly control. In other words, say what you mean. Although the tolerance of position does control orientation when it is used to locate a feature, it is not used solely to control perpendicularity. In this case, perpendicularity is the only relationship that must be refined. Consequently, the perpendicularity tolerance is the correct control for this application as shown in Fig. 6-4B below.

The composite tolerance shown in Fig. 6-4A is inappropriately applied to a single feature. This tolerance is only used to control patterns of features. A composite tolerance is used where the relationship from feature-to-feature in a pattern of features must be kept to a smaller tolerance than the relationship between the pattern and its datum features. Fig. 6-4B correctly shows the position control locating the axis of the 1.000 diameter cylinder within a cylindrical tolerance zone .010 in diameter, and a perpendicularity tolerance refining the orientation of the axis within a cylindrical tolerance zone of .005 in diameter. To refine the orientation of a single feature, specify the desired orientation tolerance, perpendicularity in this case, and place the orientation feature control frame beneath the location feature control frame.

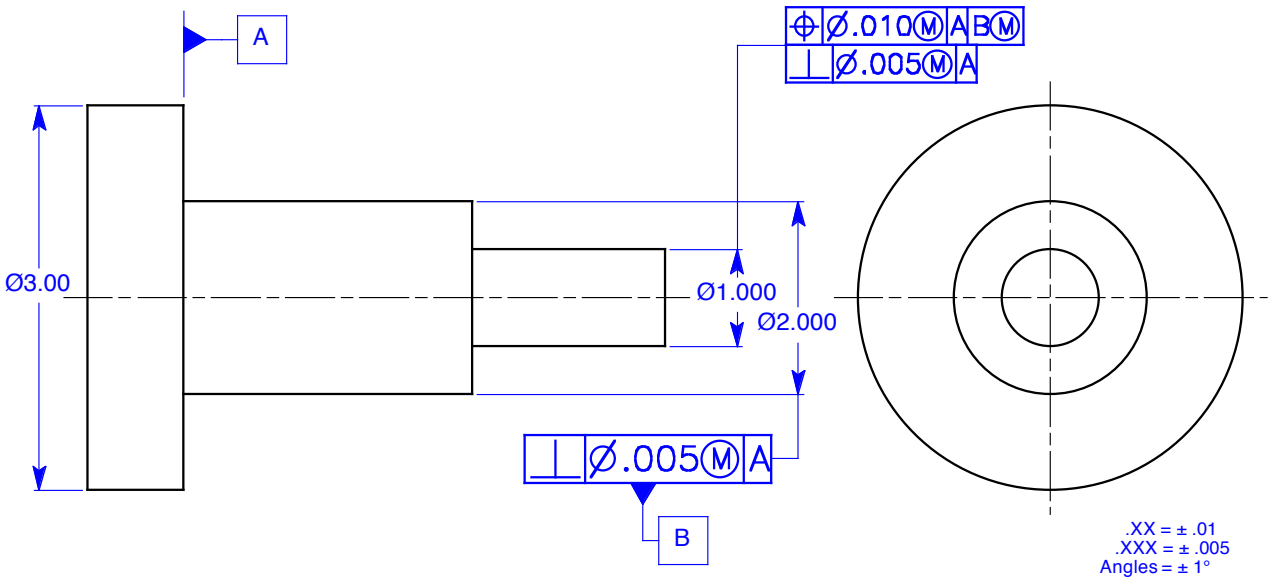

Figure 6-4B The properly toleranced part shown in Fig. 6-4A

There is one final problem with the drawing in Fig. 6-4A. The two and three-inch diameter cylinders have no coaxiality control between them. As a result, the drawing is incomplete. It is a common misconception that the size tolerance in the tolerance block will control the coaxiality between two individual cylinders. **The relationship between individual features** is **not** controlled by the limits of size. If features on a drawing are shown coaxial, or symmetrical to each other, and not toleranced for location, the drawing is incomplete. Fig. 6-4B has a note specifying the tolerance between coaxial features. The use of a note is one-way of specifying the coaxiality tolerance for two or more individual features. Some designers feel that specifying coaxiality on prints is "overkill." As a result of their mistaken beliefs, their companies have either already purchased bad parts or will purchase bad parts in the future. The proper tolerancing of parts avoids confusion, saves time, and saves money.

[1]Cogorno, Gene R., ***Geometric Dimensioning and Tolerancing for Mechanical Design, Second Edition***, McGraw-Hill, New York, 2011, pp. 91 & 142.