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Locating Coaxial Features at MMC[1]

This part has two holes through the wall of a cylinder that must be centered on the axis of the cylinder and located 2.000 inches ± .005 from datum feature A. The two holes must also be parallel to datum feature A within a cylindrical tolerance zone .002 in diameter at MMC.

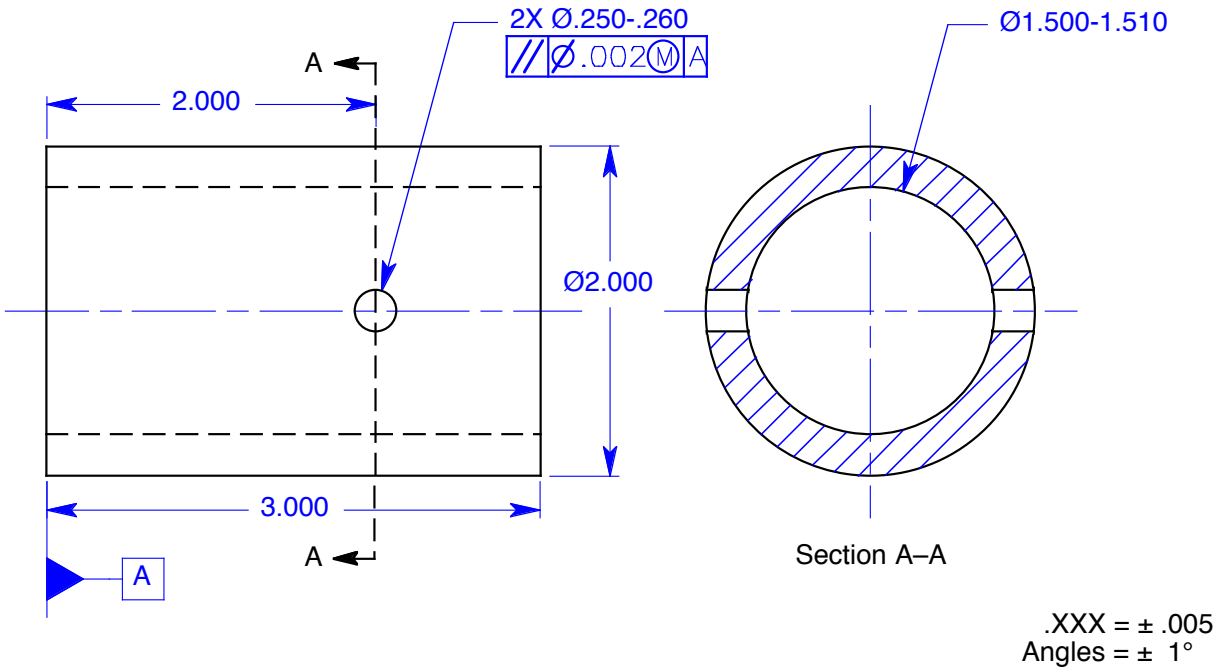

Figure 9-11 A client drawing specifying the location of two holes

What the drawing in Figure 9-11 does not show is which diameter defines the axis of the cylinder, what the hole location tolerance is with respect to the axis of the cylinder, and what the coaxiality tolerance is between the inside and outside diameters of the cylinder. This drawing leaves a lot to the imagination of machinists and inspectors.

[1]Cogorno, Gene R., ***Geometric Dimensioning and Tolerancing for Mechanical Design, Second Edition***, McGraw-Hill, New York, 2011, Chapter 9.

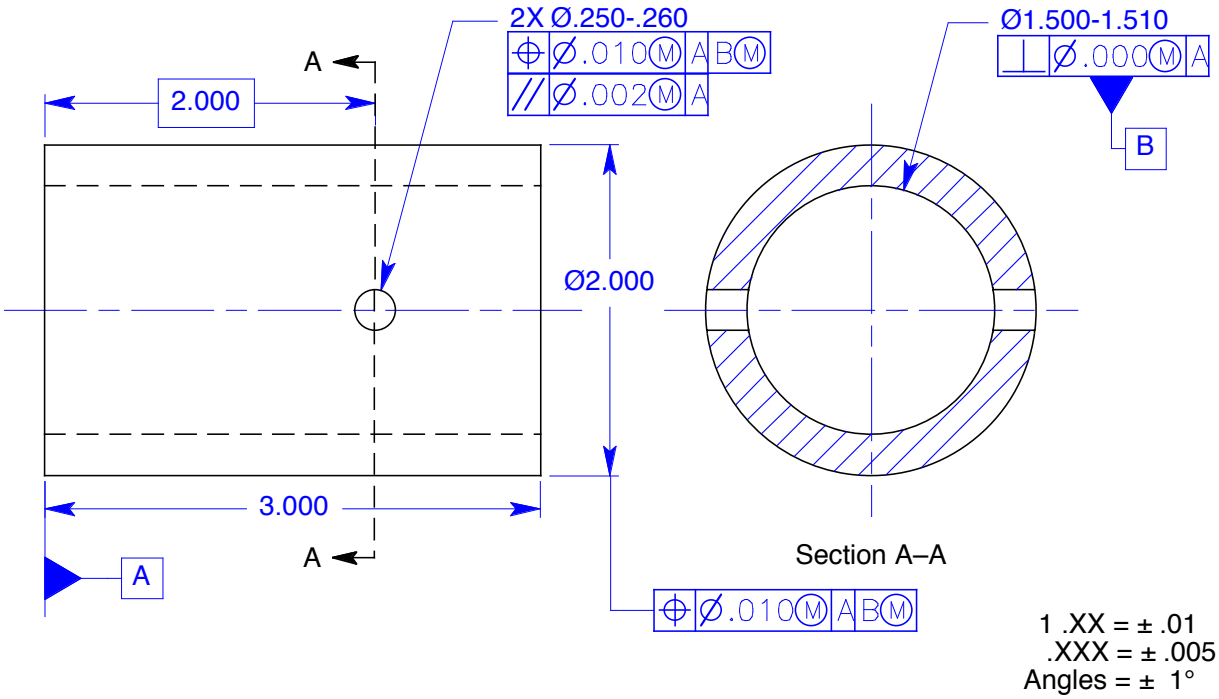

Figure 9-12 The part in figure 9-11 more completely toleranced

The drawing in Figure 9-12 demonstrates one way to properly tolerance the part in Figure 9-11. In this case, the inside diameter of the cylinder, datum feature B, has been specified as the secondary datum feature. No diameter was specified as a datum feature on the drawing in Figure 9-11. The axes of the two ¼ inch diameter holes have a parallelism refinement of .002, but they are only coaxial within .010. That is, one axis may be 1.995 and the other 2.005 from datum feature A. Consequently, a pin that passes through the two holes will not necessarily be parallel to datum feature A within .002.

The drawing in Figure 9-12 specifies that:

- The primary datum feature is the left end of the cylinder identified as datum feature A, and the secondary datum feature is the inside diameter identified as datum feature B. The axis of datum feature B must fall within a cylindrical tolerance zone .000 in diameter at MMC perpendicular to datum feature A. This perpendicularity control qualifies datum feature B perpendicular to datum feature A.
- The axes of the two ¼ inch diameter holes are located with the position control within two coaxial cylindrical tolerance zones .010 in diameter at MMC parallel to and located a basic 2.000 inches from datum feature A and centered on the axis of datum feature B at MMB.
- A parallelism tolerance is specified as a refinement of the position control. The parallelism tolerance controls each axis of each hole separately within cylindrical tolerance zones .002 in diameter at MMC parallel to datum feature A. Each .002 diameter cylindrical tolerance zone is free to float around, independently of each other, within the larger .010 diameter cylindrical tolerance zone as long as they remain parallel to datum feature A. This control does not require the two axes to be located to datum feature A or coaxial to each other within the .002 diameter cylindrical tolerance zones.
- The axis of the outside diameter must fall within a cylindrical tolerance zone .010 in diameter at MMC, perpendicular to datum feature A, and coaxial to the axis of the inside diameter, datum feature B at MMB.

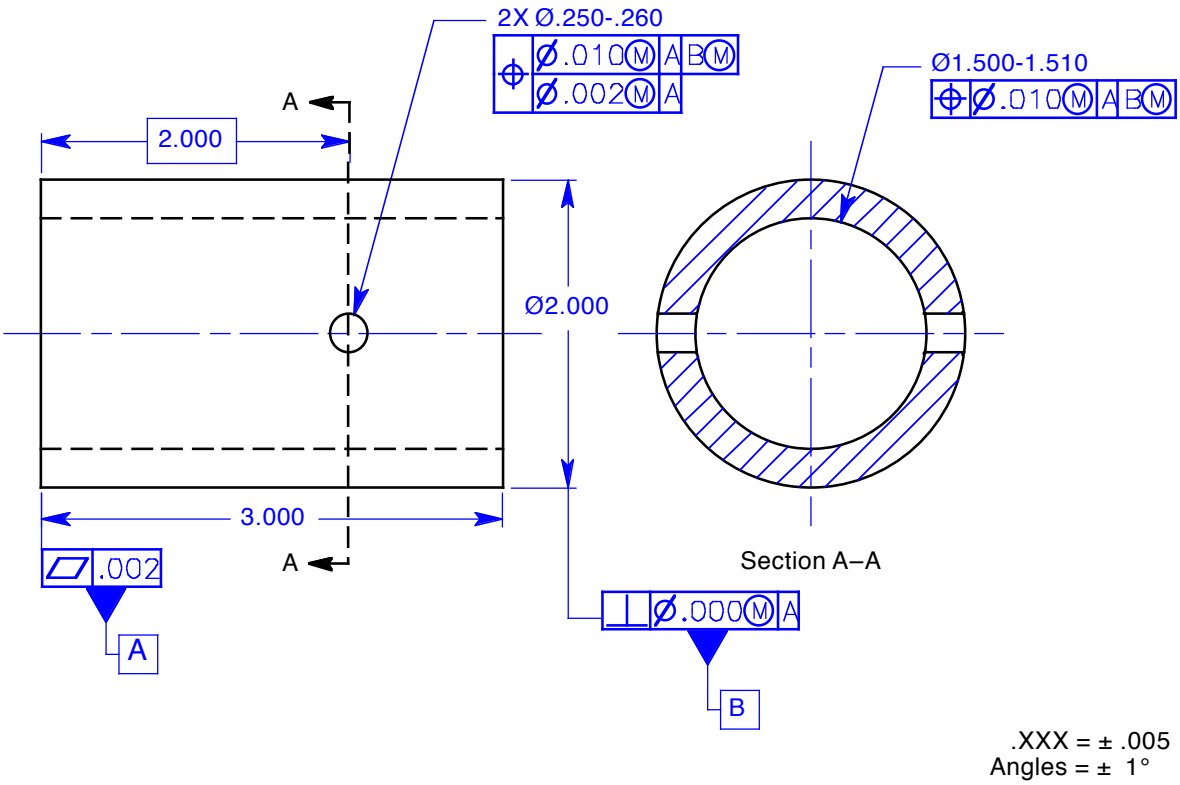

Figure 9-13 A second method of tolerancing the part in figure 9-11

There are other ways to tolerance this part. For instance, datum feature B could have been the outside diameter instead of the inside diameter. No diameter was specified as a datum feature on the drawing in Figure 9-11. Also, datum feature A could have been controlled with a flatness tolerance. The axes of the two ¼ inch diameter holes could have had a coaxiality refinement to the location tolerance in addition to the parallelism refinement.

The drawing in Figure 9-13 specifies that:

- The primary datum feature is the left end of the cylinder. It must be flat within two parallel planes .002 apart. The secondary datum feature is the outside diameter identified as datum feature B. The axis of datum feature B must fall within a cylindrical tolerance zone .000 in diameter at MMC perpendicular to datum feature A. This perpendicularity control qualifies datum feature B perpendicular to datum feature A.
- The axes of the two ¼ inch diameter holes are located with the upper segment of the composite position control within two coaxial cylindrical tolerance zones .010 in diameter at MMC parallel to and located a basic 2.000 inches from datum feature A and centered on the axis of datum feature B at MMB.
- The lower segment of the composite feature control frame is a refinement of the upper segment. The lower segment controls the axes of the two holes coaxial to each other and parallel to datum feature A within a cylindrical tolerance zone of .002 in diameter at MMC. The two .002 diameter cylindrical tolerance zones are coaxial to each other within the feature-relating tolerance zone framework (FRTZF). The FRTZF is free to float around inside the larger .010 diameter cylindrical tolerance zone as long as it remains parallel to datum feature A.
- The axis of the inside diameter must fall within a cylindrical tolerance zone .010 in diameter at MMC, perpendicular to datum feature A, and coaxial to the axis of the outside diameter, datum feature B at MMB.

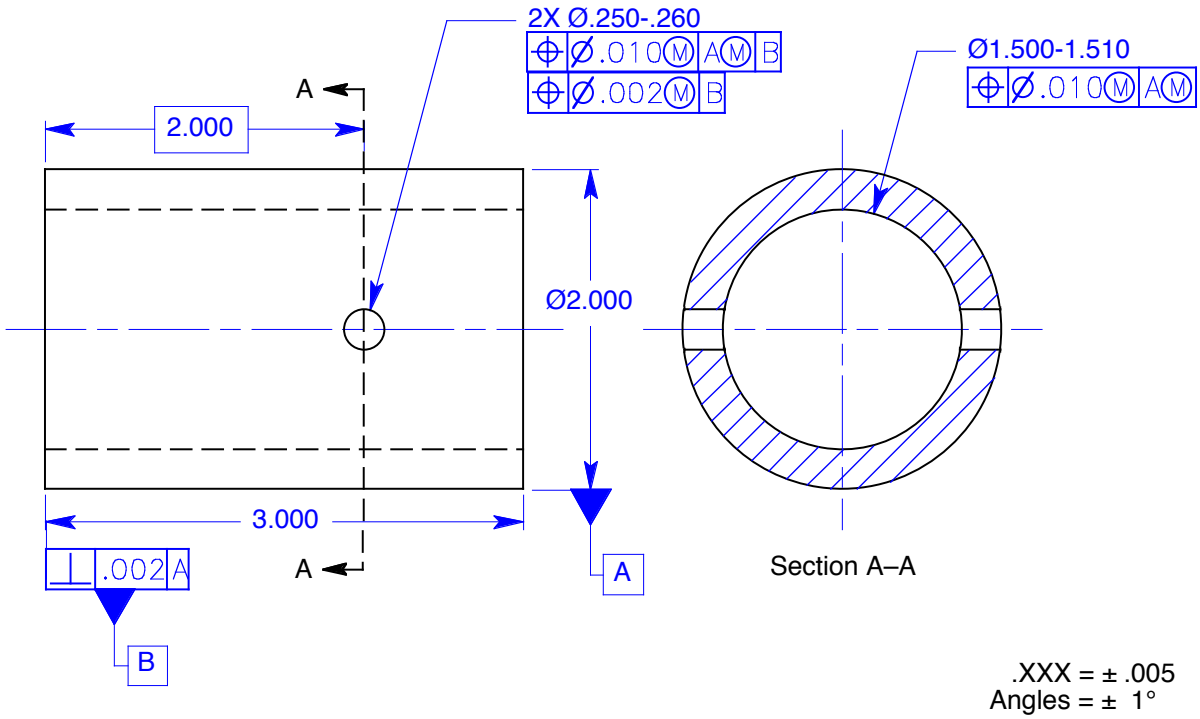

Figure 9-14 A third method of tolerancing the part in figure 9-11

Still another way of tolerancing the part is shown in Figure 9-14. In this case, the primary datum feature is the outside diameter. The secondary datum feature is the left end of the cylinder. The axes of the two ¼ inch diameter holes have a coaxiality and location refinement tolerance in addition to the parallelism refinement.

The drawing in Figure 9-14 specifies that:

- The primary datum feature is the outside diameter, datum feature A. The secondary datum feature is the left end, datum feature B. Datum feature B is perpendicular to the axis of datum feature A within two parallel planes .002 apart. Since both perpendicularity and flatness are controlled with two parallel planes, datum feature B is also flat within .002.
- The axes of the two ¼ inch diameter holes are located with the upper position control within two coaxial cylindrical tolerance zones .010 in diameter at MMC centered on the axis of datum feature A at MMB and parallel to and located a basic 2.000 inches from datum feature B.
- The second segment of the multiple single-segment feature control frame is a refinement of the first segment. The second segment controls the axes of the two holes coaxial to each other, oriented parallel to, and located to datum feature B within a cylindrical tolerance zone of .002 in diameter at MMC.
- The axis of the inside diameter must fall within a cylindrical tolerance zone .010 in diameter at MMC, coaxial with the axis of the outside diameter, datum feature A at MMB.

The designer who toleranced the drawing in Figure 9-11 was probably trying to achieve the relationships specified in Figure 9-13. This drawing requires the two holes to be located on the axis of the cylinder and a basic 2.000 from the left end of the cylinder within a tolerance of .010. It also requires the two holes to be coaxial to each other and parallel to the left end of the cylinder within a tolerance of .002. The parallelism tolerance does not control location. Location, in this case, is coaxiality.