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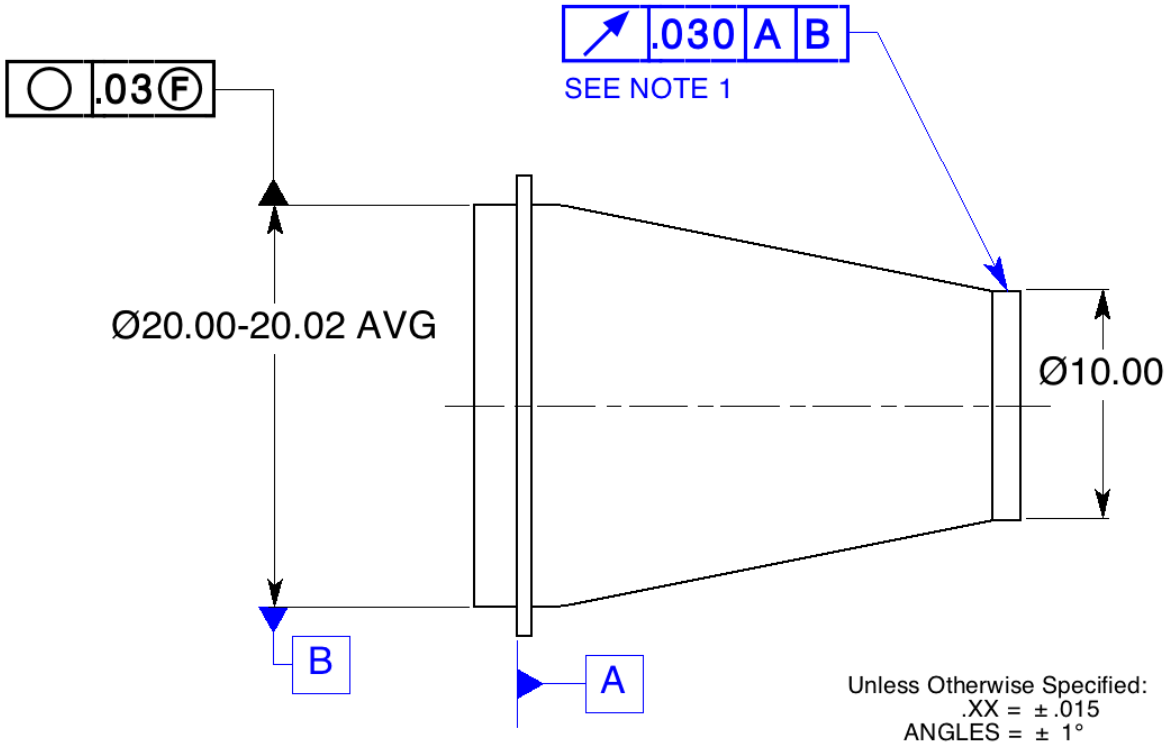
Free-State Variation[1]

Free state variation is a term used to describe the distortion of a part after the removal of forces applied during the manufacturing process. This distortion is primarily due to the weight and flexibility of the part and the release of internal stresses resulting from fabrication. A part such as this– for example, a large sheet metal tube or an O-ring – is referred to as a non-rigid part. A non-rigid part must meet its dimensional requirements in one of two ways – in the restrained or in the free state condition.

Where features are to be controlled for orientation, location, or runout in the restrained condition, a note must clearly state which features are to be restrained, how they are to be restrained, and to what extent they are to be restrained. Fig. 5-12 contains an example of a note specifying the restrained condition for the runout control. The restrained condition should simulate the actual assembly of the part.



NOTE 1 The runout tolerance applies when datum feature A is mounted against a flat surface fastened with 10 – .250-20 UNC screws torqued to 8-12 foot-pounds while restraining datum feature B within its specified MMC size.

Figure 5-12 This flexible part must be restrained before measuring the runout.

[1]Cogorno, Gene R., ***Geometric Dimensioning and Tolerancing for Mechanical Design, Second Edition***, McGraw-Hill, New York, 2011, p. 79.

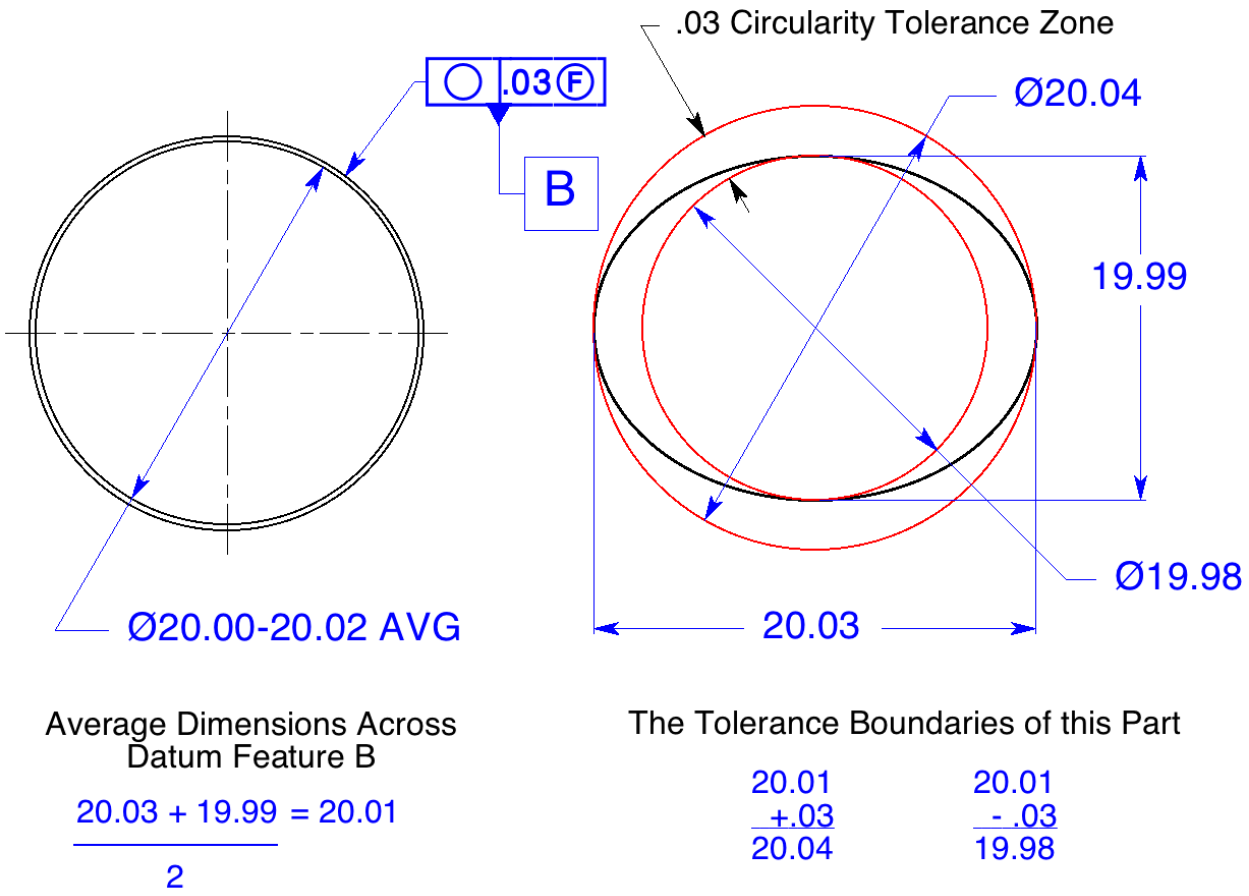


Figure 5-13 The circularity of this flexible part is to be measured in its free state.

Where a form or location tolerance is specified for a feature in the free state, the free state symbol is placed inside the feature control frame following the tolerance and any modifiers. The size dimension and tolerance are followed by the abbreviation AVG indicating that the measurements are to be averaged as shown in Fig. 5-13. The upper and lower boundaries of the maximum average dimension shown here are the maximum average, 20.02, plus and minus the circularity tolerance, .03. The upper and lower boundaries of the minimum average dimension are the minimum average, 20.00, plus and minus the circularity tolerance, .03. These extremes cannot both occur in the same cross section.

	Maximum Average Dimension		**Minimum Average Dimension**	
Max. & Min. Average	20.02	20.02	20.00	20.00
Circularity Tolerance	+.03	- .03	+.03	- .03
Upper & Lower Boundaries	20.05	19.99	20.03	19.97

If the average of measurements of a circular feature falls inside the average size tolerance range the feature is in tolerance. If the 20.00 diameter in Fig. 5-13 actually measures 20.03 in one direction and 19.99 in the other direction, the average diameter is 20.01 which falls within the average size tolerance range. Therefore, the average diameter is in tolerance. For clarity, only two measurements are shown here, but a minimum of four measurements must be taken to insure accuracy. The upper and lower boundaries of this feature are the average dimension, 20.01, plus and minus the circularity tolerance, .03, which equals 20.04 and 19.98 as shown in Fig. 5-13.