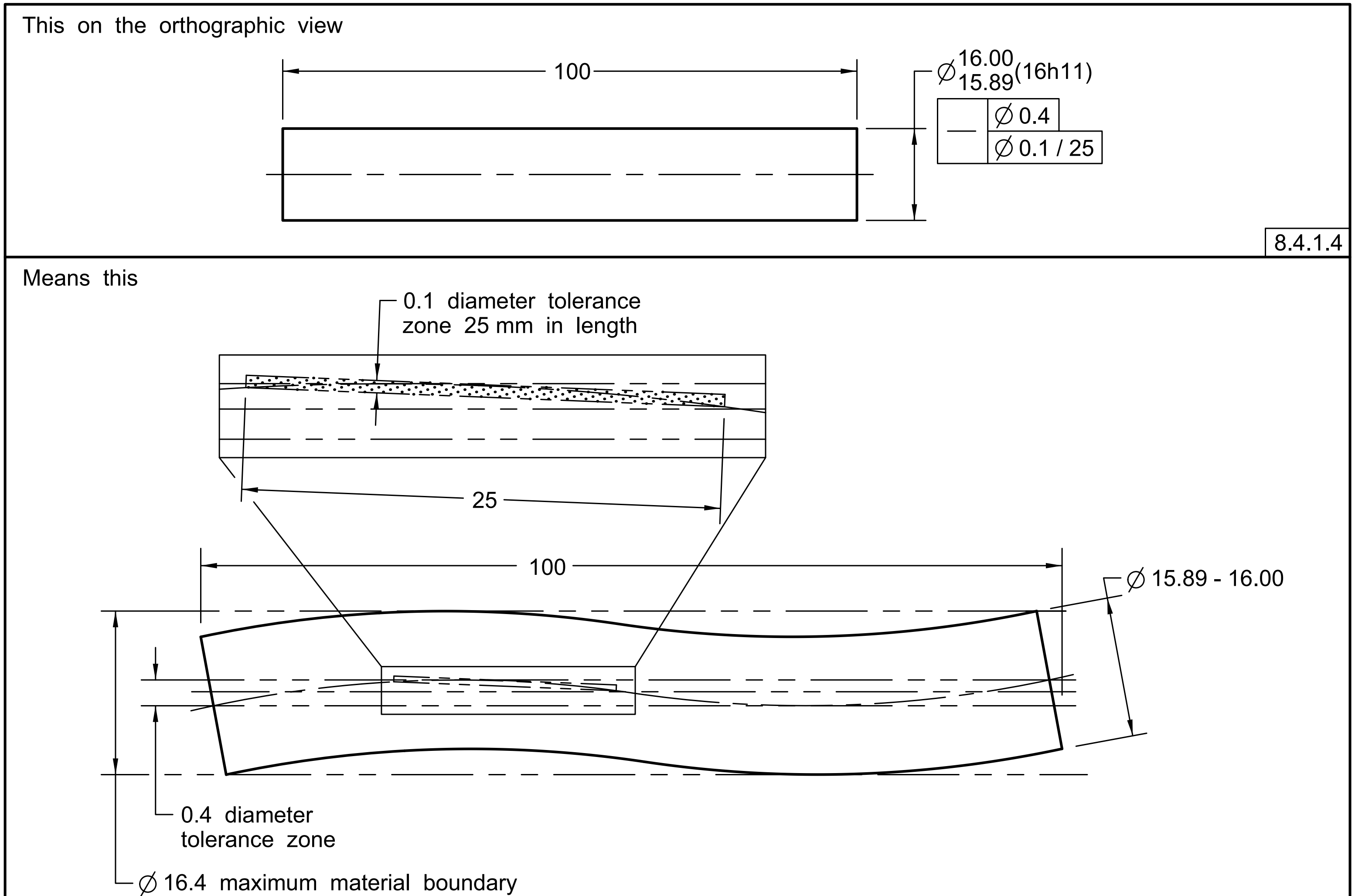
Figure 8-5 Specifying Straightness per Unit Length With Specified Total Straightness, Both RFS



The derived median line of the feature shall be within a cylindrical tolerance zone of 0.4 diameter for the total 100 mm of length and within a 0.1 diameter cylindrical tolerance zone for any 25 mm in length at any location, RFS. Each circular element of the surface shall be within the specified limits of size.

This is a preview. Click here to purchase the full publication.

Figure 8-6 Possible Results of Specifying Straightness per Unit Length RFS, With No Specified Total

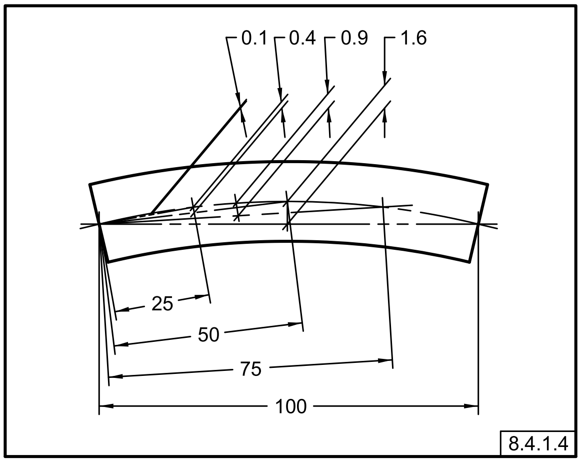
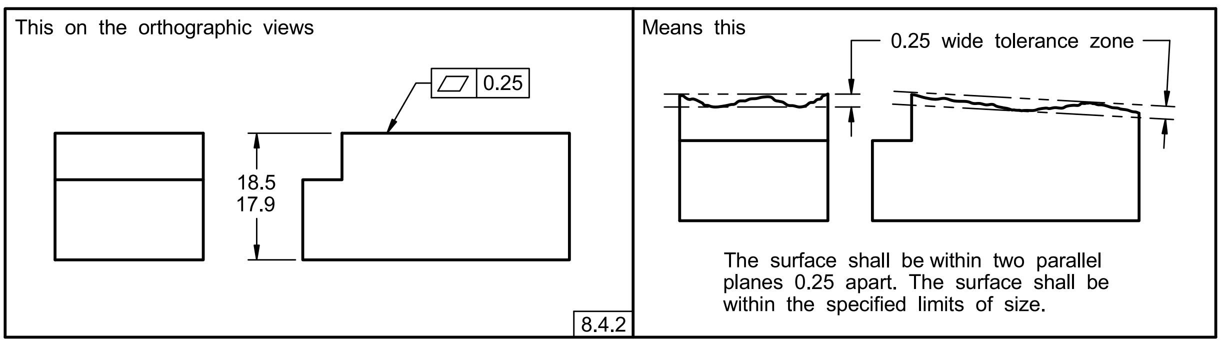
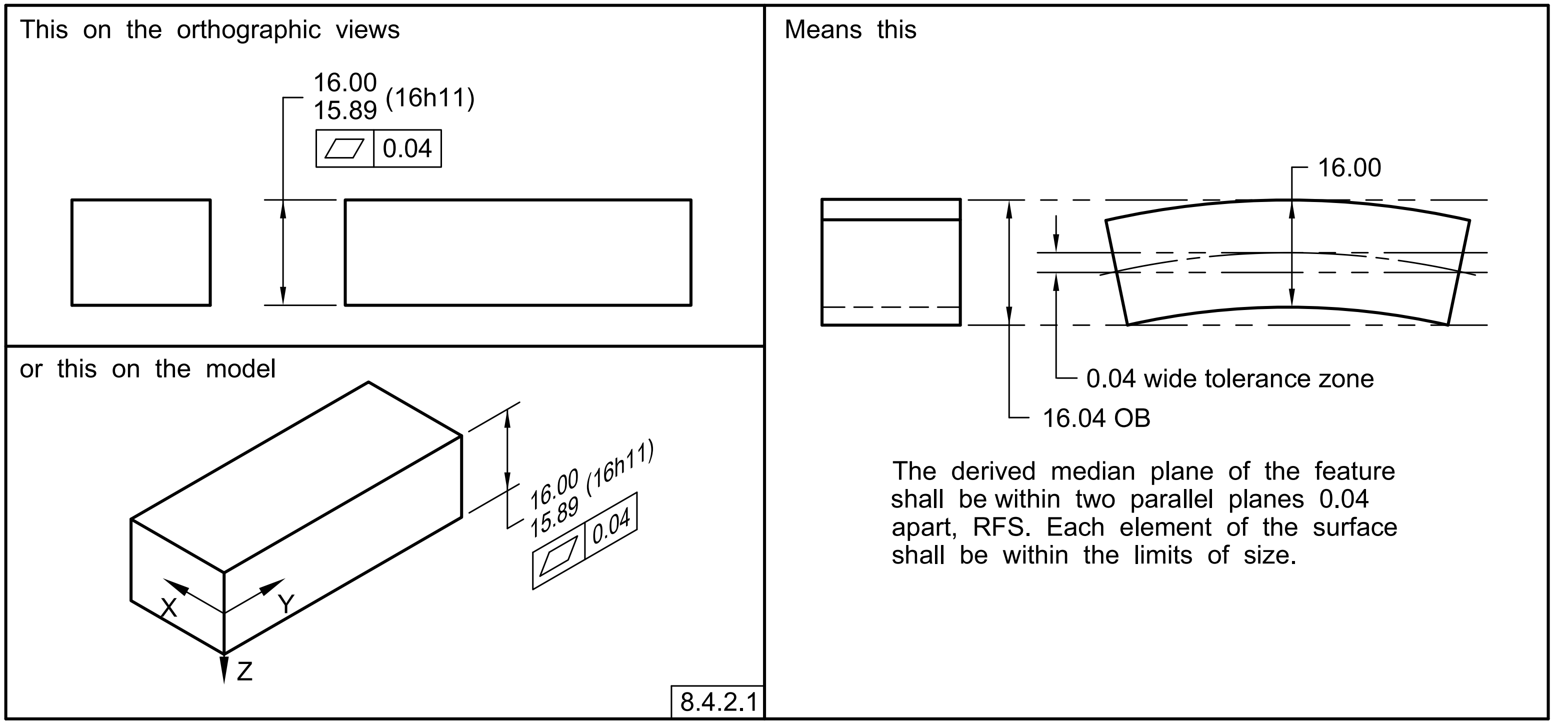


Figure 8-7 Specifying Flatness of a Surface



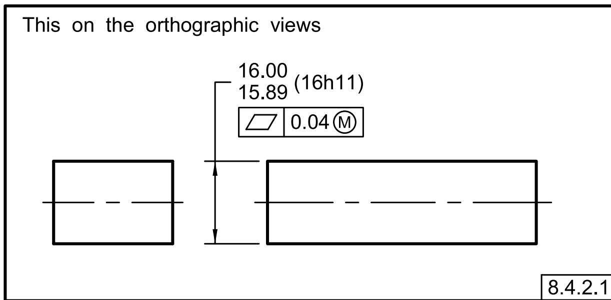
This is a preview. Click here to purchase the full publication.

Figure 8-8 Specifying Flatness of a Derived Median Plane RFS

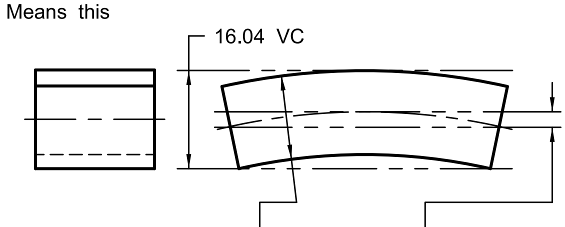


This is a preview. Click here to purchase the full publication.

Figure 8-9 Specifying Flatness of a Derived Median Plane at MMC



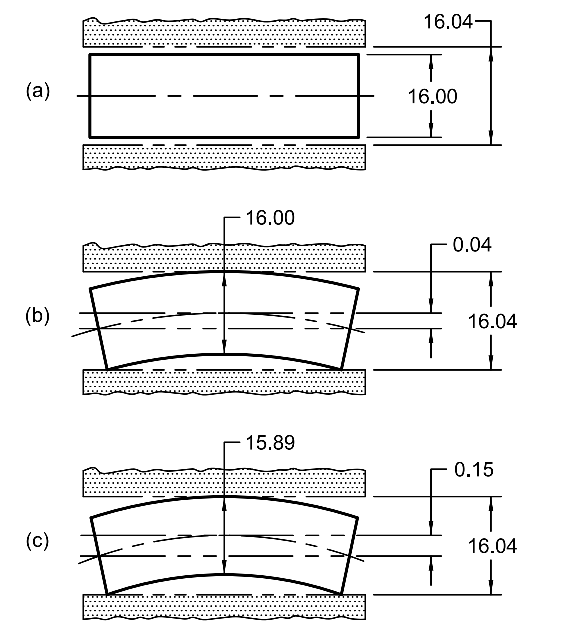
Means this



Feature size	Parallel planes tolerance allowed
16.00	0.04
15.99	0.05
15.98	0.06
↓	↓
15.90	0.14
15.89	0.15

The derived median plane of the feature shall be within two parallel planes 0.04 apart at MMC. As each actual local size departs from MMC, an increase in the local width of the tolerance zone is allowed that is equal to the amount of such departure. Each element of the surface shall be within the specified limits of size.

Acceptance boundary



Meanings:

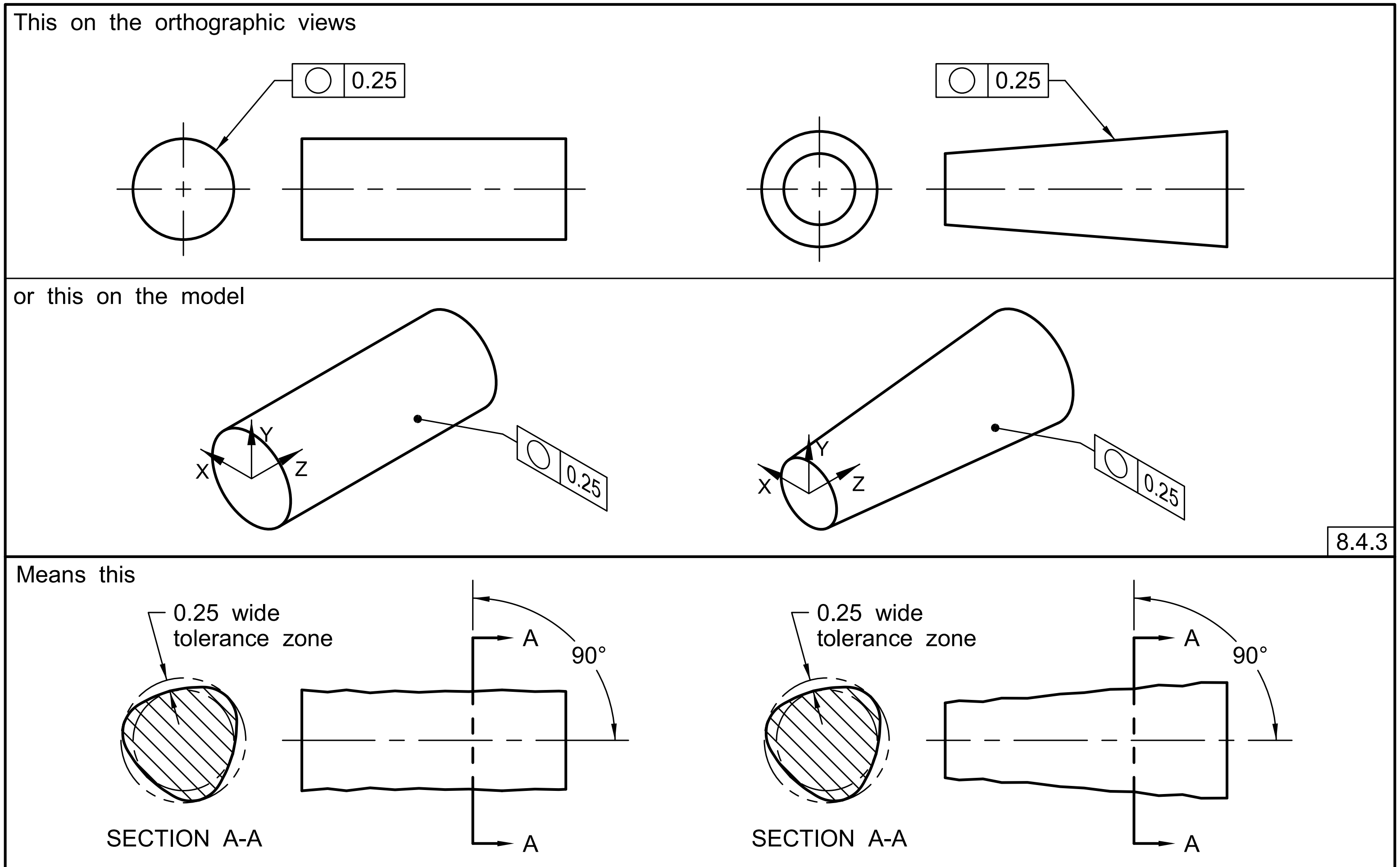
(a) The maximum thickness of the part with perfect form is shown in a simulated boundary with a 16.04 wide slot;

(b) with the part at maximum thickness (16.00), the simulated boundary will accept the part with up to 0.04 variation in flatness;

(c) with the part at minimum thickness (15.89), the simulated boundary will accept the part with up to 0.15 variation in flatness.

This is a preview. Click here to purchase the full publication.

Figure 8-10 Specifying Circularity for a Cylinder or Cone



Each circular element of the surface in a plane perpendicular to the axis of the unrelated AME shall be within two concentric circles, one having a radius 0.25 larger than the other. Each circular element of the surface shall be within the specified limits of size.

This is a preview. Click here to purchase the full publication.

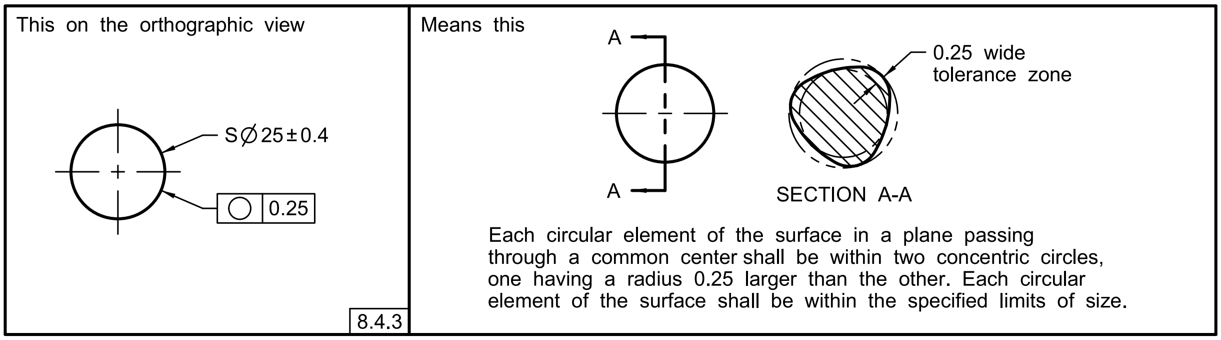


Figure 8-11 Specifying Circularity of a Sphere

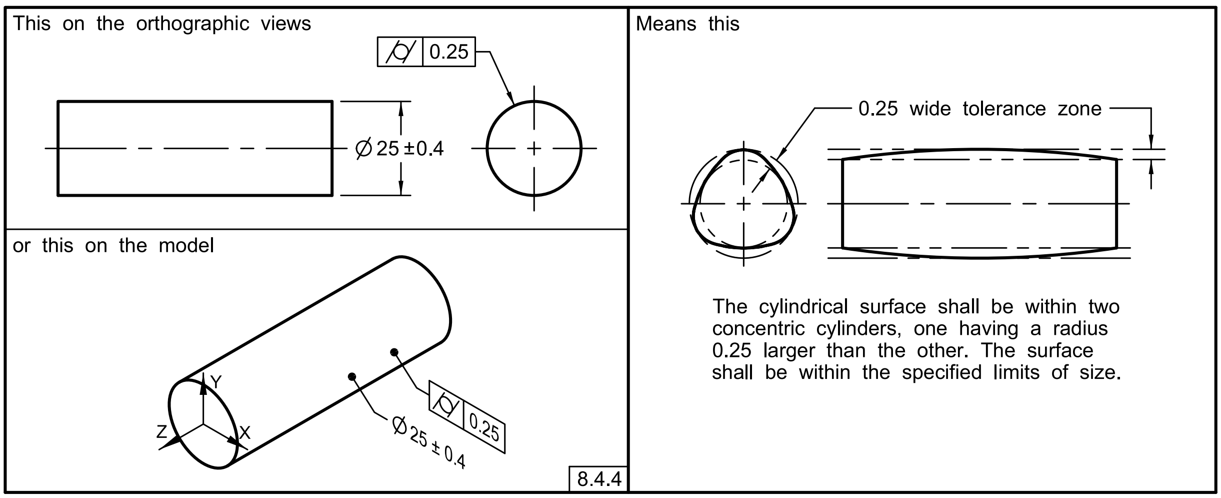
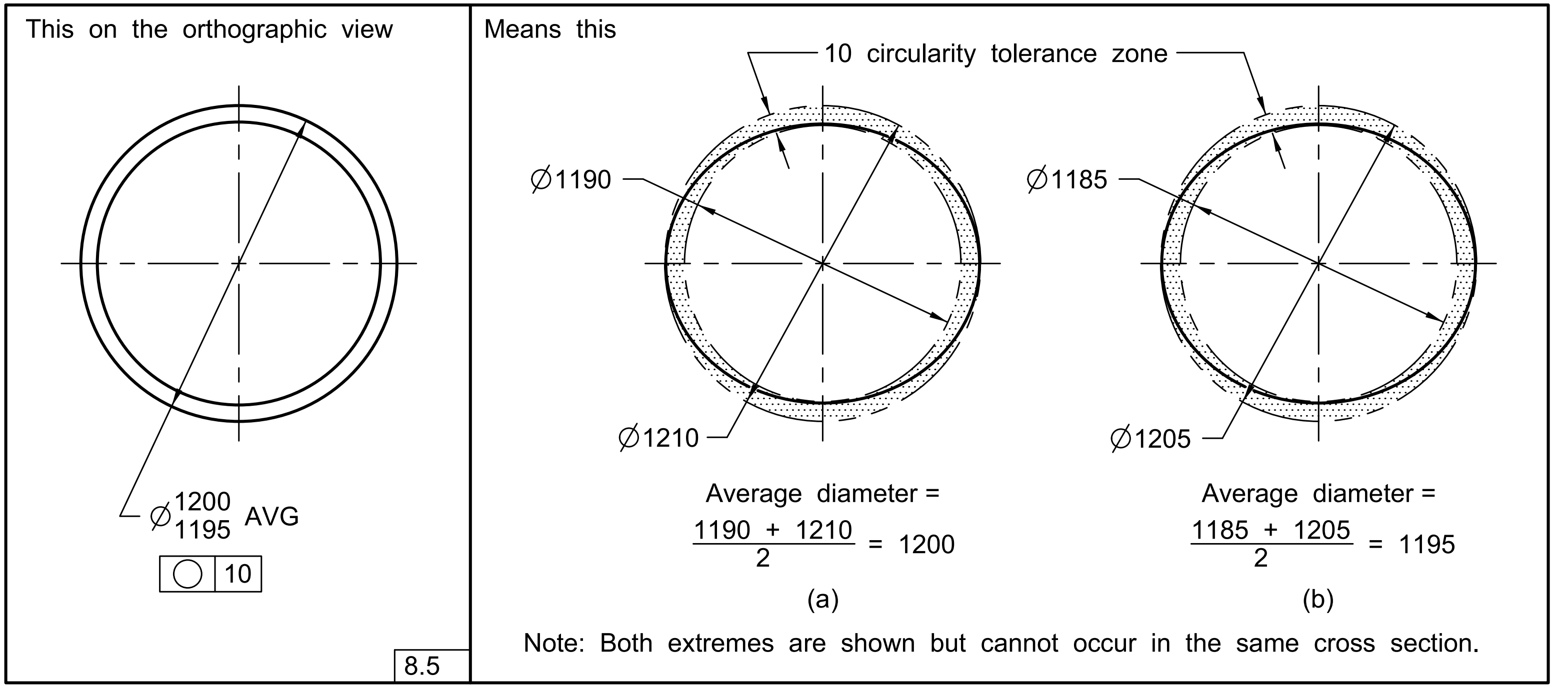


Figure 8-12 Specifying Cylindricity

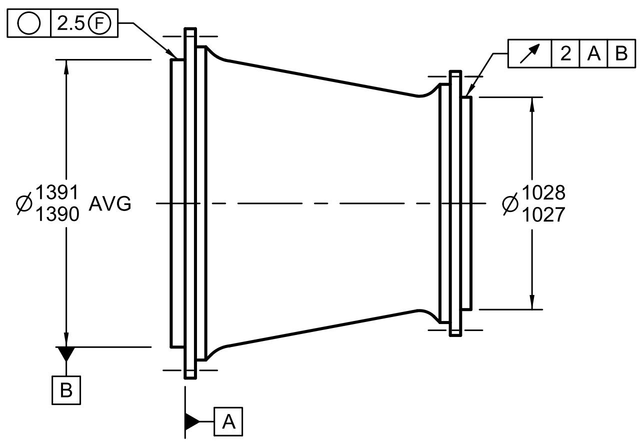
This is a preview. Click here to purchase the full publication.

Figure 8-13 Specifying Circularity With Average Diameter



This is a preview. Click here to purchase the full publication.

Figure 8-14 Specifying Restraint for Nonrigid Parts



NOTE
THE RUNOUT TOLERANCE APPLIES WHEN DATUM FEATURE A IS MOUNTED AGAINST A FLAT SURFACE USING 64-M6 X 1 BOLTS TORQUED TO 9-15 N•m WHILE RESTRAINING DATUM FEATURE B TO THE SPECIFIED SIZE LIMIT

7.20.4.2
8.5

This is a preview. Click here to purchase the full publication.

Section 9
Tolerances of Orientation

9.1 GENERAL

This Section establishes the principles and methods of dimensioning and tolerancing to control orientation of features.

9.2 ORIENTATION CONTROL

Orientation tolerances control angularity, parallelism, and perpendicularity, i.e., all angular relationships. Note that an orientation tolerance, when applied to a plane surface, controls flatness to the extent of the orientation tolerance unless the tangent plane symbol is added. When the flatness control in the orientation tolerance is not sufficient, a separate flatness tolerance should be considered. See Figure 7-15. An orientation tolerance does not control the location of features. When specifying an orientation tolerance, consideration should be given to the control of orientation already established through other tolerances, such as position, runout, and profile controls. See Figures 10-8 and 10-9.

9.3 SPECIFYING ORIENTATION TOLERANCES

When specifying an orientation tolerance, the tolerance zone shall be related to one or more datums. See Figures 7-15 and 9-4. Orientation tolerances are constrained only in rotational degrees of freedom relative to the referenced datums; they are not constrained in translational degrees of freedom. Thus, with orientation tolerances, even in those instances where datum features may constrain all degrees of freedom, the tolerance zone only orients to that datum reference frame. Sufficient datum features shall be referenced to constrain the required rotational degrees of freedom. If the primary datum feature alone does not constrain sufficient degrees of freedom, additional datum features shall be specified.

An angularity tolerance may be applied to a surface, center plane, or axis that is an implied 0° (parallel), implied 90° (perpendicular), or other basic angle from one or more datum planes or datum axes.

9.3.1 Orientation Tolerance Zone

An orientation tolerance specifies a zone within which the considered feature, its line elements, its axis, or its center plane shall be contained.

9.3.2 Orientation Tolerance

An orientation tolerance specifies one of the following:

(a) a tolerance zone defined by two parallel planes at the specified basic angle from, parallel to, or perpendicular to one or more datum planes or datum axes, within which the surface, axis, or center plane of the considered feature shall be contained. See Figures 9-1 through 9-7.

(b) a cylindrical tolerance zone at the specified basic angle from, parallel to, or perpendicular to one or more datum planes or datum axes, within which the axis of the considered feature shall be contained. See Figures 9-8 through 9-15.

(c) a tolerance zone defined by two parallel lines at the specified basic angle from, parallel to, or perpendicular to a datum plane or axis, within which the line element of the surface shall be contained. See Figures 9-16 through 9-18.

9.3.3 Application of Each Element's Tolerance Zones

Tolerance zones apply to the full extent of a feature, UOS. When it is a requirement to control only individual line elements of a surface, a qualifying notation, such as "EACH ELEMENT" is added to the drawing. See Figure 9-16. This permits control of individual elements of the surface independently in relation to the datum and does not limit the total surface to an encompassing zone. Each distance between the line element tolerance zone boundaries remains normal to the as-designed theoretically perfect surface. Orientation tolerances only constrain rotational degrees of freedom relative to the referenced datums.

Adding a notation such as "EACH RADIAL ELEMENT" invokes a translational degree of freedom that cannot be controlled by orientation tolerances. When control of radial elements is required, profile shall be used. See subsection 11.9.

9.3.4 Application of Zero Tolerance at MMC

When no variations of orientation are permitted at the MMC size limit of a feature of size, the feature control frame contains a zero for the tolerance, modified by the symbol for MMC. If the feature of size is at its MMC limit of size, it shall be perfect in orientation with respect to the datum. A tolerance can exist only as the feature of size departs from MMC. The allowable orientation tolerance is equal to the amount of the

This is a preview. Click here to purchase the full publication.

departure. See Figures 9-14 and 9-15. These principles are also applicable to features of size toleranced for orientation at LMC. There may be applications in which the full additional allowable tolerance does not meet the functional requirements. In such cases, the amount of additional tolerance shall be limited by stating "MAX" following the MMC modifier. See Figure 9-15.

9.3.5 Explanation of Orientation Tolerance at MMC

An orientation tolerance applied at MMC may be explained in terms of the surface or the axis of a cylindrical feature or the surfaces or center plane of a width feature. In certain cases of extreme form deviation (within limits of size) of the cylinder or width feature, the tolerance in terms of the feature axis or center plane may not be equivalent to the tolerance in terms of the surface. In such cases, the surface method shall take precedence as in Figure 10-6.

(a) In Terms of the Surface of a Hole. While maintaining the specified size limits of a hole, no element of the hole surface shall be inside a theoretical boundary (VC) constrained in rotation to the datum reference frame. See Figure 10-6.

(b) In Terms of the Axis of a Hole. When a hole is at MMC (minimum diameter), the feature axis shall fall within a cylindrical tolerance zone whose axis is constrained in rotation to the datum reference frame. The axis of a feature is the axis of the unrelated AME. The diameter of this zone is equal to the orientation tolerance. See Figure 9-14. It is only when the hole is at MMC that the specified tolerance zone applies. When the unrelated AME size of the hole is larger than MMC, the orientation tolerance increases. This increase of orientation tolerance is equal to the difference between the specified MMC limit of size and the unrelated AME size of the hole. When the unrelated AME size is larger than MMC, the specified orientation tolerance for a hole may be exceeded and still satisfy function and interchangeability requirements.

NOTE: These concepts are equally applicable to all features of size except spheres.

9.4 TANGENT PLANE

When it is desired to control a tangent plane established by the contacting points of a surface, the tangent plane symbol shall be added in the feature control frame after the stated tolerance. See Figures 9-17 and 9-18. When a tangent plane symbol is specified with a geometric tolerance, a plane contacting the high points of the feature shall be within the tolerance zone established by the geometric tolerance. Some points of the toleranced feature may lie outside of the tolerance zone. The form of the toleranced feature is not controlled by the geometric tolerance. When irregularities on the surface cause the tangent plane to be unstable (i.e., it rocks) when brought into contact with the corresponding toleranced feature, see ASME Y14.5.1M for definition of mathematical requirements.

NOTE: The tangent plane symbol is illustrated with orientation tolerances; however, it may also have applications using other geometric characteristic symbols such as runout and profile when it is applied to a planar feature.

9.5 ALTERNATIVE PRACTICE

As an alternative practice, the angularity symbol may be used to control parallel and perpendicular relationships. The tolerance zones derived are the same as those described in para. 9.3.2. See Figure 9-4.

This is a preview. Click here to purchase the full publication.

Figure 9-1 Specifying Angularity for a Plane Surface

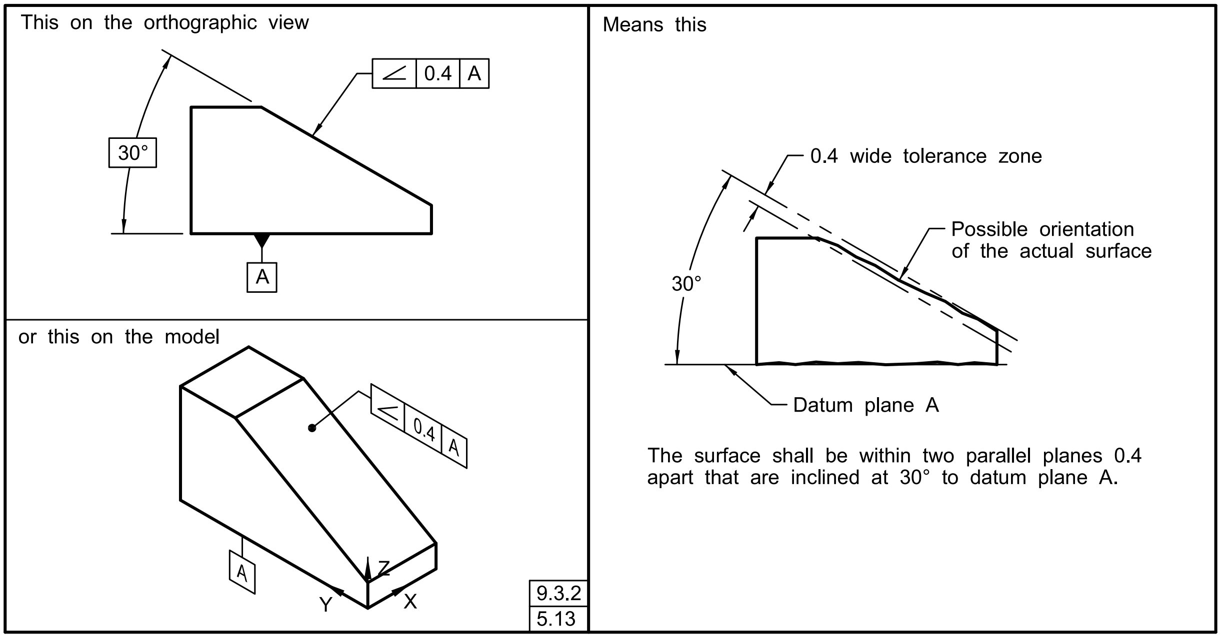
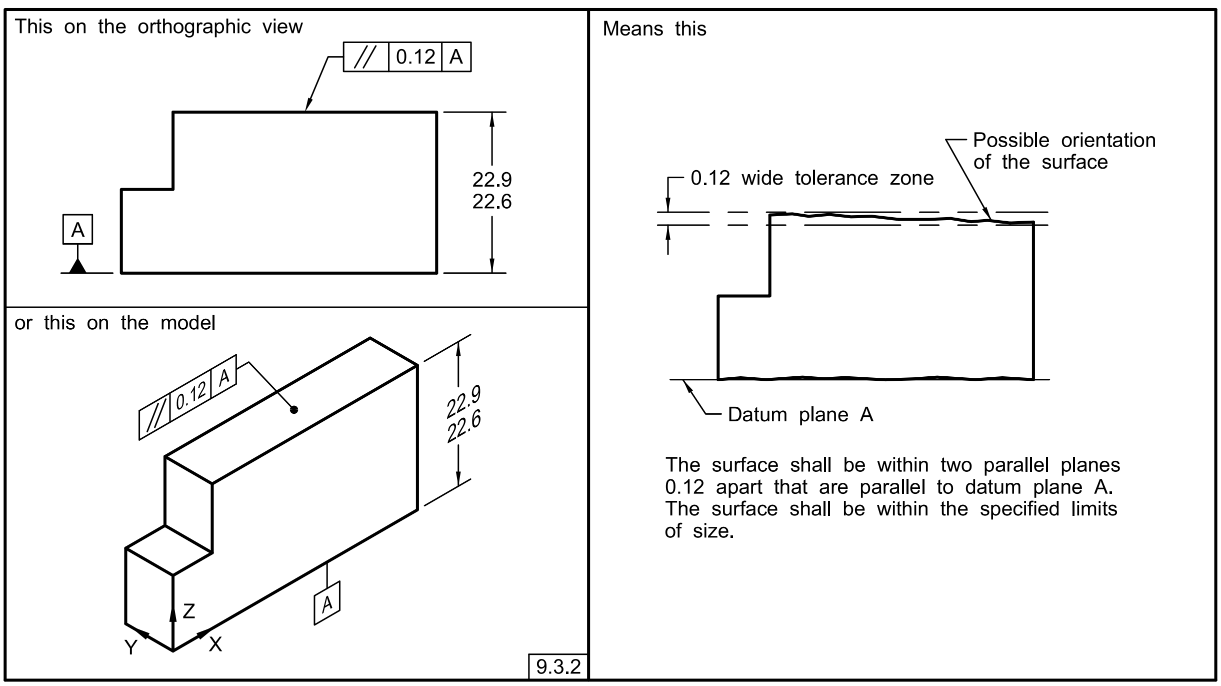


Figure 9-2 Specifying Parallelism for a Plane Surface



This is a preview. Click here to purchase the full publication.