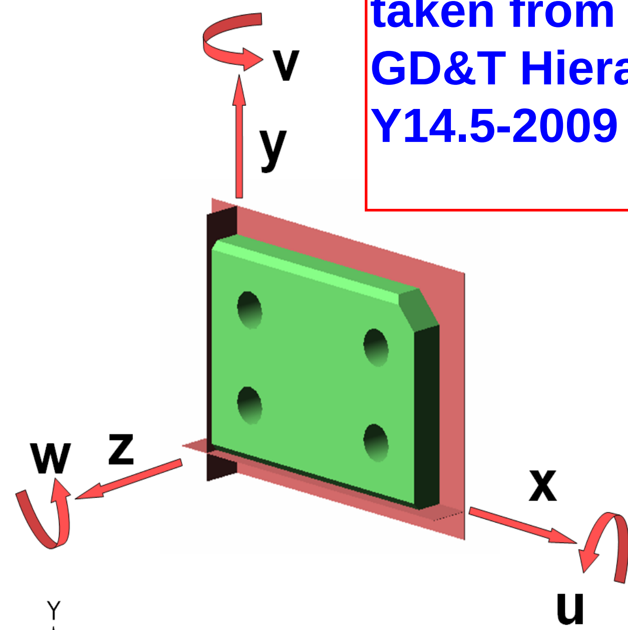
These pages are taken from The GD&T Hierarchy Y14.5-2009

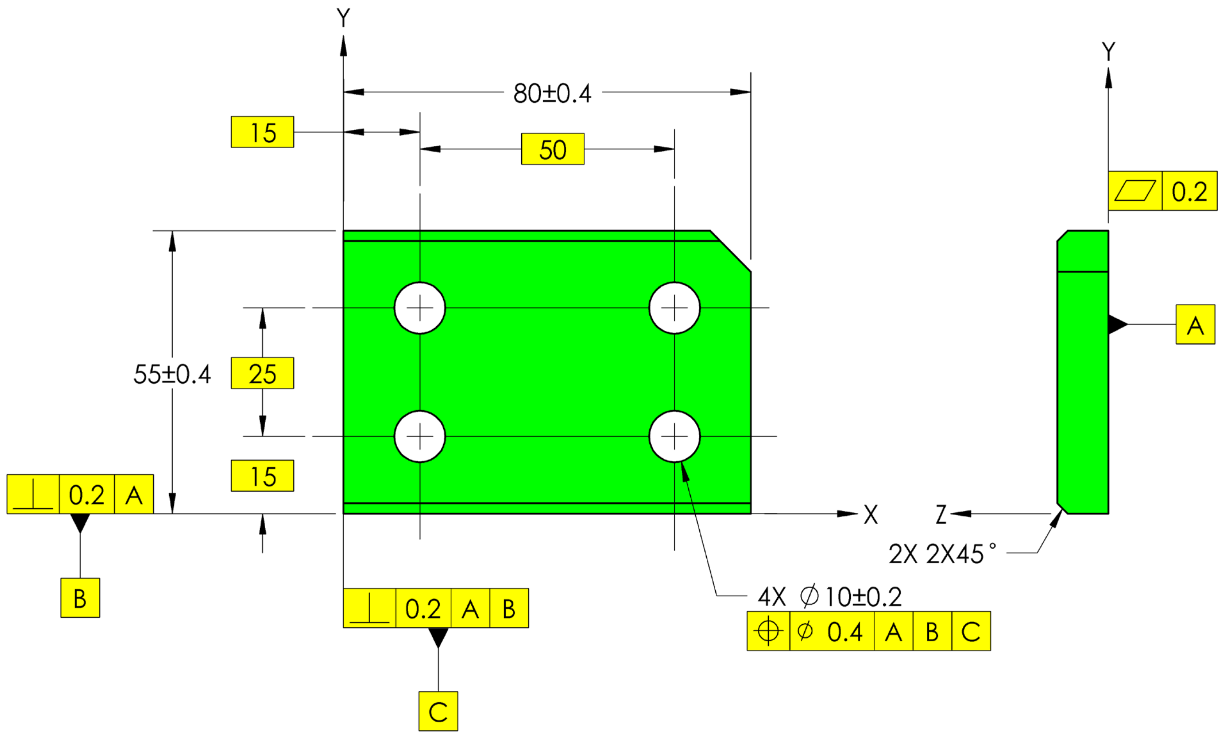
Degrees of Freedom

As pointed out in Chapter 3, every part in space has 6 degrees of freedom. In order to customize a datum reference frame, it is necessary to label the axes of the coordinate system so that the degrees of freedom may be determined.

On the drawing below, the geometric control is referencing datum features A, B and C. Three degrees of freedom will be arrested from the part in space when datum feature A contacts datum feature simulator A. In this case A will constrain **z, u** and **v**. Datum feature B, when it comes in contact with datum feature simulator B, could constrain **u, w** and **y**. Since **u** has been constrained by the primary datum, it is no longer available to datum feature B. Datum feature B, therefore, constrains **w** and **y**. The only degree of freedom left for C to constrain is **x**. Changing the order of letters in the feature control frame would change the order of precedence and, therefore, the degrees of freedom constrained by each datum feature.

This is what happens naturally if the part contacts the simulator fully on datum feature A first, B second and C third.





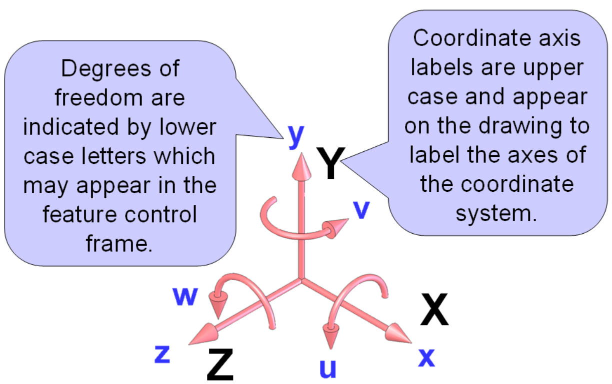
Customized Datum Reference Frame [4.22]

Until the 2009 revision of the Y14.5 standard, it was not possible to violate datum precedence. This meant that the primary datum feature had to arrest or constrain all of the degrees of freedom it possibly could. A secondary datum feature must then arrest all of the degrees of freedom that it could and so on. There are times when it is preferable to state the degrees of freedom that each datum feature may constrain. In a way this "resets" the origin.

Customizing the datum reference frame requires:

- Showing the coordinate system on the drawing
- Stating in brackets the degrees of freedom which are to be constrained by the datum feature following the datum feature reference in a feature control frame.

The axes of the datum reference frame are labeled on the drawing with capital letters. The six degrees of freedom can then be determined from these axes. The six degrees of freedom are not shown on the drawing.

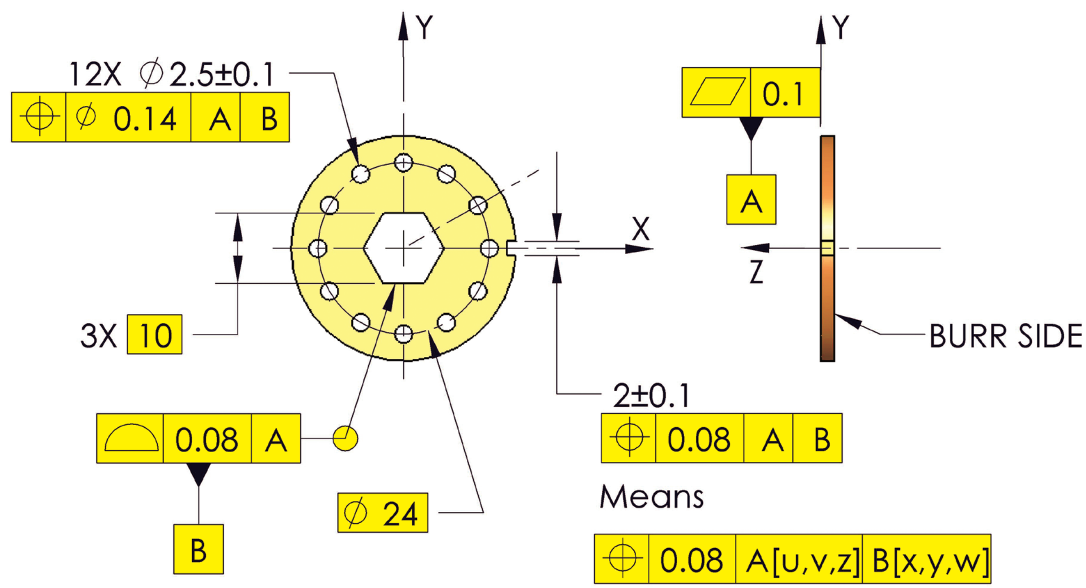


On the first drawing of this disk the coordinate system has been labeled. On the 2 mm wide slot is a position tolerance. Below it is another position tolerance that would not appear on the drawing but is shown to illustrate the degrees of freedom constrained by the datum features.

Datum feature A establishes the first datum plane. Think of it as the XY plane of the coordinate system. Because it is in the XY plane, it will constrain the rotations about the X and Y axes. These are u about the X axis and v about the Y axis. Datum feature A also will constrain the z translation. This is why the letters u, v, and z are in brackets following datum feature A.

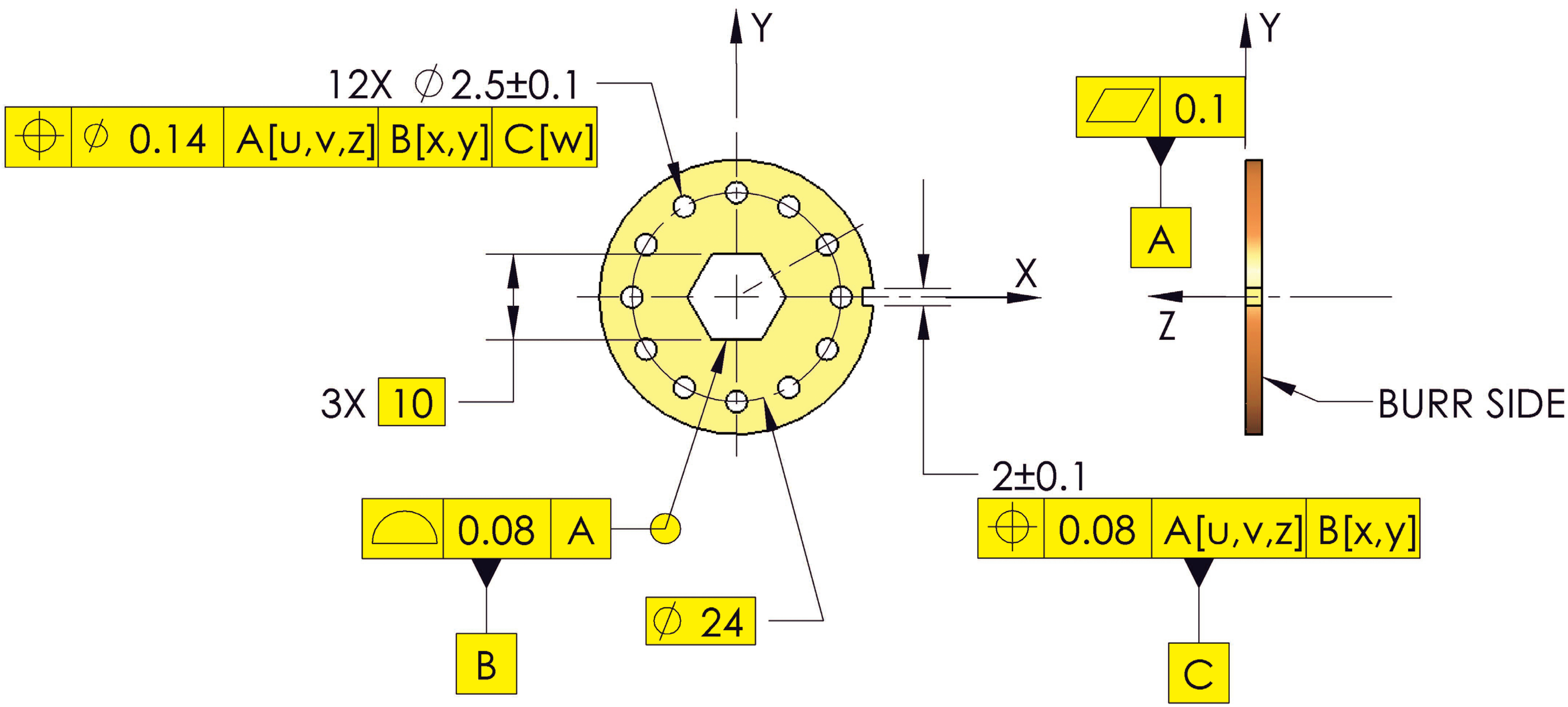
The degrees of freedom remaining that datum feature B can constrain are the last rotation, w and the two remaining translations which are x and y.

In the position tolerance on the Ø2.5 holes, the datum feature references of A, primary and B, secondary must restrain the same degrees of freedom in the same order. The default is that this datum precedence must be followed.

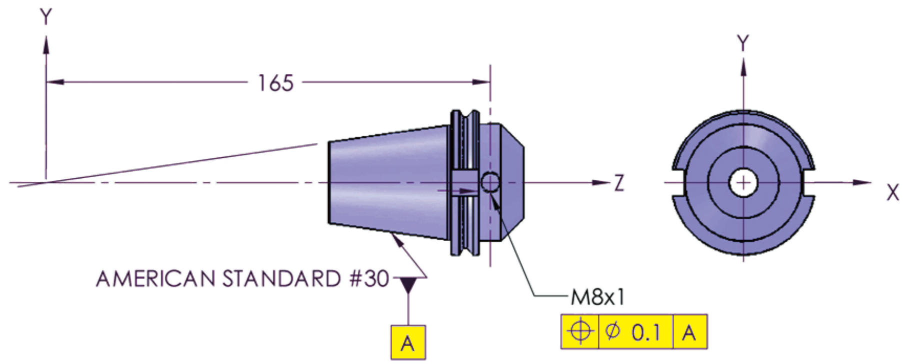


The function of the hex is only to transmit torque. Design does not want the hex feature to control the orientation of the datum reference frame. The 12 holes need to be oriented relative to the width of the 2 mm slot. Design would like to orient the datum reference frame using the width of the 2 mm slot. There was no way to do this in past Y14.5 standards. By customizing the datum reference frame, the design intent may be achieved.

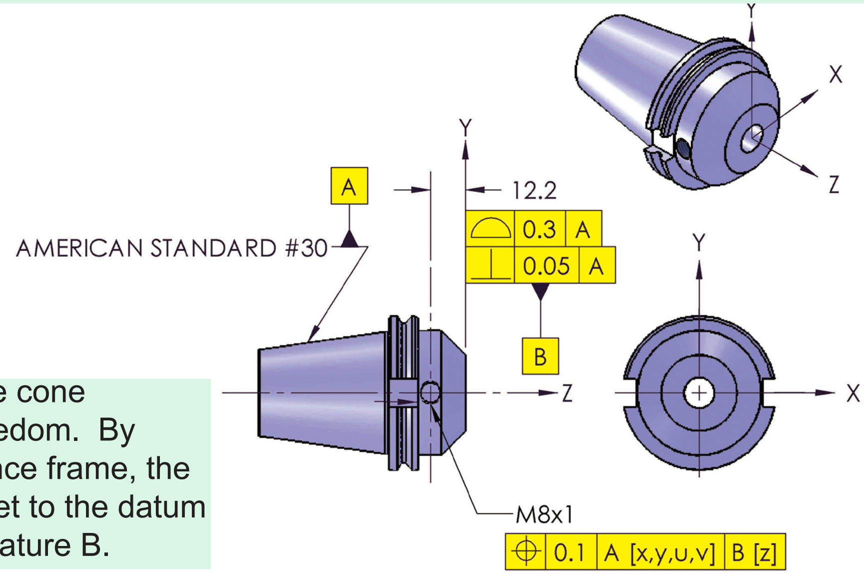
On this second drawing of the disk the datum reference has been customized. The datum references in the position tolerances state the degrees of freedom that each datum feature may constrain. Even though datum feature B would usually restrain the rotation about the Z axis, it does not in this case. Notice that in the position tolerance on the 12 holes, after the datum B reference, in brackets, are the letters x and y. This indicates that datum feature B will constrain the translational degrees of freedom of x and y but will not restrain the w rotation about the Z axis. To completely define the datum reference frame, datum feature C is added to constrain the last degree of freedom, w.



This tool holder's primary datum feature is the taper or conical feature. A cone used as a primary datum feature must arrest 5 of the possible 6 degrees of freedom. The only degree of freedom that the cone would not constrain is rotation about the Z axis (w). The 0,0,0 origin of the datum reference frame is at the vertex of the AME of the cone as is shown.



On this drawing of the tool holder the datum reference frame has been customized to override datum precedence. Datum feature A is constraining 4 degrees of freedom. In the position tolerance for the M8 threaded hole the translational degree of freedom 'z' is not in the brackets after the datum feature A reference. Datum feature B is allowed to constrain the z translational degree of freedom.



Without customization, the cone must restrain 5 degrees of freedom. By customizing the datum reference frame, the origin of measurements is reset to the datum plane established by datum feature B.