Chapter

8

Pins, Shafts and Holes

In this chapter, you will learn the following to World Class standards:

- **Assembling with Pins**
- **Types of Pins**
- **Explanation of the Design and Description of the Parts**
- **Drawing the Lazy Susan Top**
- **Drawing the Bushing, Washer and the Dowel Pin**
- **Drawing the Mounting Ring**
- **Making the Assembly Drawing**

Assembling with a Pin

When a designer wishes to assemble two or more parts together and those multiple components need to have freedom of movement, we most likely will use a dowel pin. Dowel pins are usually made of solid material and are manufactured to close tolerances. By sizing the hole to specific dimensions that correlate to the diameter of the shaft of the dowel pin, we can achieve a running fit, a locational fit, force and shrink fit or even an interference fit. The ends of the pin and the entry edge of the hole are formed specially to assist technicians in the assembly process when using pins. The ends of various pins can either be capped or shaped to help hold the pin in place. When a pin is in place, the pin's strength, measured by shear force and determined by the shaft's material can resist the stresses of the design. Whether the application is architectural, civil or mechanical, a designer's experience is not complete without studying pin selection, mating part fabrication and assembly procedures.

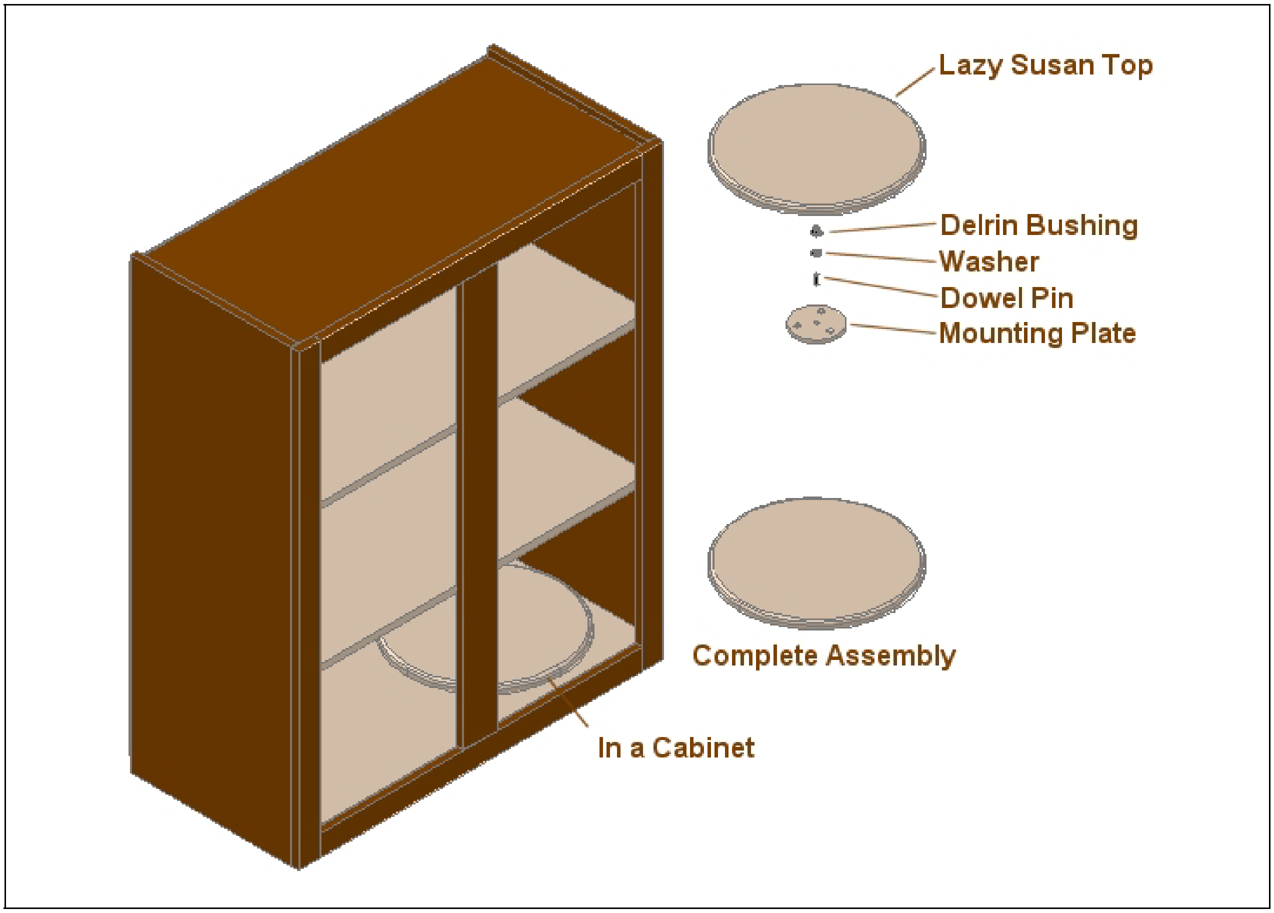

Figure 8.1 – Sheet Metal Part without any Bends

In Figure 8.1, we have a cabinet assembly that would be found in any kitchen and mounted on the lower right shelf is a lazy Susan assembly. For this rotating mechanism, we will use a bushing, dowel pin, washer and mounting plate to hold the lazy Susan top in position. The senior designer wants us to use a ¼ inch diameter austenitic stainless steel dowel pin with a Delrin bushing instead of using an off the shelf lazy Susan bearing.

Types of Pins

There are many types of dowel pins that we can select. There are series of straight dowel pins and there are taper dowels. Some pins, like the first object on the left side of Figure 8.2 are straight shafts with chamfers on each end to assist in inserting the pin. The second pin from the left has grooves on each end for a snap ring. The ring is snapped into place by the assembly technician to hold the pin in the mounting hole.

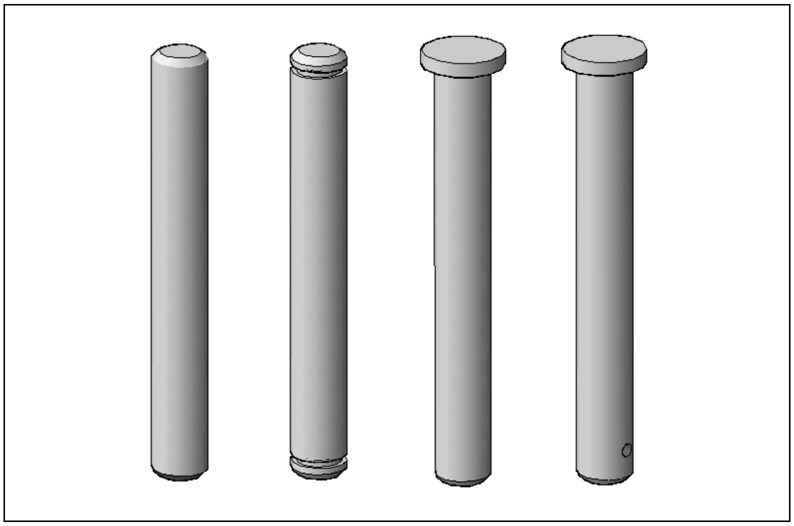

Figure 8.2 – Types of Dowel Pins

The third pin from the left has a head to prevent the pin from continuing through the hole at assembly. These types of pins sometimes called rivets go through the material they are designed to hold together and then the non-capped end is deformed to make a head. Of the type of pins shown, we use this style to fasten two or more parts together permanently.

The last pin shown in Figure 8.2 has a small hole running through the shaft at the bottom. Another type of a pin we may also be familiar with, the cotter pin is inserted in the hole of the dowel after assembly. A cotter pin's shaft is split down the axis, so the technician can bend the end 180 degrees apart, which will hold the dowel pin in place.

Another type a dowel, which some designers consider to be in the machine screw family, is the shoulders screw. A shoulder screw has the socket head style of a machines screw, the body of a straight dowel pin and at the end, the threads of a small machine screw. Engineers use the shoulders screw in designs where we do not have access to fasten one side of the pin at assembly, so we screw this special type of dowel pin into place.

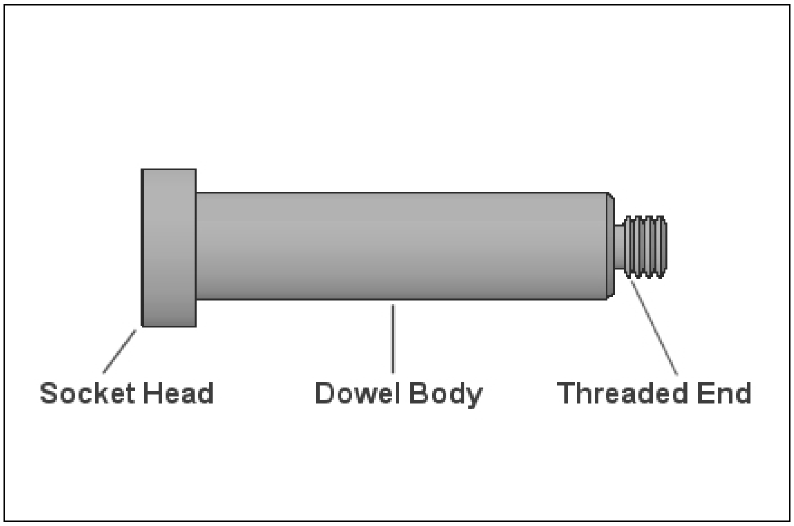

Figure 8.3 – Shoulder Screw

Explanation of the Design and Description of the Parts

We will examine an assembly where a straight dowel pin holds five components together. The lazy Susan top has a 3/8 diameter bored hole on the bottom that is 5/16 deep, so the customer does not see the hardware which holds the top. Dimensional controls guaranteeing perpendicularity of the bored hole to the bottom surface need to be on the drawing. In the 3/8 diameter bored hole, the assembly technician will place a Delrin bushing that will extend 0.302 inches into the hole and bottom out on the bushing's shoulder.

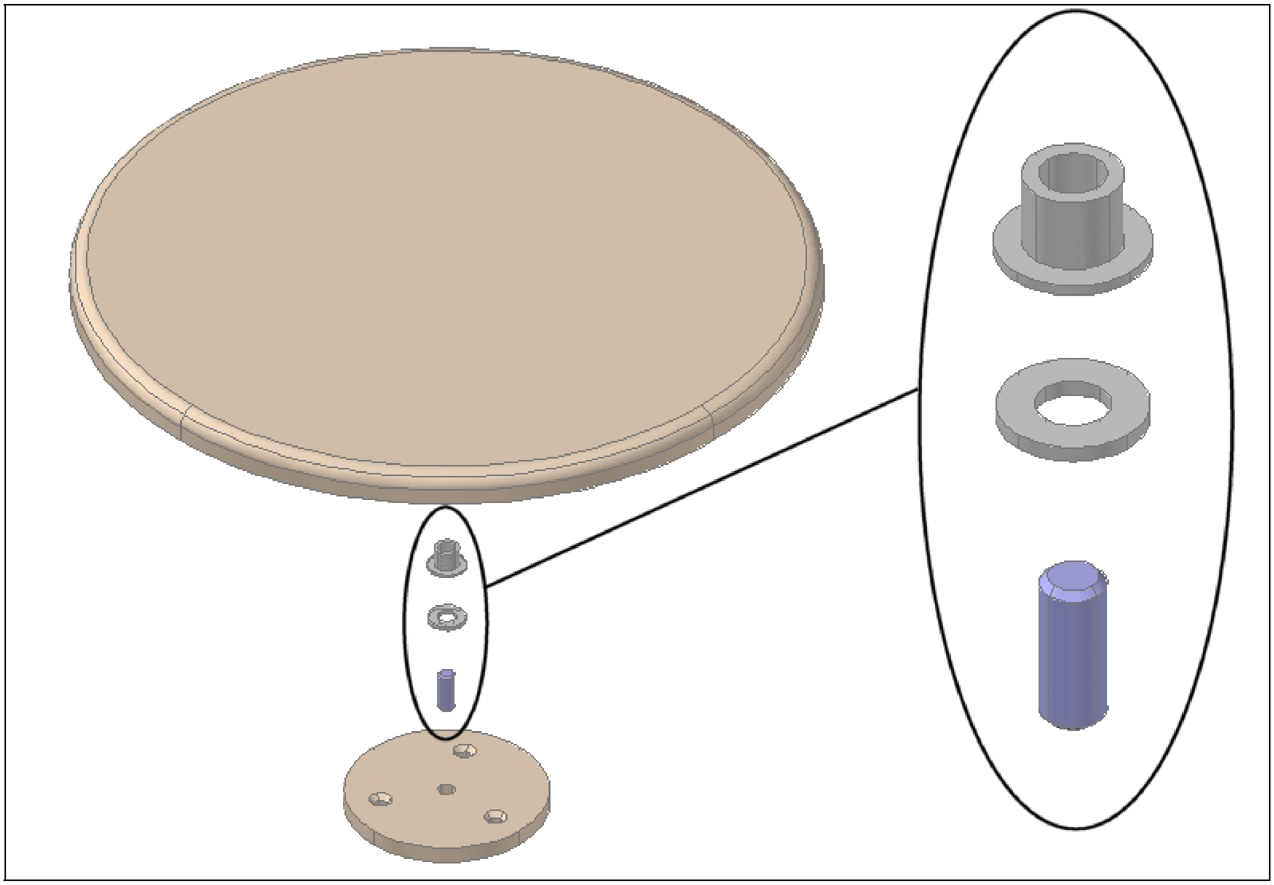

Figure 8.4 – Enlarged View of the Lazy Susan Hardware

In the center of the mounting ring, the technician will press in the 0.250 inch diameter by 0.625 long straight dowel pin using a press machine. The next step in assembly is to attach the mounting ring to the bottom of the cabinet, centered 6 inches from the back and from the right inside wall, and fasten the mounting ring to the cabinet shelf using three #8 x ½ long flathead woods screws. The assembler will set the washer on the shaft of the pin and finally set the lazy Susan top on the pin.

The hole in the 0.250 thick mounting plate should be an interference fit which will keep the shaft perpendicular to the plate. Dimensions and notes on the mounting plate drawing should emphasize the importance and control the perpendicularity of the center hole in relationship to a flat bottom of the mounting plate. The interference fit will cause the machinist to make the center hole a few thousands of an inch larger than the shaft of the dowel pin. The mounting plate has three 3/16 drilled holes on a 2 inch diameter bolt circle. Each of the three clearance holes will have an 82° chamfer formed to a diameter of 0.332 inches so the flathead screws can be recessed at assembly.

The straight dowel pin can be purchased from a hardware supplier. The pin can be made from a 300 series stainless steel to prevent the metal from oxidizing. If we select aluminum or steel, we would have to plate or treat the metal to prevent rust on the steel or white powder residue on the aluminum. For pins used near saltwater areas, we would recommend a 400 series stainless steel to prevent pitting of the shaft. The sketch will show that the dowel pin needs to be 0.625 inches long with a chamfer on both sides. The tolerance on the slip fit dowel pin is 0.2500, +0.0000 and -0.0002. The machine finish on the shaft is a 10 micro finish.

The next component is a washer, which allows the Delrin bushing to both rest and ride on a smooth surface. The stainless steel washer has a burr free finish and has a 0.281 internal diameter and a 0.500 outside diameter. The washer is 0.063 thick.

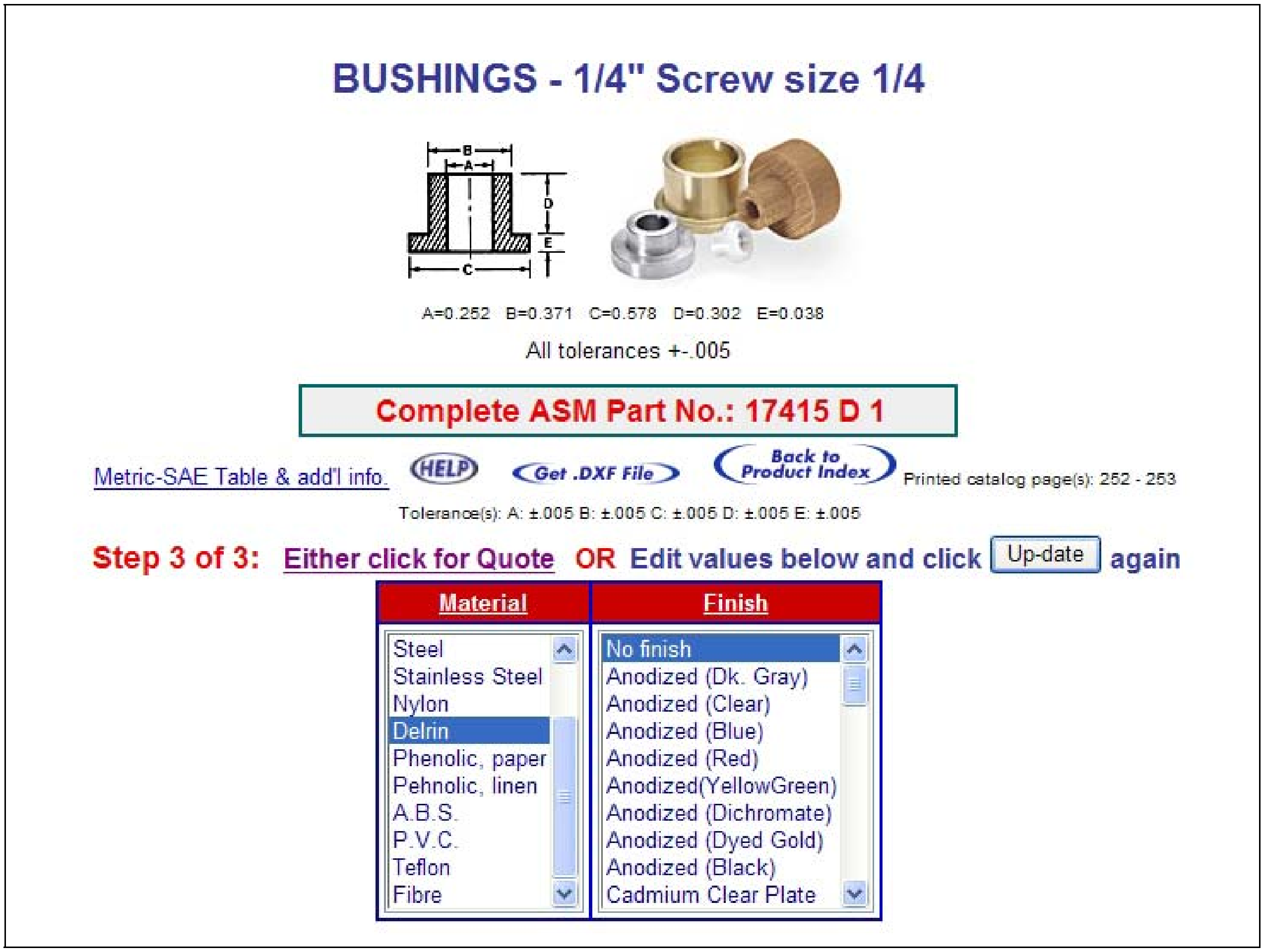

Figure 8.5 – Accurate Screw Machine Corporation Bushing No. 17415 D 1

Now, we come to the bushing. We can visit the Accurate Screw Machine Corporation at http://www.accuratescrew.com as we see in Figure 8.5. Their website takes us through a three step process to select a bushing. First, we select the size and then the material and finish. The last step is to request a quote. We can make a quote request for the amount of bushing we need annually, but more important is to have their engineering support team to send you 6 to 12 samples for the prototypes. Do not forget to get 6 to 12 samples of the other components as well.

Drawing the Lazy Susan Top

The lazy Susan's top has simple exterior features such as the 11 inch diameter and the 0.25 inch radius. The single blind sided hole in the bottom of the component requires some training to dimension properly. Before reaming a hole, we want to drill a hole 0.005 to 0.010 smaller than the ream diameter. So, we would want to drill a blind sided hole with a U (0.368) sized twist drill bit down to a maximum depth of 0.4375 of an inch. Then, we would use a 0.375 ream to create a precise 0.3750 to 0.3754 diameter and is a maximum of 0.3125 deep. Add a small 1/32 x 45° chamfer on the front of the hole.

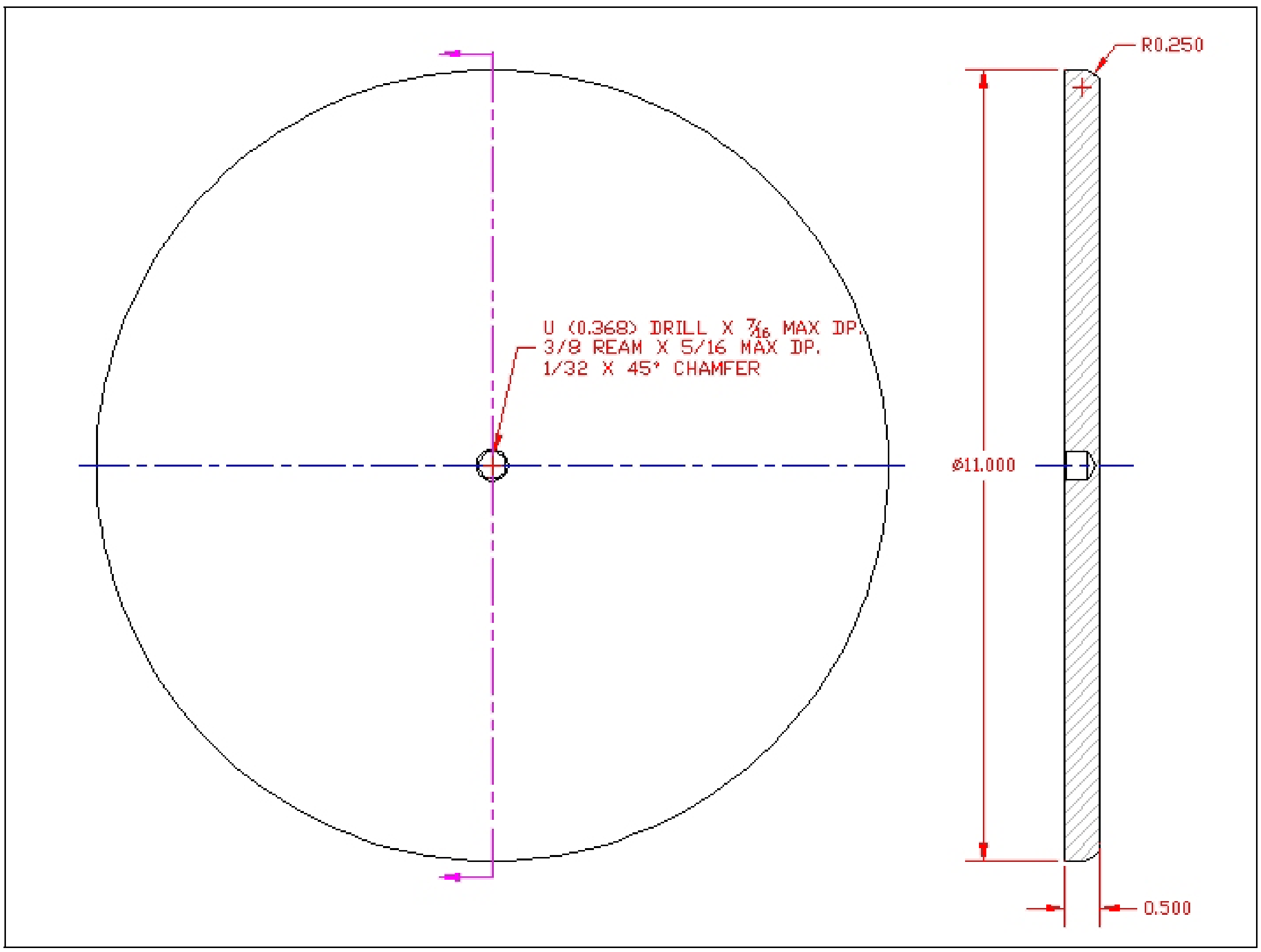

Figure 8.6 – Detail of the Lazy Susan Top

We are going to employ a light force fit from the American National Standard B4.1-1967 (R1994) where the bushing is the shaft and the lazy Susan top is the hole. In the American

National Standard chart in Figure 8.7, we find the nominal range of 0.375 on the left side of the chart. We desire the light force fit, so the limits of interference for a Class FN1 fit is a minimum of 0.0001 and a maximum of 0.00075 inches.

In Figure 8.8, we place the standard limits from the American National Standard B4.1-1967 (R1994) Class FN1 for 0.24 to 0.40 inch diameters to the 0.375 nominal hole size we are planning. A properly utilized 3/8 diameter ream will easily meet the dimension in the drawing. The bushing manufacture normally makes the outside diameter of their standard bushing with a tolerance of plus or minus 0.005 inches. Using an off the shelf bushing will not be feasible.

Nominal Size Range, inches Over To	Class FN1		
	Limits of Interference	Standard Limits	
		Hole H6	Shaft
0.24 - 0.40	0.1 0.75	+0.4 −0	+0.75 +0.5

Limits are in thousandths of an inch
ANSI B4.1-1967 (R1994)

Figure 8.7 – Force Fit FN1 from ANSI B4.1-1967 (1994)

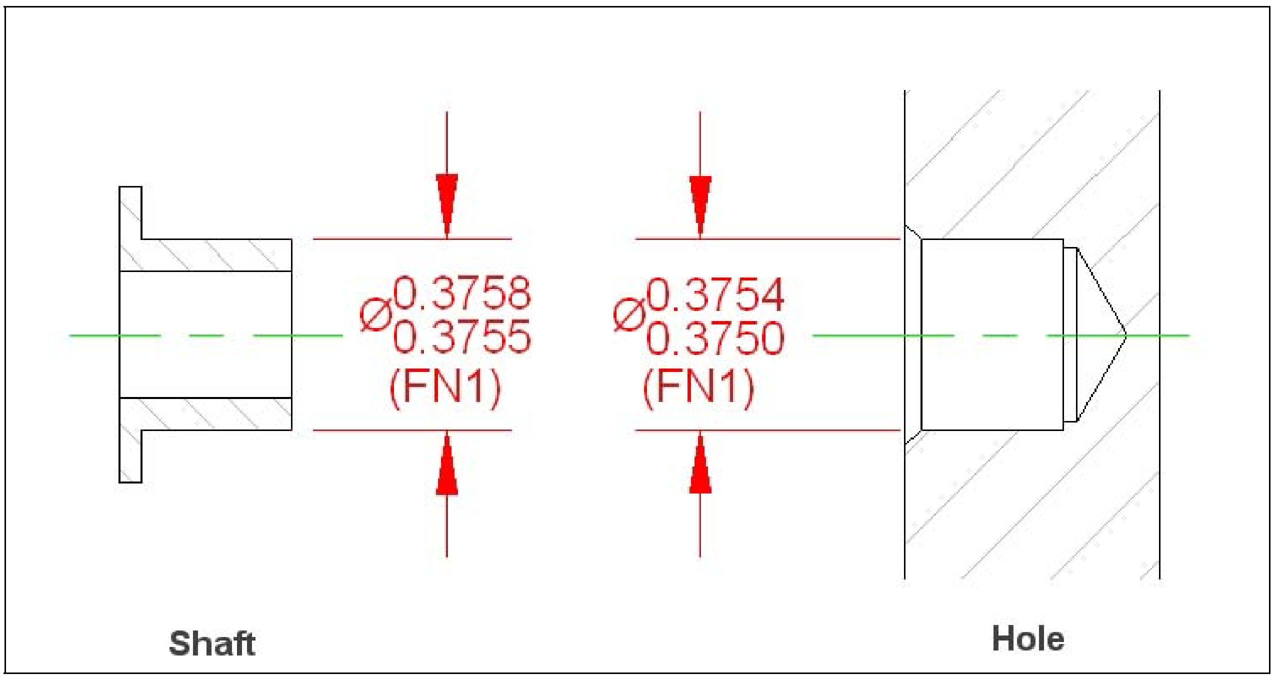

Figure 8.8 – Force Fit FN1 for the Bushing

We can purchase a Delrin bushing that has a slightly larger diameter and allow a machinist to turn the shaft diameter to the 0.3755 to 0.3758 range to give us the desired force fit. With a little research, we may find our bushing to be standard and another application.

Our experience with precision made mechanical parts shows that many of these manufacturers actually fabricate parts to closer tolerances than shown in their catalogs. When a company is meeting an ANSI standard, the actual dimensions are very close to the minimums for outside diameters and very close to the maximums for the inside diameters. This way the company uses the least amount of material while still meeting the national standard. If the company that makes the bushing already is holding tighter tolerances than their catalog states, we just need to contact their sales department and notify them that our shipments need to meet the closer tolerance. They can make a unique part number for our component, but in many cases their stock part already meets the drawing specification.

Different manufacturers use various types of machines and every machine producer builds a level of accuracy into their product. There will be many times in a career when the purchasing agent changes a part supplier and immediately there are problems on the manufacturing floor. Pick up the two parts, the original and the replacement and when dealing with tight tolerances, we may not readily see the problem. The new component may be just a few thousands of an inch different than the original part. A technique to eliminate this type of problem is to have a purchasing rule, where 10 to 25 new parts are submitted for inspection and prototype review prior to a change. Never assume that new parts will not problems when we consider all the variables that control their manufacturing.

Drawing the Bushing, Washer, and Dowel Pin

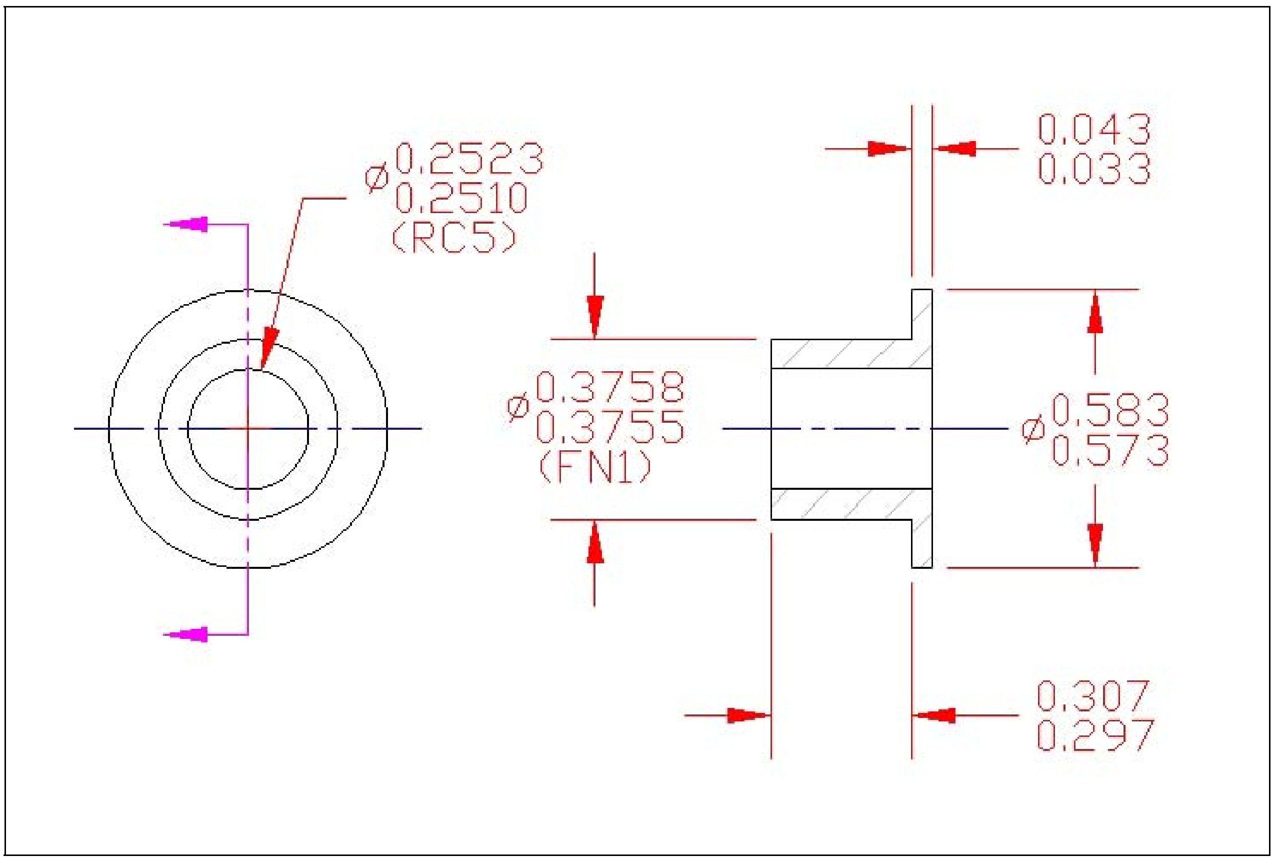

Figure 8.9 – Detail of the Bushing for RC5 Fit and FN1 Fit

The in in next drawing we will complete is the bushing itself. In our engineering handbook, we will look up the standard limits from the American National Standard B4.1-1967 (R1994) Class RC5 for 0.24 to 0.40 inch diameters to the 0.250 nominal hole size we are planning. In the American National Standard chart, we find the nominal range of 0.250 on the left side of the chart. We desire the medium running fit, so the limits of interference for a Class RC5 fit is a minimum of 0.0010 and a maximum of 0.0025 inches.

We are specifying an off the shelf dowel pin that has a shaft diameter of 0.2498 to 0.2500 standard as fabricated. And the minimum of 0.0010 from the RC5 chart to the 0.250 and the minimum limit for the inside diameter of the bushing is 0.2510. Add the 0.0025 from the RC5 chart to the 0.2498 and the maximum limit for the inside diameter is 0.2523. In this example, we used the limits of clearance data to solve the fit problem.

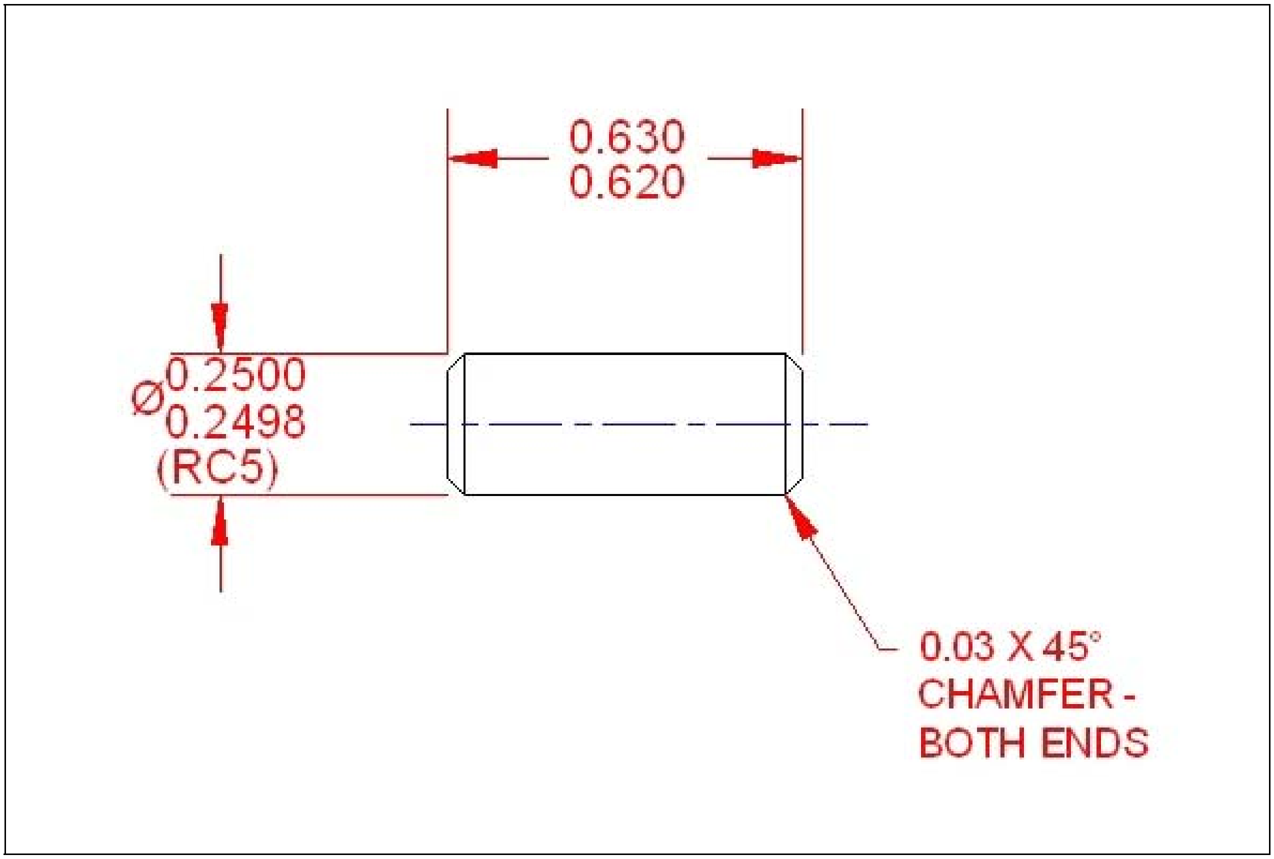

Figure 8.10 – Detail of the Dowel Pin for RC5 Fit

When building a mechanism that turns slowly, we do not need to use a bearing but in many cases a bushing is more than adequate. In the interface between two moving parts, the designer chooses to select surfaces that are smooth. In engineering, we use a V symbol to denote the surface texture. Many cast surfaces are 250 micro-inches, machine surfaces are 125 micro-inches, surfaces for bushings are 63 micro-inches and surfaces for bearings are 16 micro-inches and smaller. We would want At least a 63 micro-inch surface denoted on the drawing of the washer and the bushing. The portion of the washer sitting on the 125 micro-inch machined mounting ring will hold the washer in place, because of the increased friction between the two surfaces.

So the only critical dimension on the washer would be the surface texture, so the inside diameter and the upside diameter can have the standard tolerance from the washer fabricator of plus and minus 0.005 inches. The thickness of material tolerance should be the same as the sheet stainless steel metal obtained by the raw materials supplier.

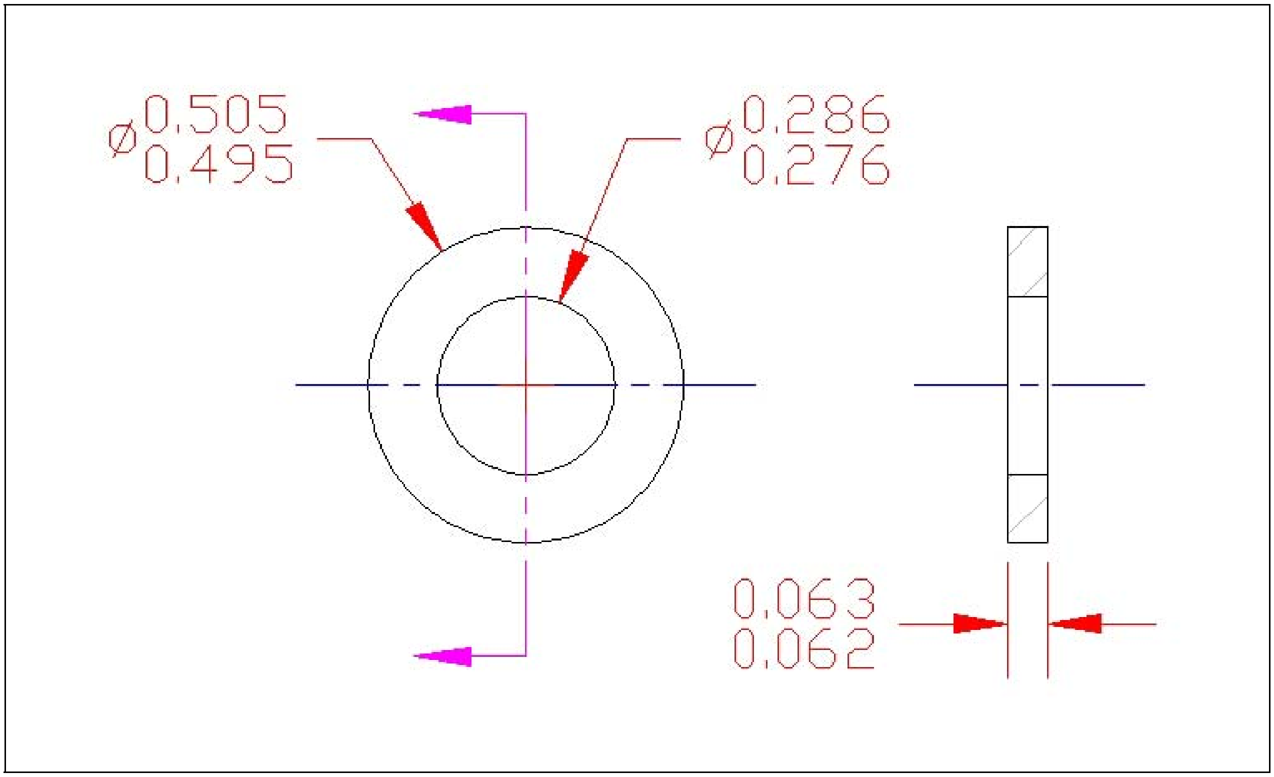

Figure 8.11 – Detail of the Dowel Pin for RC5 Fit

Drawing the Mounting Ring

Draw the mounting ring using the senior designer's instructions and place a quarter inch diameter reamed hole in the center of the ring. Remember, before reaming a hole, we want to drill a hole 0.005 to 0.010 smaller than the ream diameter, so place the drill through operation before the ream statement off the leader point to the hole. Add a small 1/32 by 45° chamfer on the front of the hole for ease of assembly.

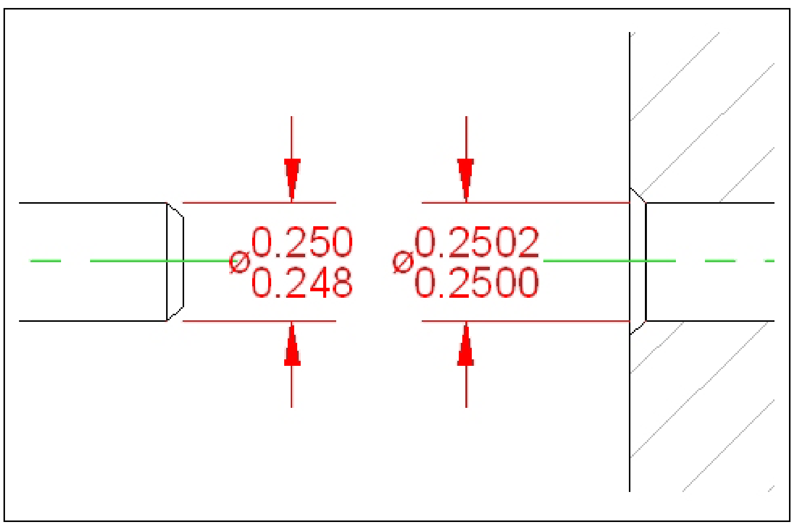

Figure 8.12 – Detail of the Dowel Pin for RC5 Fit

Making an Assembly Drawing

When we complete all of the 3D solid part drawings, insert the parts into an assembly drawing by using the XREF system in AutoCAD. Create a multiple view orthographic drawing of the assembly, add notes, a border, title block and insert a Bill of Material (BOM), calling out one of each part we designed and three of the purchased #8 x ½ long flat head wood screws. Submit all of the electronic files to another designer for checking. Make corrections to any errors they find and then submit the drawings to the senior designer for approval.

In this chapter, we completed six drawings, but in other designs, like with a cabinet hinge, we just have 3 parts. The component we mount on the cabinet, the pin and the section we at insert on the door. In the next World Class CAD challenge, we will ask those that are ready, to design a hinge for the cabinet in Figure 8.1. With the experience we now have, this task can be accomplished.

*** World Class CAD Challenge 08-39 * - Save and close the Lazy Susan Assembly drawing file. Create a new file and make a part drawing for a door hinge for the cabinet in Figure 8.1, dimension, and place the border and notes in less than 60 minutes. Continue this drill three more times for various other pin designs, each time completing the drawing under 60 minutes to maintain your World Class ranking.**