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Tolerancing Fixed Fasteners[1]

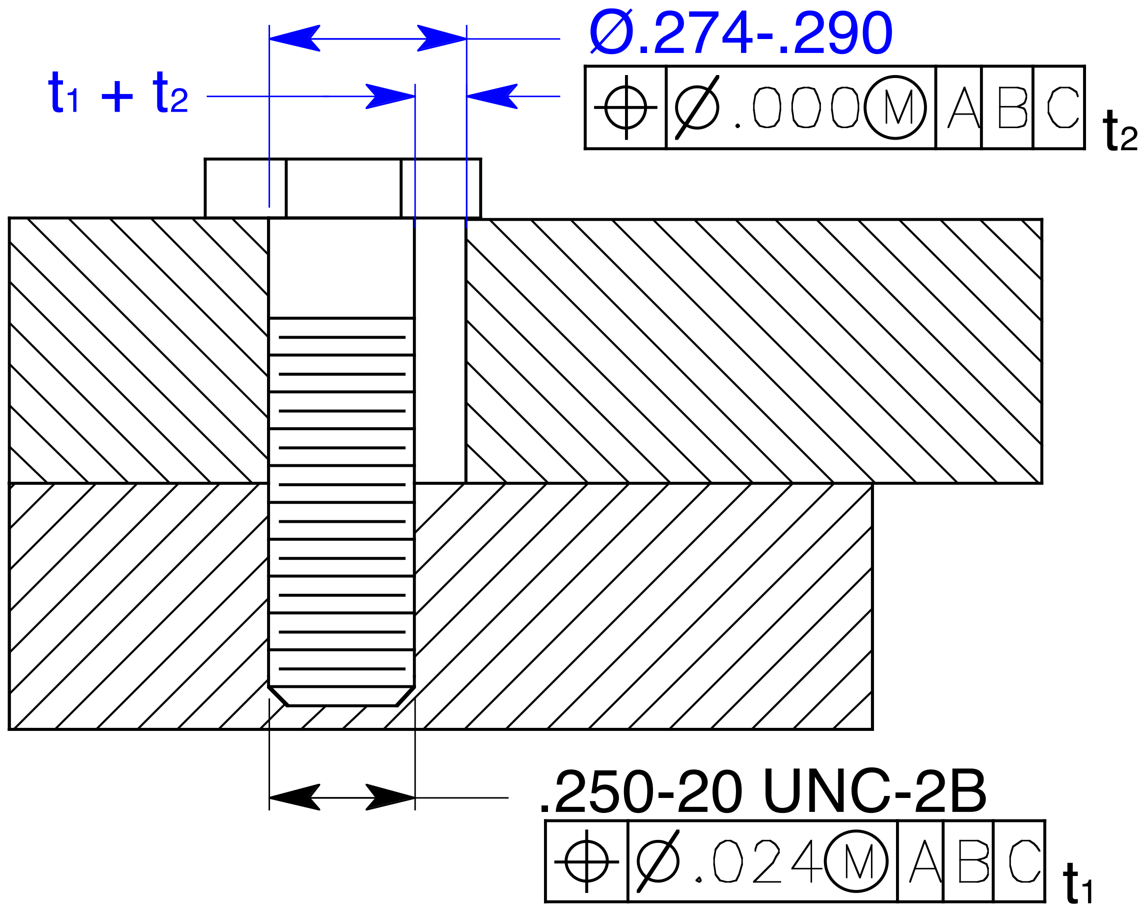

Figure 8-5 Fixed fastener

The fixed fastener in Fig. 8-5 is fixed by one or more of the members being fastened. The calculations for fixed fasteners are a bit more complicated than those for floating fasteners.

The fixed fastener formula is

$$t_1 + t_2 = H - F \quad \text{or} \quad H = F + t_1 + t_2$$

t_1 is the threaded hole location tolerance at MMC

t_2 is the clearance hole location tolerance at MMC

H is the clearance hole MMC diameter

F is the fastener's MMC diameter, the nominal size.

$$H = F + t_1 + t_2$$

$$H = .250 + .024 + .000 = .274$$

This formula is sometimes expressed in terms of 2T instead of $t_1 + t_2$; however, 2T implies that the tolerances for the threaded and clearance holes are the same. In most cases, it is desirable to assign more tolerance to the threaded hole than to the clearance hole because the threaded hole is usually more difficult to manufacture.

Once the fastener is determined, four pieces of information are needed to complete the clearance hole dimension and tolerances. They are illustrated in Fig. 8-6 and listed below.

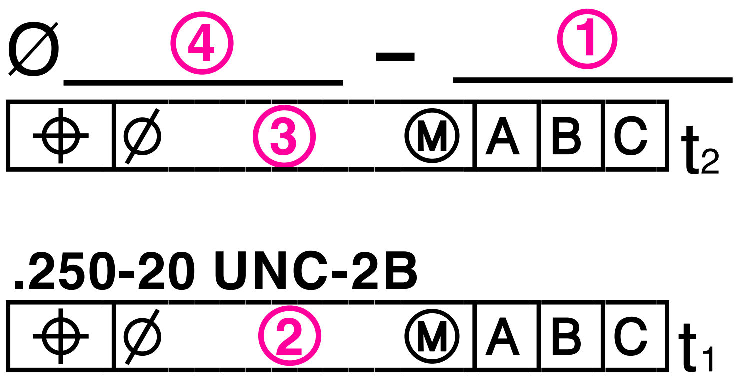

Figure 8-6 Fixed fastener dimension and tolerances

1 Clearance hole LMC diameter
2. Threaded hole location tolerance t_1
3. Clearance hole location tolerance t_2
4. Clearance hole MMC diameter **H**

1. Clearance Hole LMC Diameter

The first step in calculating the tolerance for fasteners is to determine the diameter of the clearance hole at LMC, the largest possible clearance hole diameter. This step is the same for fixed fasteners as it is for floating fasteners shown in the previous article, but it will be repeated here. The LMC hole diameter is essentially arbitrary. Of course, the clearance hole must be at least large enough to include the fastener plus the stated positional tolerance, and it cannot be so large that the head of the fastener pulls through the hole.

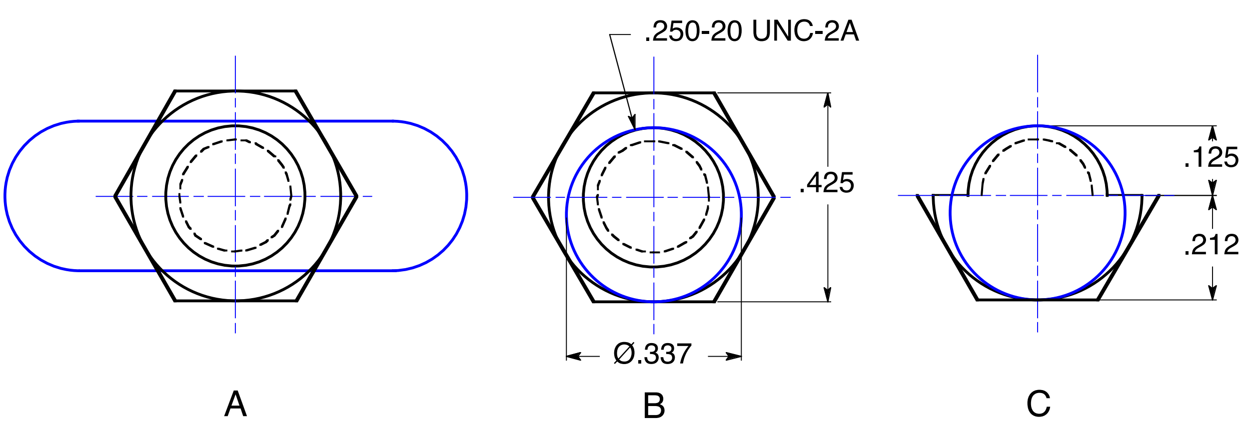

Figure 8-3 Clearance hole least material condition diameter

It has been suggested that the clearance hole should not be larger than the largest hole that will fit under the head of the fastener. If a slotted clearance hole (Fig. 8-3*A*) will fit and function, then surely the .337 diameter hole in Fig. 8-3*B* also will fit and function. How is the clearance hole diameter in Fig. 8-3*B* determined? The largest hole that will fit under the head of a fastener is the sum of half the diameter of the fastener plus half the diameter of the fastener head or half the distance across the flats of the head, as shown in Fig. 8-3*C*. The LMC clearance hole also can be calculated by adding the diameter of the fastener and the diameter of the fastener head and then dividing the sum by two.

Clearance hole LMC diameter = $(F + F_{head}) / 2 = (.250 + .425) / 2 = .337$

This method of selecting the LMC clearance hole size is a rule of thumb that will yield the largest hole that will fit under the head of the fastener. Engineers may select any size clearance hole that is required. The .337 clearance hole diameter might have been selected for our example, but instead, a more conservative hole size of .290 in diameter was assigned in Fig. 8-5. With the use of the preceding formula, engineers can make an informed decision and not have to solely depend on an arbitrary clearance hole tolerance chart.

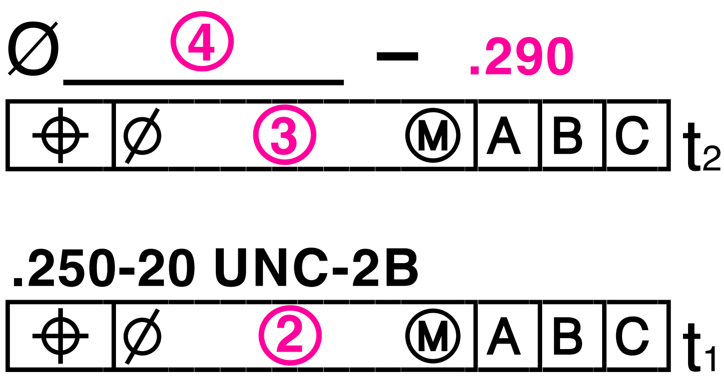

Figure 8-6A Dimension and tolerances for the fixed fastener in Figure 8-5, the LMC hole size is assigned

2. Threaded Hole Location Tolerance t_1

The location tolerance for both the threaded hole and the clearance hole must come from the difference between the actual diameter of the clearance hole and the diameter of the fastener, the total tolerance available.

Total location tolerance = clearance hole LMC diameter – fastener = .290 – .250 = .040

Since drilling and tapping a hole involve two operations and cutting threads in a hole is more problematic than just drilling the hole, it is common practice to assign a larger portion of the location tolerance to the threaded hole. In this example, 60% of the tolerance is assigned to the threaded hole; the remaining tolerance applies to the clearance hole.

Thread location tolerance = 60% × total location tolerance = 60% × .040 = .024

The position control locating the threaded hole has a cylindrical tolerance zone .024 in diameter at MMC. Zero positional tolerance is not appropriate for a threaded hole because there is almost no tolerance between mating threaded features. The tolerance is specified at MMC because there is some movement, however small, between the assembled threaded features, and a very small bonus tolerance may be available. Those who are tempted to specify a location tolerance at RFS should be aware that costly inspection equipment, a spring-thread gage, is required to inspect the thread. Also, a more restrictive tolerance is imposed on the thread. Parts should be toleranced and inspected the way they fit and function in assembly.

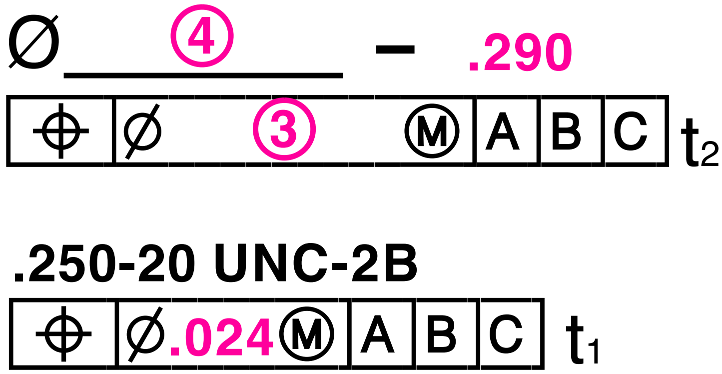

Figure 8-6B Dimension and tolerances for the fixed fastener in Figure 8-5, the LMC hole size and the threaded hole location tolerance are assigned

3. Clearance Hole Location Tolerance t_2

There are those who like to assign a position tolerance of .005 or .010 at MMC for the clearance hole location. However, a tolerance at MMC is arbitrary because bonus tolerance is available. If there is any doubt about which location tolerance to use, specify a zero positional tolerance at MMC. Zero positional tolerance at MMC will provide all the tolerance available and give the machinist the most size flexibility in producing the clearance hole. Zero positional tolerance at MMC has been assigned to the clearance hole in this example and will be used to calculate the MMC hole diameter.

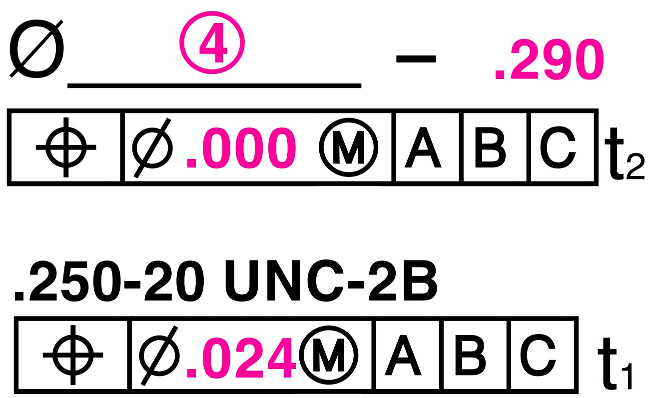

Figure 8-6C Dimension and tolerances for the fixed fastener in Figure 8-5, the LMC hole size and the threaded and clearance hole location tolerances are assigned

4. Clearance Hole MMC diameter *H*

Once the fastener and the position tolerances for the threaded and clearance holes have been selected, it is a simple matter to calculate the clearance hole MMC diameter. The positional tolerance for the threaded hole $\mathbf{t_1}$ is .024 in diameter, and the positional tolerance for the clearance hole $\mathbf{t_2}$ is .000. Whichever tolerance is selected, it is important to use this formula to calculate the correct clearance hole MMC diameter. If the clearance hole MMC diameter is incorrect, either a possible no-fit condition exists or tolerance is wasted.

$$\boldsymbol{H = F + t_1 + t_2}$$

$$\boldsymbol{H = .250 + .024 + .000 = .274}$$

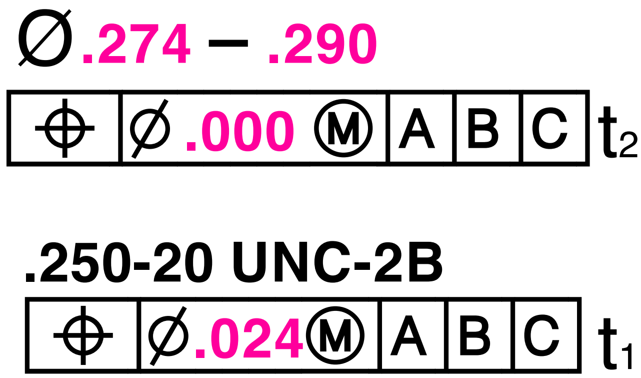

Figure 8-6D Dimension and tolerances for the fixed fastener in Figure 8-5, the LMC hole size, the threaded and clearance hole location tolerances, and the MMC clearance hole diameter are assigned

At this point, the engineer may wish to check a drill chart (Table 8-1) to determine the actual tolerance available. The letter L drill would not be used because the drill probably will produce a hole .002 or .003 over size. If the letter K drill were used and drilled a hole only .002 oversize, the clearance hole tolerance would be .283 in diameter.

Clearance hole location tolerance = actual clearance hole diameter – MMC

Clearance hole location tolerance = .283 – .274 = .009

Because of the drill size used, the total tolerance available is not .040 but .033, and the amount of tolerance assigned to the threaded hole is over 70% of the total tolerance. At this point, the designer may want to increase the clearance hole LMC diameter or reduce the threaded hole location tolerance.

Letter	Fraction	Decimal
	17/64	.266
H	–	.266
I	–	.272
J	–	.277
	9/32	.281
K	–	.281
L	–	.290

Table 8-1 Drill chart

[1]Cogorno, Gene R., ***Geometric Dimensioning and Tolerancing for Mechanical Design, Second Edition***, McGraw-Hill, New York, 2011, p. 134.