# Establishing a Datum Reference Frame

Recently a client asked me to look at a drawing that is similar to the one shown in Fig. 14-14A below. The primary datum feature is the back of the part and has been controlled with a flatness tolerance of .002. The secondary datum feature is one of the holes in the four-hole pattern, and the tertiary datum feature is one of the holes in the two-hole pattern.

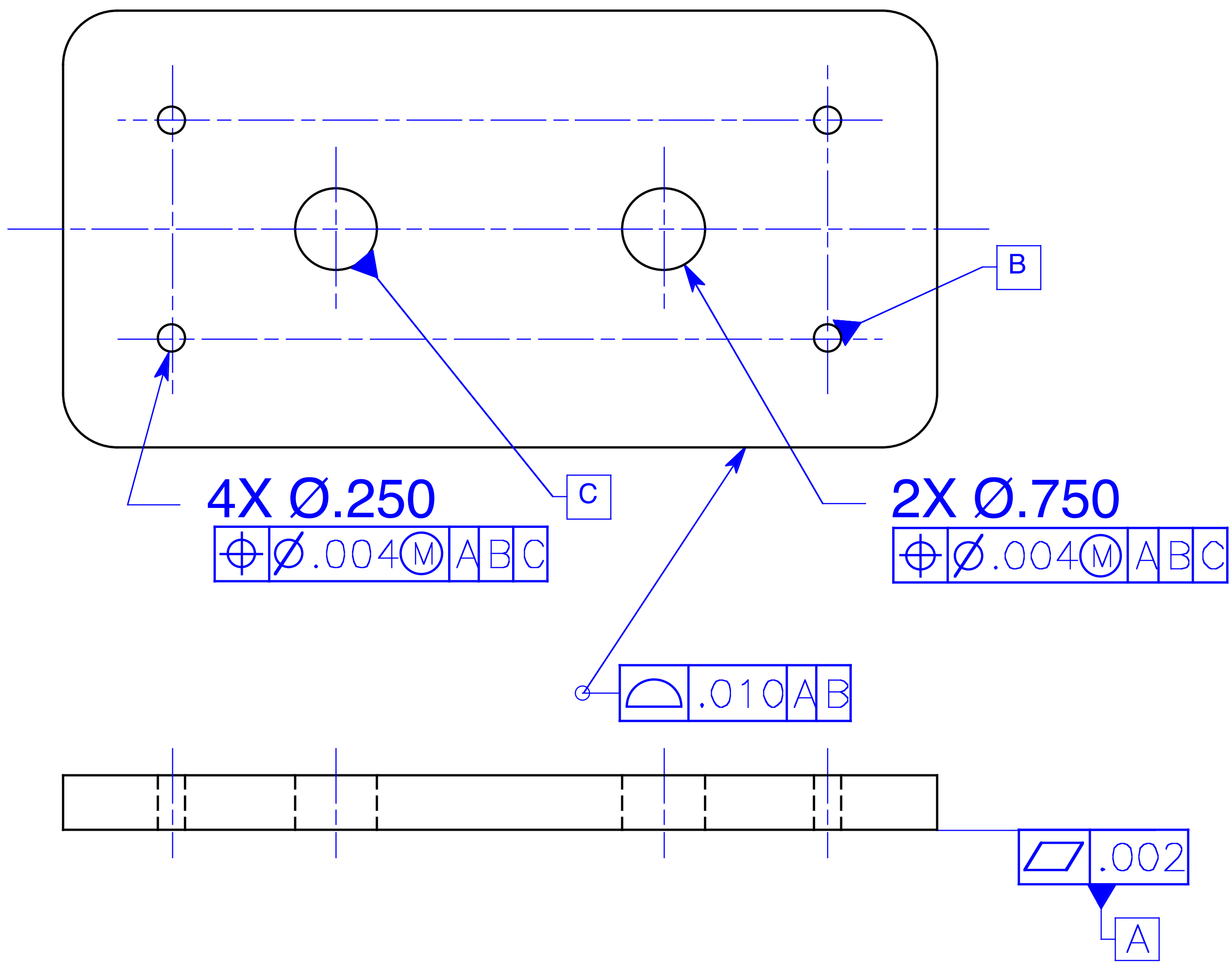


**Figure 14-14A The inappropriate use of datum features to control a pattern of features to another pattern of features**

The back of this part was selected as datum feature A. This is an appropriate primary datum feature because it is a large mating surface, and the four-hole pattern is a pattern of clearance holes that are typically perpendicular to the mating surface.

Datum feature B, in Fig. 14-14A, is not such a good datum feature selection. Datum feature B is used to locate both patterns of holes. The four-hole pattern is already located to datum feature B by virtue of the fact that it is one of the holes in the pattern. Consequently, the pattern is located to itself. It makes no sense to control a pattern of features to one of the features in the pattern.

Datum feature C is the clocking datum feature. That is, datum feature C is supposed to prevent the patterns from rotating about the axis of datum feature B. However, datum feature C does no such thing. The four-hole pattern does not need to be clocked, and the two-hole pattern can't be clocked with one of the features in its own pattern.

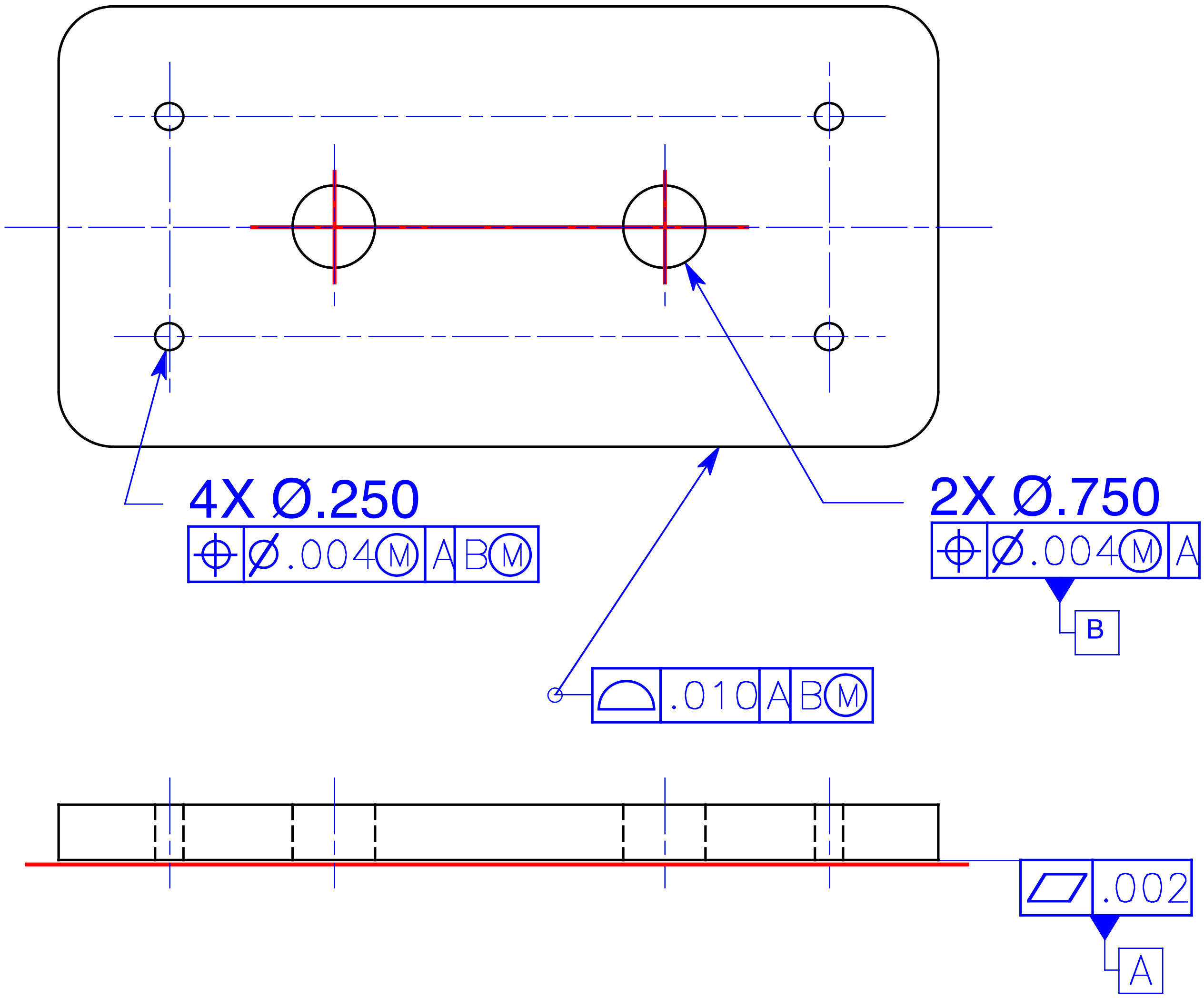


**Figure 14-14B A properly toleranced part shown in Fig. 14-14A**

The first step in tolerancing a part is to establish a datum reference frame. If the datum reference frame happens to be three mutually perpendicular intersecting datum planes, assigning datum features is relatively easy. However, if one or two of the datum features is a feature of size, then more thought is required to establish a suitable datum reference frame.

The drawing in Fig. 14-14B has an established datum reference frame that consists of datum features A and B. Datum feature B is the two-hole pattern. The position control is used to locate the two holes in the pattern to each other and orient them perpendicularly to datum feature A. Now we have established a datum reference frame consisting of the plane of datum feature A, the common plane through the axes of the two holes, and the two planes through the axes of the two holes perpendicular to the common plane of datum feature B. The four planes of this datum reference frame are shown in red on the drawing in Fig. 14-14B.

With the datum reference frame established, the four-hole pattern and the profile can be located as a composite pattern of features locked together and located to datum feature B. Patterns of features are locked together as one composite pattern of features if they are located with basic dimensions and referenced to the same datum features, in the same order of precedence, and with the same material condition modifiers. Datum feature B not only locates the two patterns, but it also clocks the patterns preventing them from rotating about the axes of the two holes.

Typically, the maximum material boundary modifier, circle M, is placed in the feature control frame following datum feature B when tolerancing static assemblies. The maximum material boundary modifier doesn't give the assembly any more tolerance; it just allows the inspector to use all of the tolerance that is available.

Start the tolerancing process by establishing the datum reference frame. Then, tolerance all other features to that established datum reference frame. Although it is not always possible, it is usually best to tolerance the entire part to the same datum reference frame.

[1]Cogorno, Gene R., ***Geometric Dimensioning and Tolerancing for Mechanical Design, Second Edition***, McGraw-Hill, New York, 2011, p. 241.