As a general rule, appropriate size and geometry tolerances should be specified on datum features and the magnitude of these tolerances should be smaller than those specified for the features they locate. This is to ensure that the variations introduced by datums in a geometry tolerance specification are relatively small and insignificant.

10.3 INTERPRETATION OF A SINGLE DATUM FEATURE

A Datum is described in AS 1100.101—1992 as:

"a perfect geometric element, such as a point or a line or a plane which alone or in combination with others of its kind defines precisely the basic shape of the geometric reference frame for a particular group of features."

Referring to Figure 10.1 (d) the datum is a plane representing the face **A** and in Figure 10.2(d) it is a line representing the axis of the cylinder **A**. The plane **A**, and the axis line **A**, are the basic construction features of the geometric reference frames for each case. They are extended from these features to include the feature **B** for each case.

It is recognised that datum features are subject to the variabilities of manufacturing processes as any other feature. Hence, the *"perfect geometric element"* indicated above is not achieved. Thus, AS 1100.101-1992 then describes a Datum Feature as: -

"a real feature of an item (such as a surface, a hole) which is used to establish the location of a datum in the geometric reference frame.

NOTE: Datum features are subject to manufacturing errors and variations and should be assigned tolerances appropriate to their design function".

This leads to the need for representing imperfect actual datum surfaces or lines as perfect geometric elements.

10.3.1 Interpretation of a Datum Plane

METHOD 1: Simulating an actual datum surface for datum alignment and location procedures using dial gauges, probes in coordinate measuring machines, etc.

1. The upper diagram in Figure 10.3 shows the specification of the datum Plane **A**.

2. Immediately below is a cross-section of the perfect datum plane **A**.

3. The actual imperfect profile of this cross-section is shown next.

4. A simulated datum is then obtained from the actual datum **A** as follows.

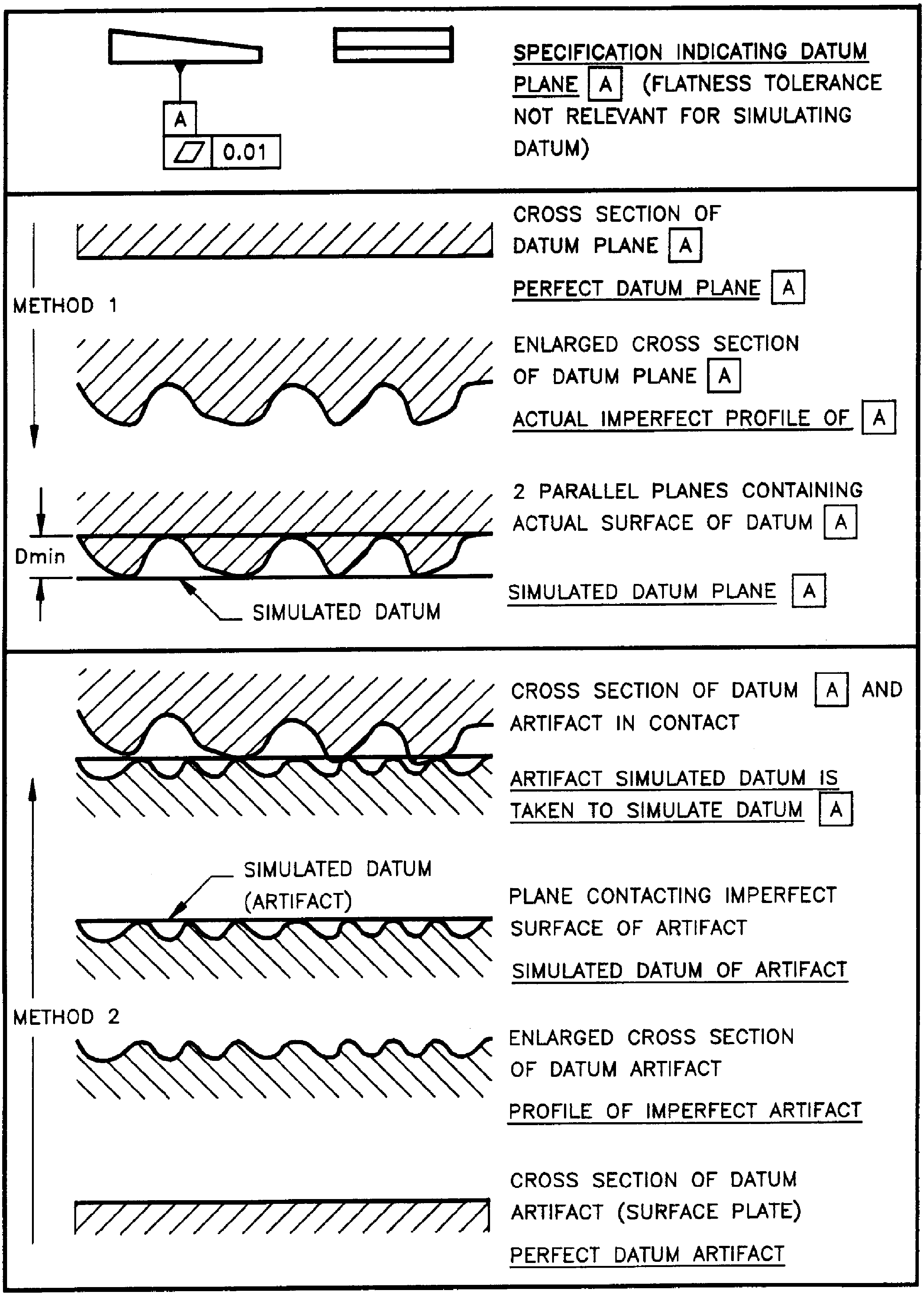

FIGURE 10.3 METHODS FOR SIMULATING DATUM PLANES

Two parallel planes are established that contain the actual profile of the surface **A**. The orientation of these planes is adjusted to obtain the minimum separation distance, **Dmin**, between them. The plane on the outside of the actual surface **A** is taken as the simulated datum plane of the surface **A**.

METHOD 2: Datums are often located on simulated datum artifacts. The AS 1100.101—1992 describes a SIMULATED DATUM as:

"an actual feature or features of equipment such as a surface plate, V-block or cylinder, from which the corresponding datum point, line or plane is derived."

1. The bottom diagram in Figure 10.3 shows a cross-section of a perfect datum artifact.

2. Moving upwards, the actual profile of this cross-section of the artifact is shown to have some deviations from perfect form.

3. The line (plane for whole surface) shown contacting this surface in the next diagram simulates a perfect datum artifact surface.

4. The profile of the actual surface **A** is then shown in contact with the surface of the artifact. The simulated datum surface of the artifact is taken as the datum surface of the actual surface **A**.

It can be seen that the simulated datum of the surface **A**, established by the METHOD 1 procedure, is not the same as the surface obtained from the METHOD 2 procedure that uses the simulated datum of the artifact. The discrepancies between the two methods is a function of the magnitude of the variation in geometry of the artifact surface. An artifact with perfect form will give the same results as a pair of perfectly orientated planes. Of course both cannot be achieved in practice.

Thus, to obtain relatively consistent results with both METHODS, the Form errors in artifacts (surface plates) should be considerably smaller than those in the workpiece datum features and the errors in the workpiece datums should be considerably smaller than the permissible errors in the features located from these datums.

1. Suggested tolerances for the datums of workpieces are 20-50 percent of the tolerances on the workpiece features they locate.

2. Suggested tolerances for the datums of jigs and fixtures are 20-50 percent of the tolerance specified on the workpiece datum features and 10 percent for gauges and inspection artifacts.

10.3.2 Interpretation of a Datum Cylinder

The cylindrical surface is subject to the same "Datum" description as the plane, the difference being that the axis of the cylindrical surface is the datum.

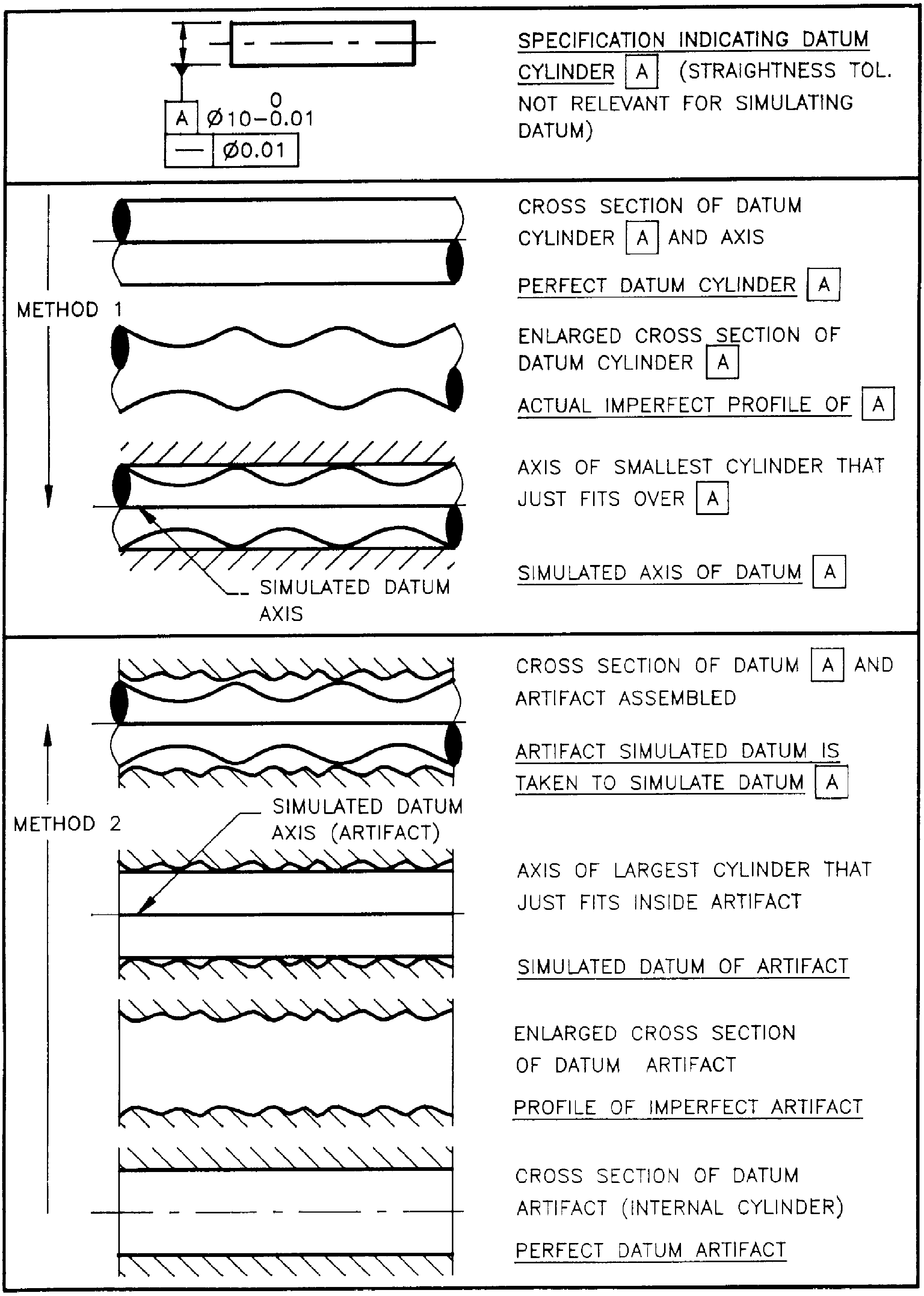

FIGURE 10.4 METHODS FOR SIMULATING THE AXIS OF DATUM CYLINDERS

METHOD 1: Simulating the axis of an actual datum cylinder for datum alignment and location procedures using dial gauges, probes in coordinate measuring machines, etc.

1. The upper diagram in Figure 10.4 shows the specification of the datum cylinder **A**.
2. Immediately below is a cross-section the perfect datum cylinder **A** and its axis.
3. The actual imperfect profile of this cross-section is shown next.
4. The simulated datum of this actual datum **A** is the axis of the smallest perfect cylinder that will just fit over the surface of the actual cylinder.

METHOD 2: Like the plane, the axis of cylindrical datums are often located or simulated from the axis of datum artifacts, such as location pins, collets, gauge pins, etc.

1. The bottom diagram of Figure 10.4 shows a cross-section of a perfect datum artifact (internal cylinder).
2. Moving upwards, the actual profile of this cross-section of the artifact is shown to have some deviations from perfect form.
3. The axis of the largest perfect cylinder that will just fit into the artifact simulates the axis of a perfect datum artifact cylinder.
4. When the artifact is assembled over the cylindrical datum feature **A**, the simulated axis of the datum artifact is taken as the datum axis of the actual datum cylinder **A**.

As for the datum plane, the simulated datum axis of the cylinder **A** established by the METHOD 1 procedure is not the same as the axis obtained from the METHOD 2 procedure that uses the simulated axis of an artifact. Therefore to minimise the discrepancies between the two methods the same strategy is used for selecting artifacts and tolerancing cylindrical datums as was described for datum planes.

The same procedures apply for locating the axis of an internal datum cylinder.

10.4 SPECIFICATION OF MULTIPLE DATUM FEATURES

Examples of multiple feature datums or datum systems are shown in Figures 2.7, 2.8 and 3.2(a). These datum systems are various combinations of planes and cylinders. Figure 10.5(a) shows a three plane datum system for locating the position of a hole in a block. The datum system comprises the following elements:

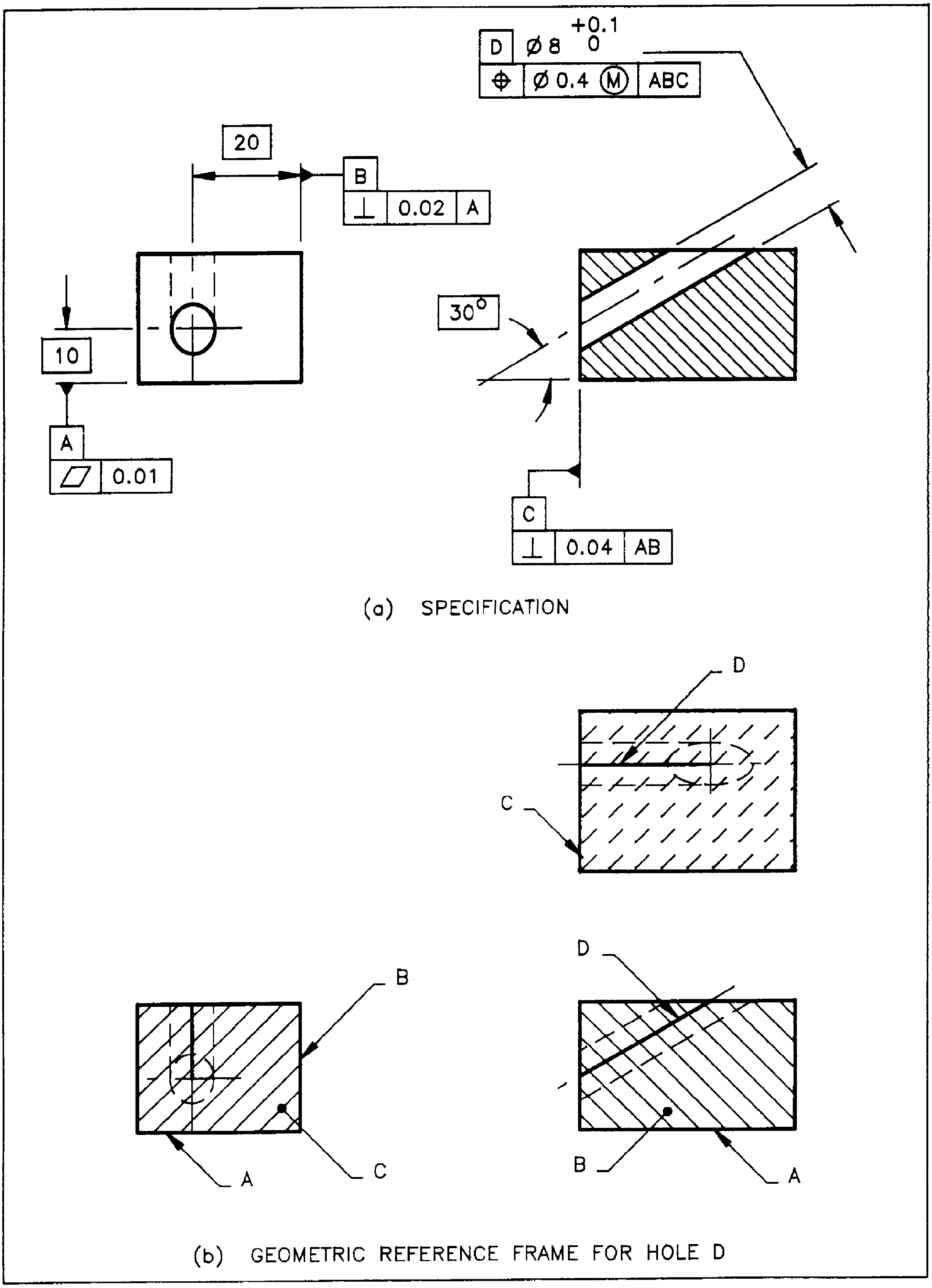

FIGURE 10.5 HOLE WITH 3 PLANE DATUM SYSTEM

FACE A — does not have a datum, only a flatness form tolerance.

FACE B — has a perpendicularity tolerance relative to datum face **A** (1 plane datum system).

FACE C — has a perpendicularity tolerance relative to datums **A** and **B** (2 plane datum system)

HOLE D — has a position tolerance relative to datum faces **A**, **B** and **C** (3 plane datum system).

10.5 INTERPRETATION OF MULTIPLE DATUM FEATURES

10.5.1 Primary, Secondary and Tertiary Datums

The order in which datum features appear in a tolerance specification is most important.

Datum **A** appears first in the list of datums in the hole position specification, Figure 10.5(a) and is therefore a PRIMARY DATUM. The second datum feature in the list is face **B** and this is a SECONDARY DATUM. Finally, the third datum feature in the list is face **C** and this is a TERTIARY DATUM.

1. The geometric reference frame and tolerance diagram are shown in Figures 10.5(b) and 10.6(a). These were drawn, commencing with datum **A** first (primary) then **B** (secondary) and finally **C** (tertiary).

2. Location planes for the three datum faces **A**, **B** and **C** have been superimposed on the tolerance diagram in Figure 10.6(b). These location planes could represent the location surfaces for the assembled block in use, or the location surfaces of a jig or fixture for producing the hole, or the location surfaces in an inspection procedure for assessing the position of the hole. It is intended by the specification that these datum surfaces be used for all these purposes. A simulated actual component has been added to this Figure to illustrate these points.

10.5.2 Six Point Location Principle

This principle requires:

Primary datum planes be located on at least *3 points*.

Secondary datum planes be located on at least *2 points*.

Tertiary datum planes be located on at least *1 point*.

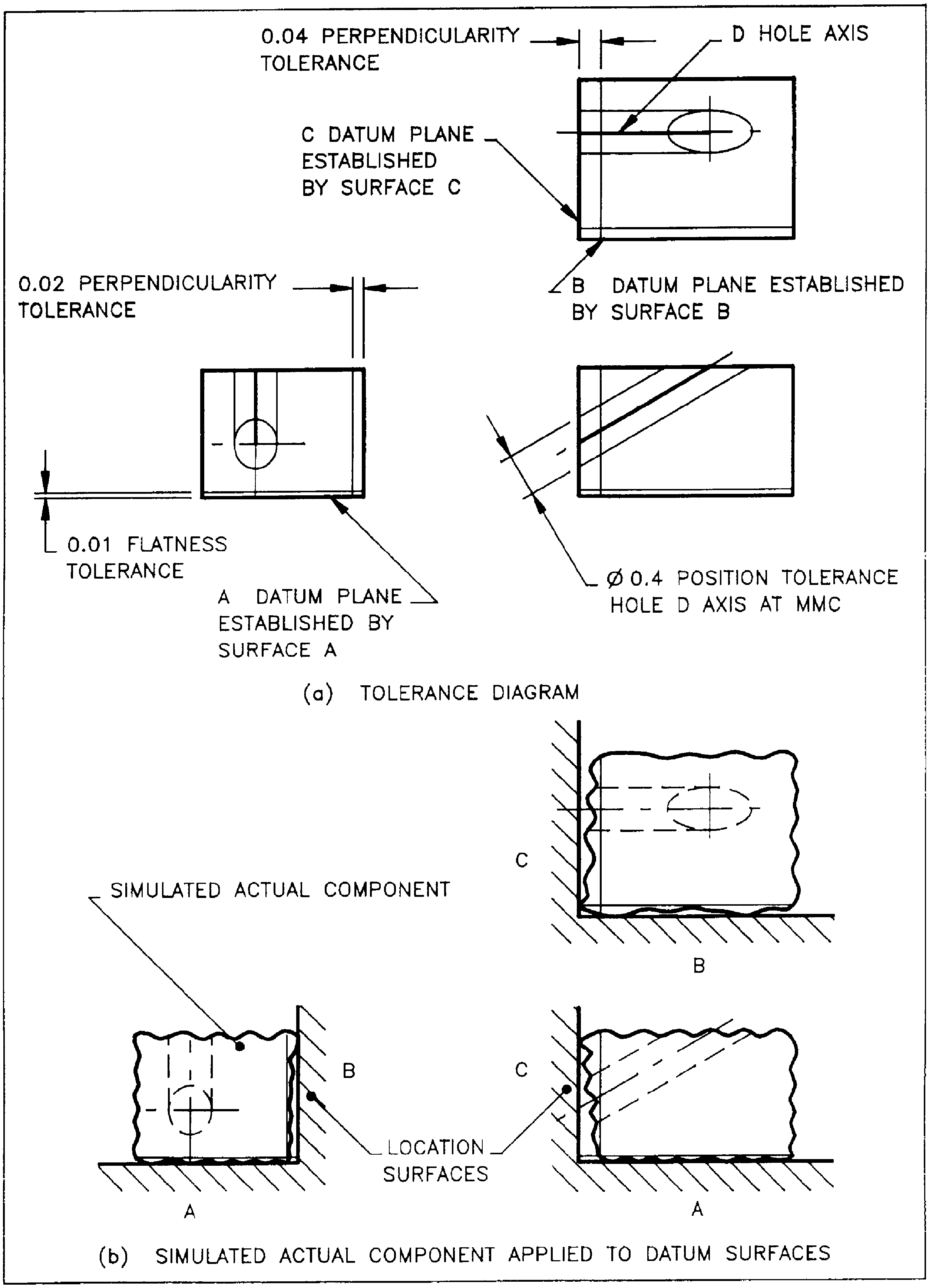

FIGURE 10.6 HOLE WITH 3 PLANE DATUM SYSTEM

This is illustrated in Figure 10.6(b) with face **A** of the simulated actual component contacting its location face at 3 or more points, face **B** is contacting its location face at 2 or more points and face **C** is contacting its location face at 1 or more points.

The practical application of this principle means:

1. The datum face **A** of the block is located first with a minimum of three contact points.

2. When the block is stable on face **A** it is then moved against the datum face **B** location surface and a minimum of 2 contact points are made with this location surface. This is to be achieved without reducing or disturbing the contact on datum face **A**.

3. When the block is stable on faces **A** and **B** it is then moved against the datum face **C** location surface and a minimum of 1 contact point is made with this location surface. This is to be achieved without reducing or disturbing the previously determined contact on faces **A** and **B**.

The location on datum features is to be made in the order specified. Changing the order can result in quite significant variations in the dimensional performance of a specification.

10.6 DATUM TARGETS

The use of targets to establish datum surfaces has been introduced for the first time in AS 1100.101. The technique is based upon the application of the Six Point Location principle, described in Clause 10.5.2. That is, to locate one body relative to another, it is necessary and sufficient to supply six location positions. These are referred to as targets and may take the form of points, lines or areas. They are selected to correspond with the six points of the foregoing principle and become datum features in the geometric reference frame. Datum targets have greatest application in the field of large components, such as building construction, aircraft fuselages, automobile bodies, large castings, forgings, weldments and the like. The basic reason underlying the use of datum targets is to overcome inconsistencies in datum location that result from relatively large irregularities that appear in the products produced by some manufacturing processes/methods.

The relative magnitude of these variations can be so large in some instances, the entire surface of some datum location features cannot be effectively used to establish a datum. An example would be the unmachined, as cast, datum surfaces **C** and **D** of the CAST GUIDE FRAME in Figure 10.7. A means of overcoming this difficulty is to use Datum Targets to indicate either points, lines or areas of contact on the part that are to be used as datums.

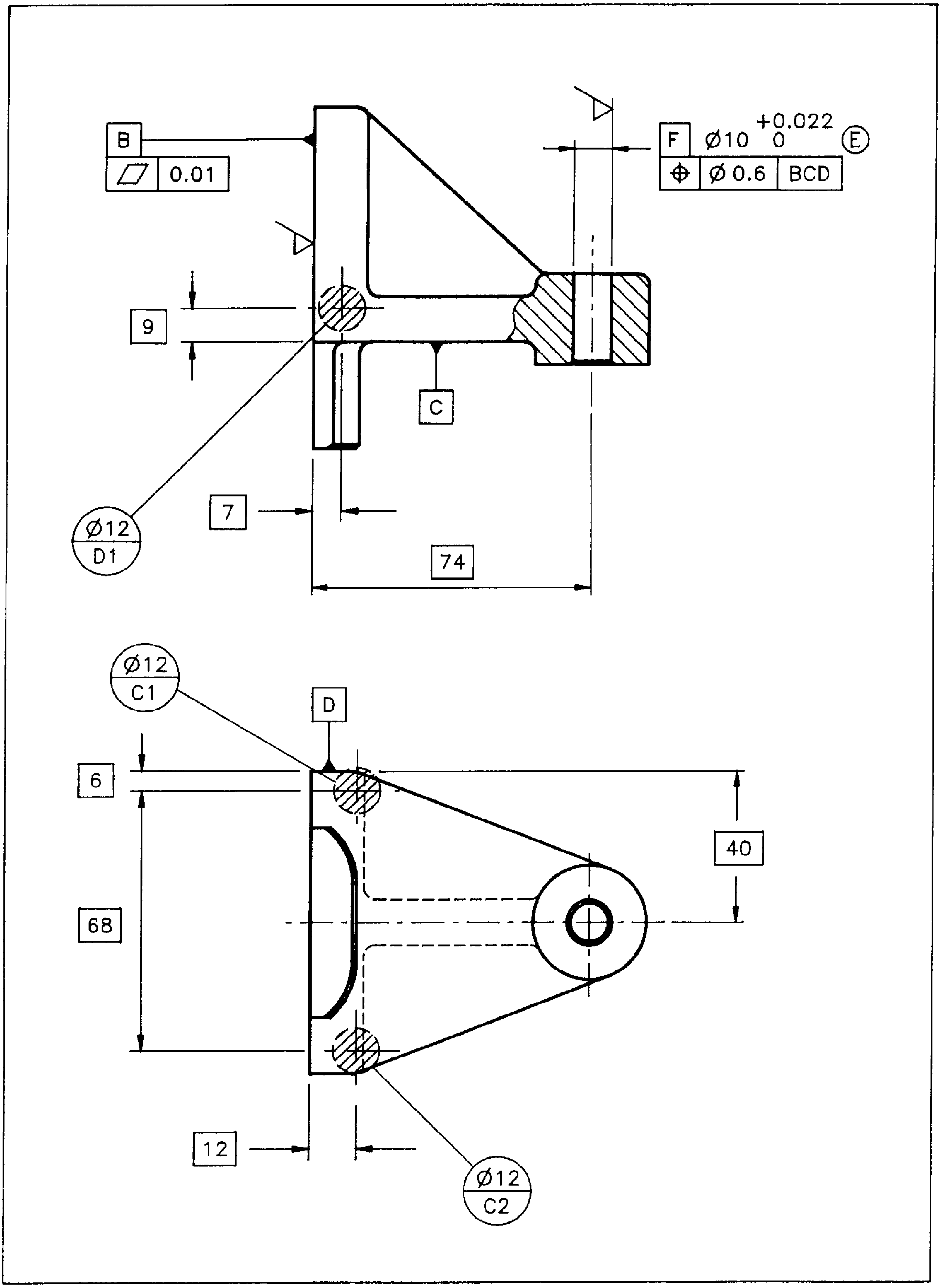

FIGURE 10.7 CAST GUIDE FRAME — DATUM TARGET AREAS SPECIFICATION