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OPTICAL INSPECTION OF CONSTANT
FORM ELEMENTS

by

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OPTICAL INSPECTION OF CONSTANT FORM ELEMENTS

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Mil-Std-8 dimensions and tolerances can be used to define specific optical projector chart gages and indicate the staging fixtures to be used when variables inspection data is not required. This paper will discuss some basic principles of chart gage design when certain positional and form tolerances are used and describe how part fixturing and alignment is affected when RFS¹ and MMC² are specified to part datum-axes and tolerances. Note: Part datum surfaces should be of high quality so that variations in their form will not unduly effect the set ups shown.

Figure 1 shows primary part datum-feature A, modified by the RFS symbol (S) and the 0.001-inch concentricity tolerance modified by the MMC symbol (M). The (S) modifier requires datum A to be "centered" (the actual axis of datum A is the origin of all measurements regardless of its size) during gaging and the (M) symbol allows the concentricity tolerance to vary as the finished parts vary in size.

Figure 1A shows the optical chart gage and a nominal part shadow combined. The chart gage will be prepared at the same magnification as the part. Diameter A must be "centered" by the projector operator and therefore axially aligned between the 0.099-inch and 0.101-inch chart gage lines as the first step in gaging the part.

The part may be arbitrarily staged by setting it on either end surface. The projector X-Y table and chart gage can be adjusted to effect axial alignment of datum-feature A. The 0.060-inch nominal diameter shadow of the part must then fall between the 0.003-inch chart gage lines for acceptance.

¹RFS = Regardless of Feature Size. The datum-feature must be "centered" in the inspection equipment. Symbol = (S)

²MMC = Maximum Material Condition. The center of the datum-feature may be displaced from the origin of measurement by one-half the difference between its actual and MMC size. Symbol = M

The 0.063-inch chart gage spacing is determined by adding the 0.001-inch concentricity tolerance to the 0.062-inch, or MMC, size of the 0.060-inch diameter. Since the 0.001-inch concentricity tolerance is required only when the 0.060-inch diameter is 0.062-inch, or at its MMC size, the chart gage allows a greater concentricity tolerance when the 0.060-inch diameter is smaller than 0.062-inch as follows:

<u>Feature Size (inch)</u>	<u>Concentricity Tolerance (inch)</u>
0.062	0.001
0.0615	0.0015
0.061	0.002
0.0605	0.0025
0.060	0.003
0.0595	0.0035
etc.	etc.

The 0.062-0.058-inch limits must, of course, be inspected separately and another chart gage could be used. The chart gage (Figure 1A) checks the size of part datum A during the "centering" process.

Figure 2 shows part primary datum-feature A modified by symbol (M) and the 0.001-inch concentricity tolerance modified by symbol (M). The (M) symbol does not require datum A to be "centered" unless it approaches its 0.101-inch diameter, or MMC, size. Thus, if the part shadow falls within the 0.101-inch and 0.063-inch chart gage lines (Figure 2A), the part is acceptable for concentricity. The 0.062, 0.058, and 0.099-inch limits must be inspected separately as they are not included on the chart gage.

Figure 3 shows the end surface of the part specified as primary datum-feature A and diameter B as the secondary datum-feature modified with (M). The same chart gage shown in Figure 2A can be used, however, it must be set up 90° to the part mounting surface on the optical projector (see Figure 3A). The X-Y table can be used to adjust the part shadow for location. The part must be mounted on part surface A, which should be flat to 0.0001-inch to be suitable "datum", and the part shadow must fall within the chart gage lines to be acceptable. Datum diameter B must only be perpendicular to datum surface A when it approaches its MMC size of 0.101-inch diameter.

Figure 4 states that the 0.100-inch diameter must be perfectly perpendicular to part datum surface A when it is at MMC (0.101-inch diameter). The chart gage lines must again be set up 90° to the part mounting surface on the optical projector. When part datum surface A is mounted, the 0.100-inch diameter must

fall within the chart gage lines. Thus, the 0.100-inch diameter must be perpendicular when it is at MMC (0.101-inch diameter) and can have the following perpendicularity tolerances depending on its size:

<u>Feature Size (inch)</u>	<u>Perpendicularity Tolerance (inch)</u>
0.101	0.000
0.1005	0.0005
0.100	0.001
0.0995	0.0015
etc.	etc.

Since the chart gage checks the 0.101 limit, only the 0.099 limit must be inspected separately.

Figure 5 shows the application of the contour tolerance zone. This 0.001 tolerance zone is equally disposed about the basic part contour unless otherwise specified and includes all size and form tolerances. The datum-axis on the part is established by centers A and B.

Figure 5A shows the chart gage lines which must be located from the axis established by the two centers on the staging fixture. (A set line on the chart gage should be used to align the chart gage with the shadow of the centers on the optical screen.) When the part is rotated 360° on the staging centers (inserted into Centers A and B on the part) the part shadow must fall within the chart lines for acceptance.

Figure 6 shows a further application of contour tolerancing. The contour tolerances are equally disposed about the basic part diameters and define the chart gage shown in Figure 6A. The entire part shadow must fall within the chart gage lines at one setting for acceptance. This method of tolerancing demands that the particular part contour have perfect form and location when it approaches its two size limits. Thus, nominal parts may have the greatest deviation in form and locational tolerances. The contour tolerancing method applies to small, mass produced parts and is compatible with actual die wear conditions.

FIG. 1

FIG. 1A

FIG. 2

FIG. 2A

FIG. 3

FIG. 3A

FIG. 4

FIG. 4A

FIG. 5

FIG. 5A

FIG. 6

FIG. 6A

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