1. PURPOSE

1.1. This procedure provides general product fabrication requirements. It also provides interpretation of certain requirements specified on product drawings, models, and electronic files.

2. SCOPE

2.1. This procedure applies to all manufactured and procured machined components and tooling. Specific requirements on product drawings, models, and electronic files always take precedence over these general requirements and interpretations.

3. DEFINITIONS

3.1. GD&T - Geometric Dimensioning and Tolerancing

4. RESPONSIBILITY

4.1. Machinist

4.1.1. Produces and inspects parts using the methodology described in this procedure.

4.2. Quality Technician

4.2.1. Inspects parts using the methodology described in this procedure.

5. PROCEDURE

5.1. Dimensions, Tolerances and Measurements

5.1.1. Dimensions

5.1.1.1. Basic Dimensions

5.1.1.1.1. Basic dimensions describe the theoretical exact size, profile, orientation, or location of a feature or datum target.

5.1.1.1.2. Basic dimensions are characterized by a rectangle or box around the dimension.

5.1.1.1.3. Basic dimensions are exempt from inspection unless otherwise required by the customer.

5.1.1.2. Reference Dimensions

5.1.1.2.1. Reference dimensions provided for information only and are often an accumulation of other dimensions that are defined elsewhere.

5.1.1.2.2. Reference dimensions are characterized by parentheses around the dimension.

5.1.1.2.3. Reference dimensions are exempt from inspection.

5.1.1.3. Surface Coatings

5.1.1.3.1. Dimensional limits apply after/over metallic platings, dry film lubricants, electrochemical and chemical film coatings. Dimensional limits apply before the application of primers, paints or other such organic and synthetic coatings. When verification of dimensions is necessary, the organic finish shall be removed and then replaced after verification.

5.1.2. Tolerances

5.1.2.1. Design shall provide the correct tolerance for each feature dimensioned, which means

that the desired value of the characteristic shall be within the tolerance stated and within the number of decimal places stated in the tolerance. An acceptable degree of conformance of product will be at the stated number of decimal places rounding will be used.

5.1.3. Conversion

5.1.3.1. Specified metric (SI) dimensioned products tolerances may be converted to imperial units (British) or vice versa by use of industry accepted conversion factors. The rounding method and number of decimal places retained shall not allow converted values to violate the original maximum and/or minimum limits. Regardless of the units of measuring instruments used, product acceptance procedures will be such that acceptance to the specified tolerance is assured.

5.1.4. The interpretation of dimensional limits and tolerances shall be performed per **QP200**.

5.1.5. Calibrated gages shall be used for measurement that meet the minimum specification tolerance requirement per **QP220**.

5.1.6. Counter Bores

5.1.6.1. In curved surfaces or on flat surfaces where the hole axis is not perpendicular to the surface, the depth of a counterbore is the minimum distance from the bottom of the rim as shown in Figure 1. The interior corner at the bottom of a counterbore produced by a standard tool is acceptable.

5.1.7. Counter Sinks

5.1.7.1. In curved surfaces or on flat surfaces where the hole axis is not perpendicular to the surface, the diameter of a countersink is the diameter of the lowest point on the rim in a plane perpendicular to the hole axis. See Figure 1. Holes for flat head screws shall be countersunk to allow the head of the screw to be flush to 0.25" [.010 mm] below the surface.

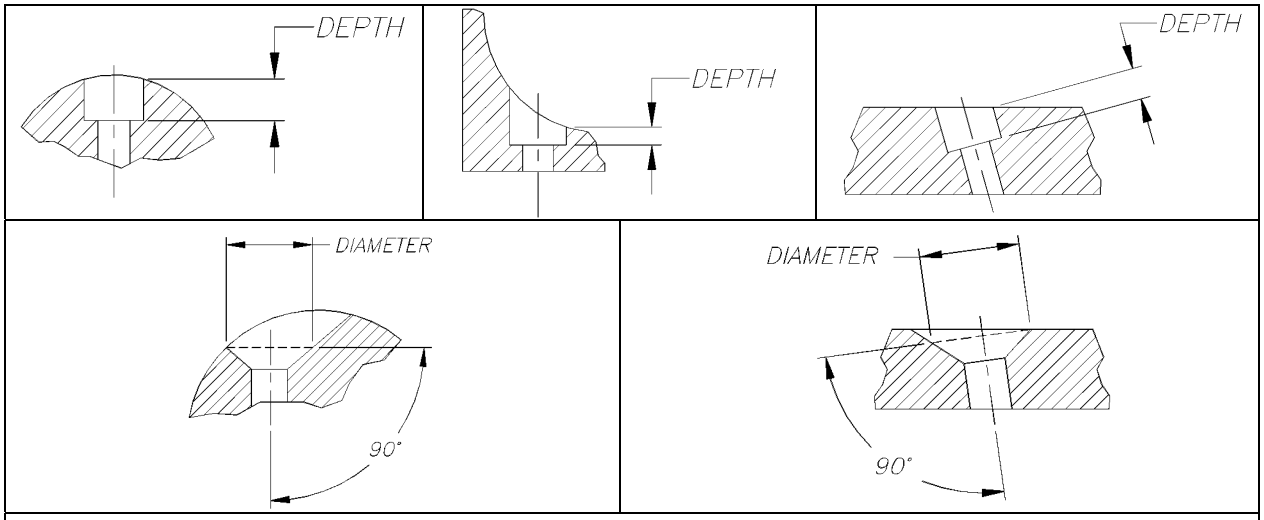

Figure 1 – Counterbores & Countersinks

5.1.8. Spotfaces

5.1.8.1. Spotfaces shall provide for a minimum of 75% bearing area around a hole and must be visible on the part surface. The interior corner at the bottom of a spotface produced by a standard tool is acceptable.

5.1.9. Tangent Radii

5.1.9.1. A toleranced radius with an unlocated center creates a tolerance zone defined by two arcs (the minimum and maximum radii) that are tangent to the adjacent surfaces. The part contour may be anywhere within the crescent-shaped zone shown below in Figure 2.

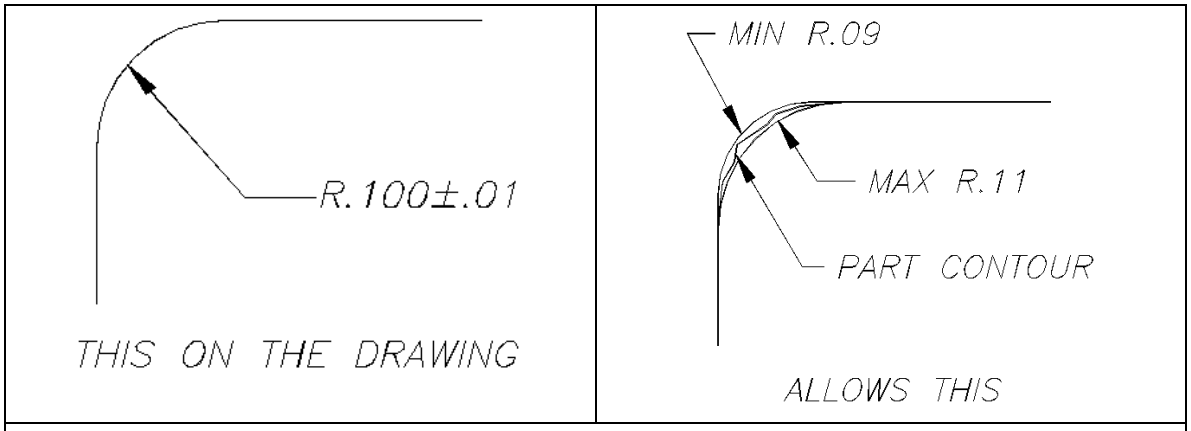

Figure 2 – Tangent Radii

5.1.10. Stock Material Thickness

5.1.10.1. When the drawing specifies nominal cross-sectional dimensions for material used to fabricate the part but does not specify tolerances for these dimensions, the widest tolerances applicable to the material, form, and process may be used.

5.1.11. Positional Limit Basic Explanation

5.1.11.1. Boundary

5.1.11.1.1. The positional limit is a boundary of specified configuration established by untoleranced dimensions which are in relation to a datum reference frame. See Figure 3.

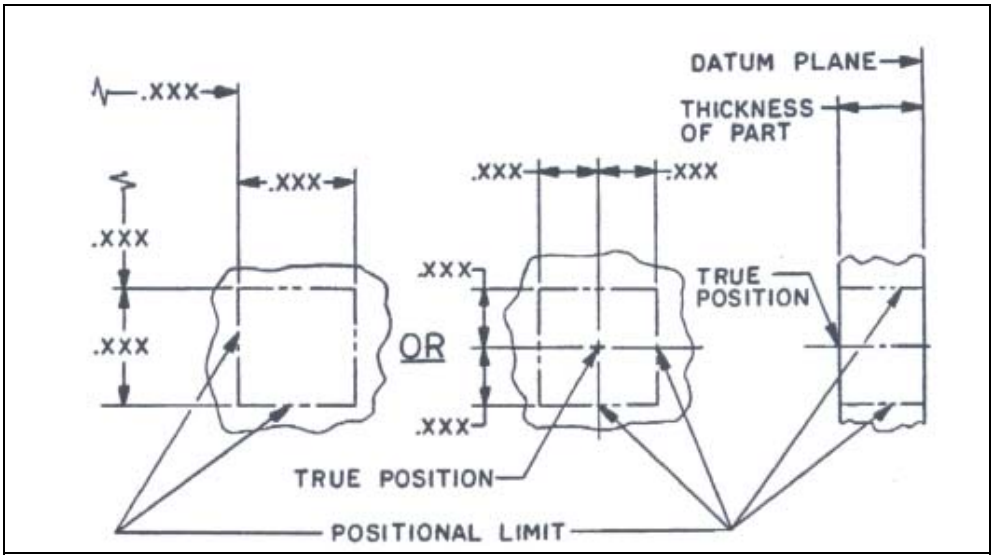

Figure 3 - Boundary

5.1.11.2. Control

5.1.11.2.1. The positional limit is independent of the feature size. It controls feature location and may control orientation. The feature must be located so that no portion of its surfaces shall extend into the positional limit (boundary) specified. See Figure 4.

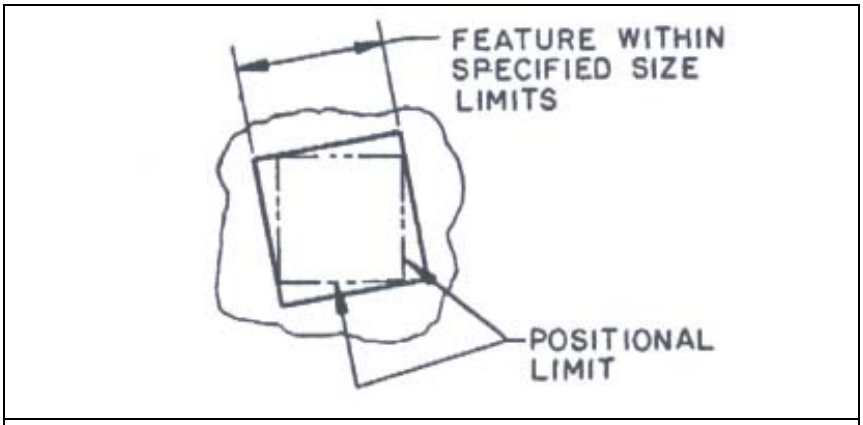

Figure 4 - Control

5.1.11.3. Interpretation

5.1.11.3.1. Positional limits may be used to control features of size as illustrated in Figure 5.

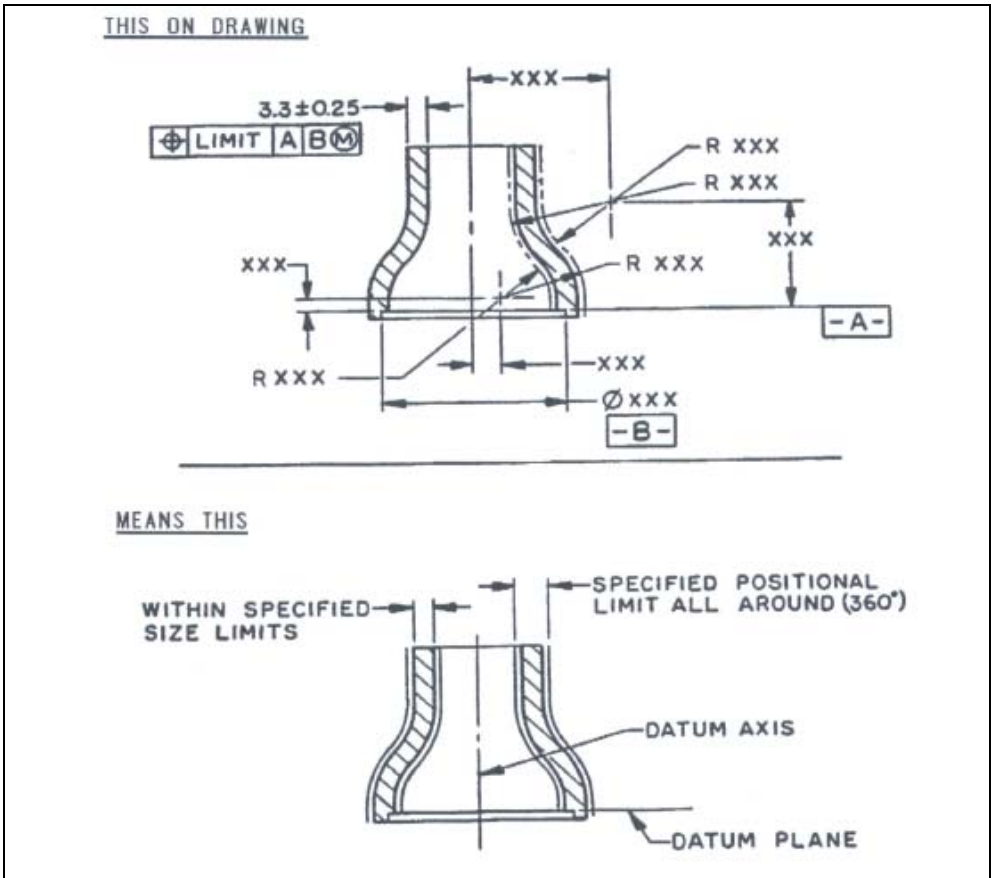

Figure 5 – Features of Size

5.1.12. Surface Texture Requirements

5.1.12.1. Surface texture requirements are expressed by symbols on the drawings. These symbols shall be interpreted and the texture measurements performed. The following interpretation shall apply.

5.1.12.2. The surface roughness number is an arithmetic average called roughness average (Ra). For conversion to a root-mean-square (RMS) value, RMS = 1.11 * Ra. Roughness limits, specified as a roughness height rating (RI-IR) or centerline average (CLA), have the same meaning as (Ra). Metric surface roughness is specified in micrometers. Customary surface finish is in microinches, micrometers will be noted in []. The method of measure must be by industry standard process or equipment.

5.1.12.3. The following table gives the metric (micrometer) equivalents for the customary inch (microinch) surface roughness number.

TABLE I - RELATED SURFACE TEXTURES

MICROMETER	MICROINCH
0.025	1
0.05	2
0.1	4
0.2	8
0.4	16
0.8	32
1.6	63
3.2	125
6.3	250
12.5	500
25	1000

5.1.12.4. Applicability

5.1.12.4.1. Surface texture requirements apply over metallic platings, electrochemical and chemical film coatings. Surface texture requirements apply before the application of organic finishes.

5.1.12.4.2. Flaws in surfaces having specified surface texture limits shall be excluded from surface texture measurements.

5.1.12.4.3. Surface texture measurements shall be taken in the area and direction that will result in the maximum reading.

5.1.12.4.4. Surface texture limits given in general note form do not apply to the cut edges of sheet metal, to the surfaces of screw threads, to the walls of punched or drilled holes, or to the mold or flash lines of molded plastic parts.

5.1.12.4.5. Unless otherwise specified, maximum surface roughness for all machined surfaces shall be 63 microinches [1.6 micrometers].

5.1.12.5. Stock Material Finish

5.1.12.5.1. When a “stock” dimension is called out, the surface finish must be the equivalent of normal finish for commercially available stock.

5.1.13. Dimensional Requirements and Allowances

5.1.13.1. Formed Parts

5.1.13.1.1. Final material thickness may be “as formed” for areas of parts affected by forming processes such as bending, drawing, or stretching.

5.1.13.2. Fillets

5.1.13.2.1. When two machined surfaces on a part intersect to form an angle exterior to the part of less than 180 degrees, there shall be a blending fillet of 0.4"

[.015 mm] maximum at the intersection of the two surfaces as illustrated in Figure 6. No cut shall be made beyond the intersection of the two surfaces unless relieved.

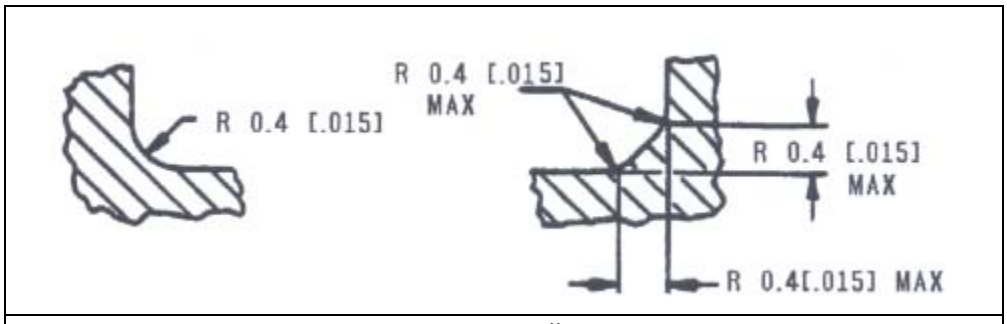

Figure 6 - Fillets

5.1.13.3. Turning Centers are permissible.

5.1.13.4. Relief

5.1.13.4.1. Diameters that terminate at a shoulder may be relieved as illustrated in Figure 7. The diameter, or both the diameter and the shoulder, may be relieved within the limits illustrated and may have any curved shape (no sharp corners) within those limits.

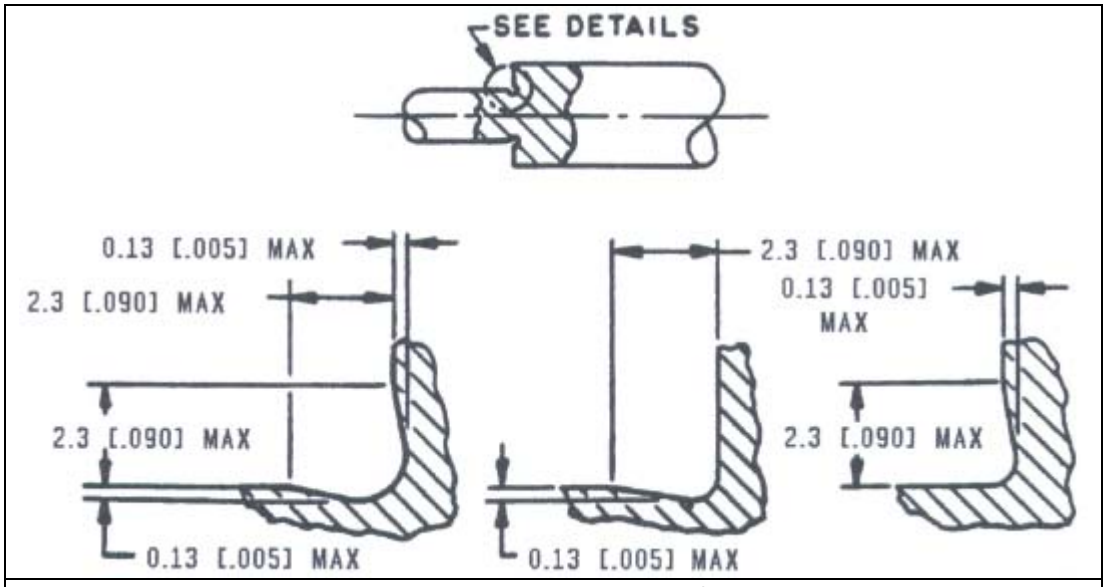

Figure 7 – Shoulder Relief

5.1.13.5. Plain Holes

5.1.13.5.1. Blind Holes

5.1.13.5.1.1. The drill point shall not penetrate or deform the material surface opposite the mouth of the hole.

5.1.13.5.2. Gaging Hole Diameters

5.1.13.5.2.1. The diameter of a hole is within required limits when accepted by “GO” and “NO GO” plug gages of appropriate size without reasonable evidence during plug gaging that the hole is out of round in excess of the diameter limits. Performance of a variable measurement (micrometer, etc.) normally will be required only for the specific holes that are suspect as a result of the “GO” and “NO GO” gaging. Bell-mouthed holes are acceptable if the “NO GO” gage does not enter more than 20% the nominal length of the hole as illustrated in Figure 8.

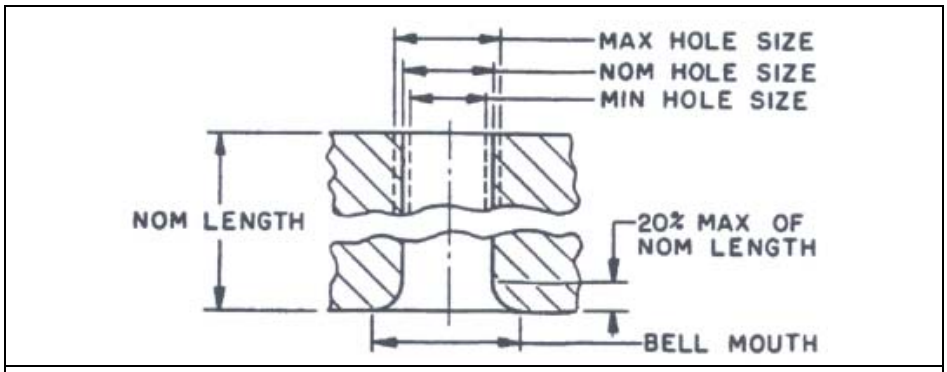

Figure 8

5.1.13.5.3. Hole Quality

5.1.13.5.3.1. The walls of holes shall be clean cut and shall present a good machined surface. Hole edges shall be free from burrs and shall not be ragged, chipped, or torn. These requirements are subject to visual inspection only and are to be evaluated in terms consistent with the characteristics of the material and with the method used to produce the hole.

5.1.13.6. Removing Burrs and Sharp Edges

5.1.13.6.1. All burrs and sharp edges shall be removed to the extent that material fragments are not visible and sharpness cannot be felt by using either a 0.015" [0.38 mm] maximum x 0.015" [0.38 mm] maximum chamfer or a 0.015" [0.38 mm] maximum radius. Only those edges that appear to exceed these limits upon visual inspection need be measured for conformance to these dimensions.

5.1.13.7. Coaxiality and Symmetry

5.1.13.7.1. Machined Diameters

5.1.13.7.1.1. Where no coaxiality requirement (positional, runout, or concentricity tolerance) is specified, the datum diameter and any other diameter having a common axis (including holes, countersinks and counterbores) shall be coaxial

within a Full Indicator Movement (FIM) of one-half the arithmetic sum of their size tolerances. THE DIAMETER HAVING THE SMALLEST TOLERANCE SHALL BE THE DATUM FEATURE FOR ALL COAXIAL DIAMETERS. See Figure 9. If size tolerance values are equal, the diameter having the longest axis shall be used as the datum feature.

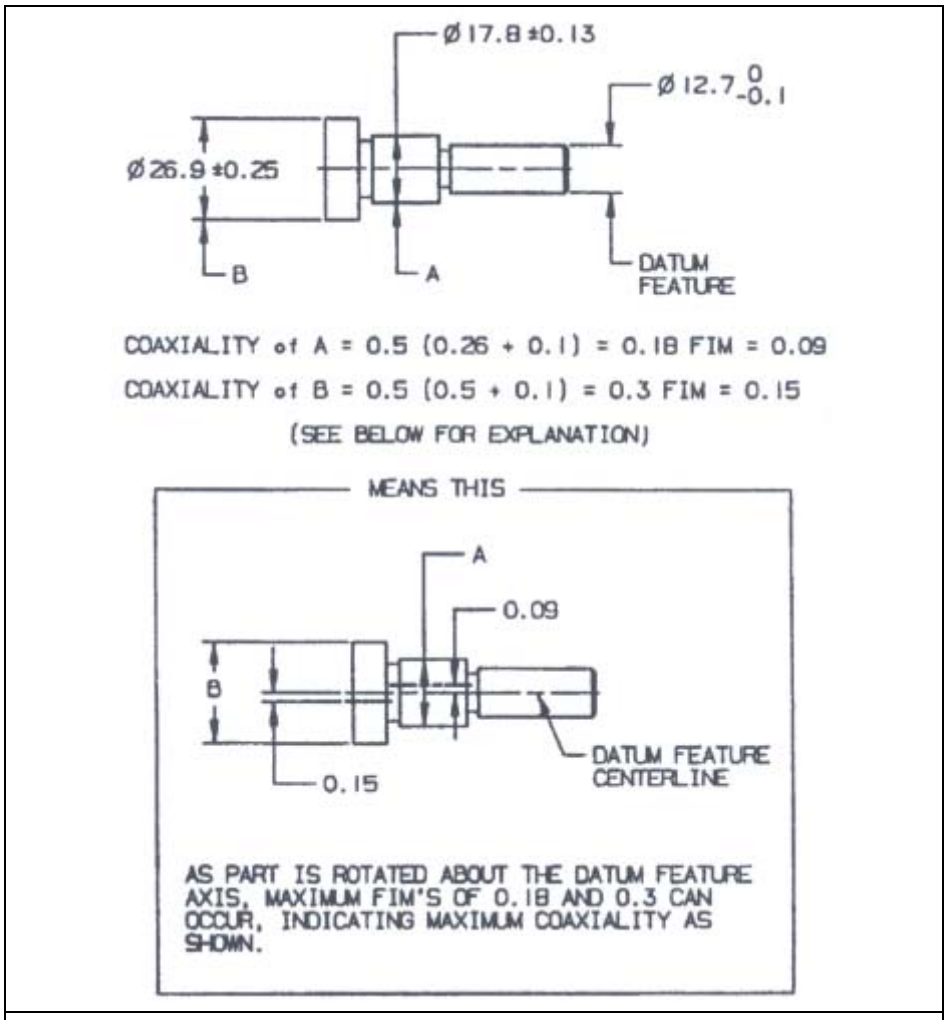

Figure 9 – Machined Diameters

5.1.13.7.2. Machined Widths

5.1.13.7.2.1. Where no symmetry requirement (positional tolerance) and no location tolerance (positional, profile, or non-geometric) are specified, the datum width and any other width having a common center plane shall be located symmetrically about this center plane within one-half the arithmetic sum of their size tolerances. THE WIDTH HAVING THE SMALLEST TOLERANCE SHALL BE THE DATUM FEATURE FOR ALL SYMMETRICAL WIDTHS. See Figure 10. If size tolerance

values are equal, the feature having the longest center plane shall be used as the datum feature.

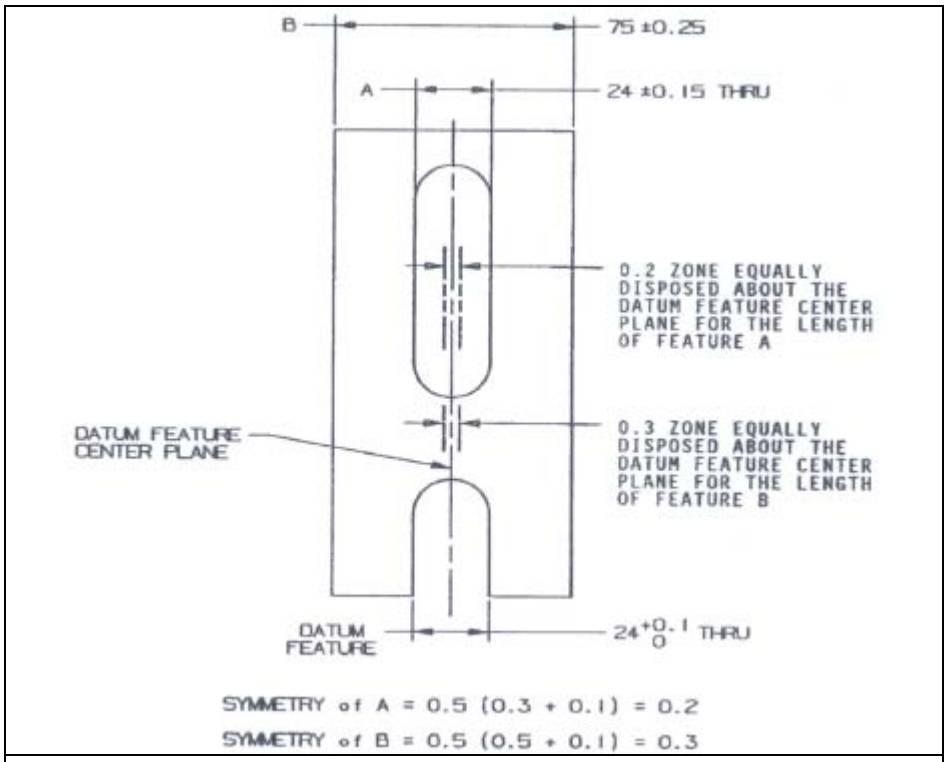

Figure 10 – Machined Widths

5.1.13.7.3. Combination of Machined Diameters and Widths

5.1.13.7.3.1. When a diameter and a width share a common axis and where no coaxiality or symmetry requirements are specified, both features shall be located symmetrically about this axis within one-half the arithmetic sum of their size tolerances. THE FEATURE (DIAMETER OR WIDTH) HAVING THE SMALLEST TOLERANCE SHALL BE THE DATUM FEATURE. See Figure 11. If size tolerance values are equal, the feature having the longest axis shall be used as the datum feature. See Figure 12.

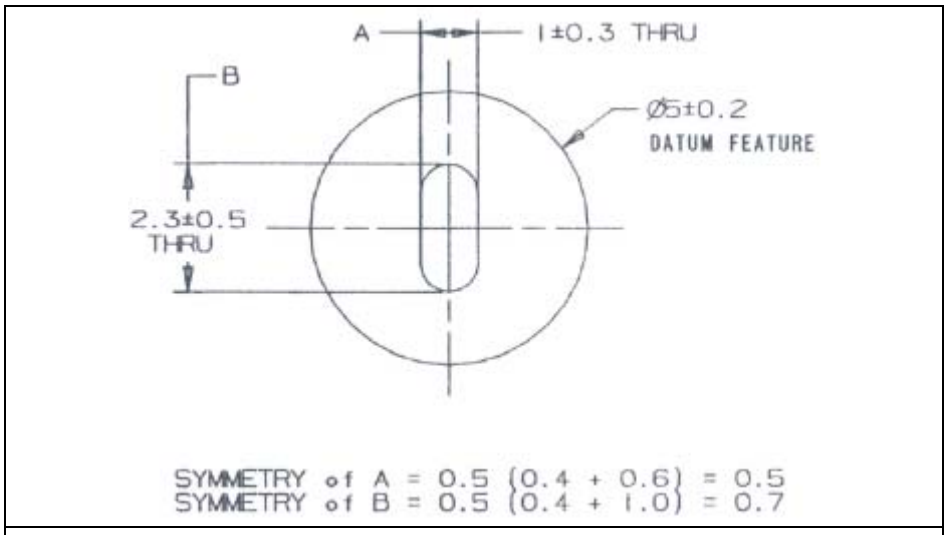

Figure 11 - Machined Diameters and Widths

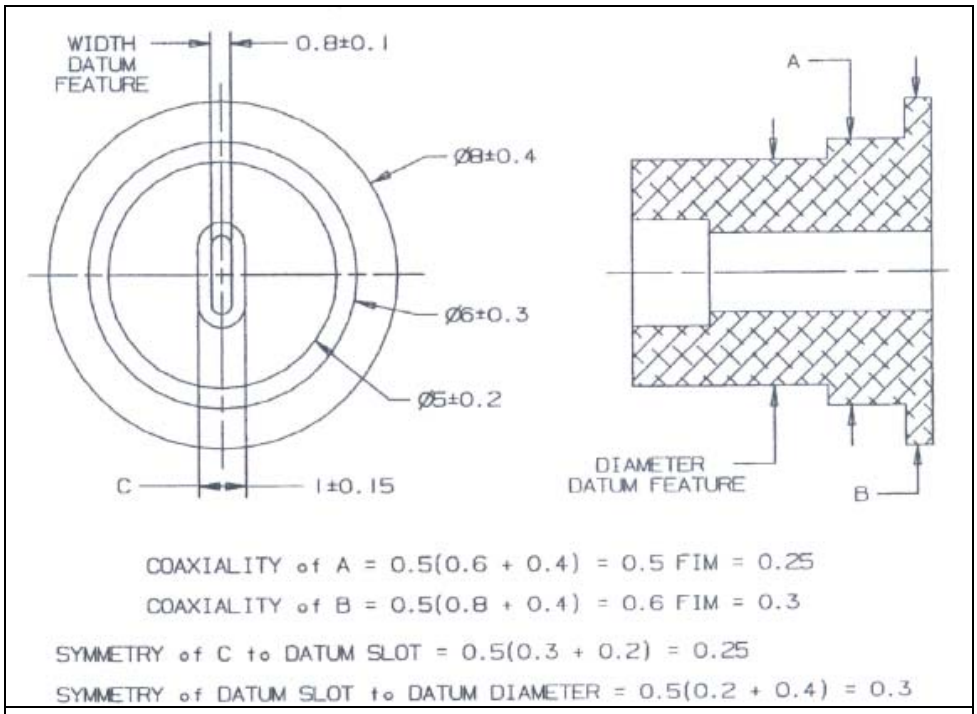

Figure 12 - Machined Diameters and Widths

5.1.13.8. Correction of Manufacturing Defects

5.1.13.8.1. Requirements applicable to correction of defects found in product during original manufacture are as follows.

5.1.13.8.2. Permissible Corrections

5.1.13.8.2.1. Correction is permissible if the method used is one of completing, or repeating, regular work rather than changing

the nature of the product. Examples are replacement of gaskets and seals, re-tapping of undersize threads, re-turning of oversize diameters, etc.

5.1.13.8.3. Non-Permissible Corrections

5.1.13.8.3.1. Corrective methods that add material to the product, or that employ techniques abnormal to the production process, are not permissible. Examples are welding of cracks and other flaws, building up undersize metal parts by welding or electroplating, filling voids in encapsulations or metal castings, plugging of off-location or oversized holes, etc.

5.1.13.9. Flat Surfaces

5.1.13.9.1. Where no parallelism tolerance is specified, flat surfaces of a part shown as parallel on a drawing shall be parallel within their limits of size.

5.1.13.9.2. Flat surfaces of a part shown as perpendicular on a drawing shall be perpendicular within +/- 0.5˚.

5.1.13.9.3. The perpendicularity requirement for a flat surface and an axis, or an axis and another axis, shown perpendicular on a drawing, is that they shall be perpendicular within +/- 0.5˚.

5.1.14. Threaded Part Requirements

5.1.14.1. General

5.1.14.1.1. See **QP158** for thread inspection.

5.1.14.1.2. Form and Class of Fit

5.1.14.1.2.1. All threads shall conform to the drawing requirements whichever applies to the thread size, form, and class of fit specified. Thread callouts on drawing are specified in inches unless otherwise noted.

5.1.14.1.3. Appearance

5.1.14.1.3.1. All threads shall be free from burrs, nicks, and rough or chattered surfaces that are visible without magnification.

5.1.14.1.4. Lubrication

5.1.14.1.4.1. Oil-free gages shall be used on beryllium parts (typically copper alloys). Gages used on items having extremely stringent cleanliness requirements shall also be oil-free if the item cannot be cleaned after thread gaging is performed. For other applications, the threads of “GO” and “NO GO” plug and ring gages should be lubricated with a very thin film of low viscosity non-silicone oil. Gages that have been cleaned with degreasing solvents such as alcohol or trichloroethylene shall be lubricated before reuse.

5.1.14.2. External Threads

5.1.14.2.1. Thread Length

5.1.14.2.1.1. Dimensions of axial thread length shown on drawings indicate minimum required length of complete threads. When the dimensioned thread length terminates at a shoulder and an undercut is not specified, the two threads next to the shoulder may be incomplete. As an alternate, an undercut to the minor diameter, within its tolerance, for a maximum of two threads is permissible.

5.1.14.2.2. Chamfer

5.1.14.2.2.1. The leading end of externally threaded parts shall be chamfered. The resulting incomplete threads are included in the measurement of thread length but must not exceed two pitches in length.

5.1.14.2.3. Coated Class 2A Threads

5.1.14.2.3.1. Class 2A threads to which metallic plating, chemical-film coatings, resin bonded dry film lubricants, or any combination thereof have been applied may be gaged with basic “GO” gages in determining conformance to maximum size limits.

5.1.14.3. Internal Threads

5.1.14.3.1. Tap Drills

5.1.14.3.1.1. The hole diameter prior to tapping shall be of a size that will assure a tapped thread height that falls within the guidelines of **ANSI/ASME B 1.1**. The formulas contained therein are suitable for general applications having lengths of engagement up to 1.5 diameters. The thread height requirement may be reduced to 55% for tapped holes having a thread depth exceeding 1.5 times the nominal thread diameter. Acceptance criteria for final threaded hole dimensions shall be per drawing requirements.

5.1.14.3.2. Blind Hole Depth

5.1.14.3.2.1. The tap drill point shall not break through or deform the surface opposite the mouth of the hole.

5.1.14.3.3. Thread Depth

5.1.14.3.3.1. Dimensions of axial thread depth shown on drawings indicate minimum required depth of complete threads.

5.1.14.3.4. Perpendicularity

5.1.14.3.4.1. Where no projected tolerance zones are specified, the perpendicularity or normality of threaded holes in flat or curved surfaces shall be within +/- 1°. In meeting this requirement, measurement may be made using the pitch

diameter, the major diameter, or the minor diameter of the thread.

5.1.14.3.5. Chamfer

5.1.14.3.5.1. The leading ends of internal threads shall be chamfered as shown in Figure 13. If accessible, both ends of through-tapped holes shall be chamfered. Chamfering shall not result in elimination of more than one pitch of thread depth. For the purpose of determining the number of complete threads from the surface adjacent to the hole, the chamfered thread may be counted.

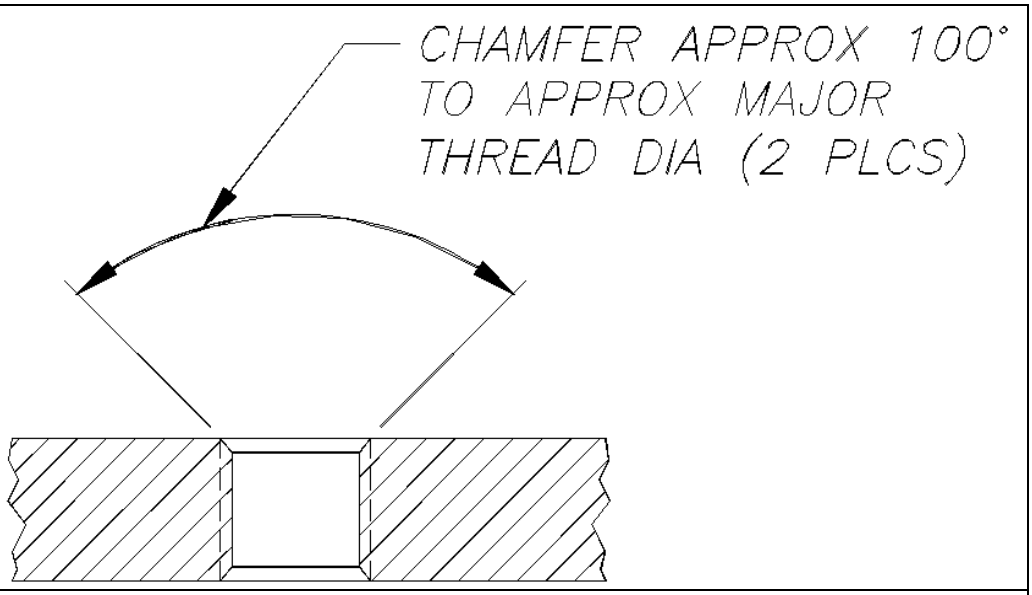

Figure 13 – Internal Thread Chamfer

5.1.14.3.6. Hole Tapping Option

5.1.14.3.6.1. Cold forming thread taps such as Besly “X-Press” taps may be used in lieu of metal cutting taps. A slight groove may appear along the thread crest as a result of the metal flowing action of these taps. See Figure 14. The groove is acceptable if the overall thread crest height conforms to limits.

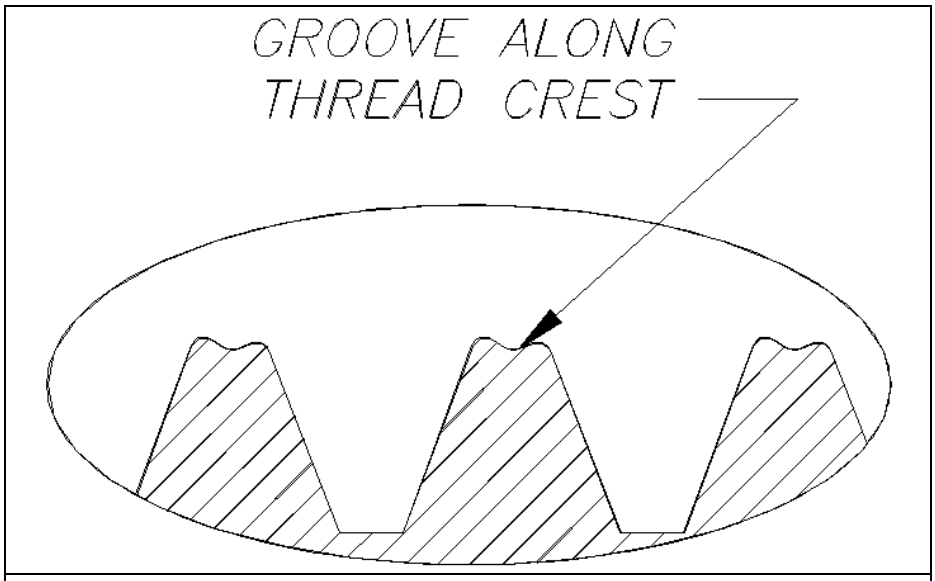

Figure 14 – Cold Forming Thread Taps

5.1.15. Metal Heat Treatment Requirements

5.1.15.1. When necessary to facilitate fabrication, parts made from heat treatable alloys for which material is specified in terms of the final temper or condition required may be fabricated from raw stock of a temper or condition different from the final temper and then heat-treated to the specified temper or condition.

5.1.15.2. After the completion of in-process heat treatment, sample parts from each heat treat lot shall be tested to determine that the material properties influenced by heat treatment conform to the applicable material specification requirements. If tests of actual parts are impractical, suitable samples of the same alloy and starting condition as the parts shall be heat treated with the lot and tested for conformance to the applicable requirements.

5.1.15.3. Parts specified to be made from a work-hardened temper of a non heat treatable alloy must be fabricated from material of the required temper or condition.

5.1.15.4. Thermal treatments, such as hot forming, stress-relieving, drying, bonding, and baking, other than those specifically permitted by the product drawings, shall not be used.

5.1.16. Machined parts shall be preserved per **QP230**.

6. RECORDS

6.1. Inspection records are retained per **QP130**.

7. REFERENCE DOCUMENTS

7.1. QP130 Control of Records
7.2. QP158 Thread Inspection
7.3. QP200 Inspection and Testing
7.4. QP220 Control of Monitoring and Measuring Equipment
7.5. QP230 Preservation of Outputs
7.6. ANSI/ASME B 1.1 Unified Inch Screw Threads (UN and UNR Thread Form)