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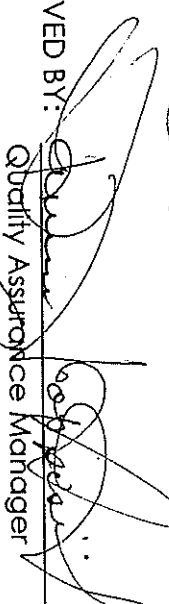
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GENERAL WORKMANSHIP STANDARD
 MACHINED PARTS; TOLERANCES, SURFACE FINISH
 AND STANDARD CONFIGURATIONS

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GENERAL WORKMANSHIP STANDARD

1.0 SCOPE

1.1 **Scope.** This specification covers the requirements for tolerances, surface finishes and standard configurations for machined parts and final assemblies.

1.2 **Justification.** There is no government or industry specification equivalent to this specification.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents, of the latest issue in effect except as otherwise indicated, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirement.

2.1.1 **Government Documents.**

Military Specifications

- MIL-S-7742 Screw Threads, Standard, Optimum Selected Series, General Specification for
- MIL-S-70335 Screw Threads, Internal Cold Formed, General Specification for

Federal Standards

- FED-STD-H28 Screw Thread Standards for Federal Services

2.1.2 **Non-Government Documents.**

American National Standard Institute (ANSI) Specifications

- ASME Y14.5M Dimensioning and Tolerancing (Latest Revision)

3.0 REQUIREMENTS

In the event of any conflict between the requirements of this specification and drawings calling out this specification, the requirements of the drawing shall take precedence. Exceptions are as stipulated in the requirements section.

3.1 **In-process Parts Protection.** Machined parts shall be protected, handled, and stored in accordance with Vacco standards.

3.2 **Machined Surface Finishes.** The specific method used to machine a surface shall be optional. Drawing notes that specify "Lap 16" or "Grind 20" shall not restrict manufacturing to that particular process, provided the alternate process used results in a surface roughness not greater than that specified on the drawing (see paragraph 5.1.1 for the definition of roughness).

3.3 **Surface Cleaning.**

3.3.1 **Surface Cleaning of Machined Metal Parts.** Machined parts surfaces shall be cleaned per standard commercial practices unless otherwise specified.

3.4 **Machining fluids for plastics.** Plastics shall be machined dry (no lubricant) and be cooled with air or an air/water mist. If deemed necessary, organic lubricants or coolants may be used, only with the approval of Vacco Industries Engineering.

3.5 **Detailed Requirements.**

3.5.1 **Engineering.**

3.5.1.1 **Tolerances.**

3.5.1.1.1 **Form Tolerance.** Form tolerance shall apply to all dimensions, whereas the part can be of any shape or size providing it is within the tolerance envelope. Specific requirements, such as flatness, roundness, parallelism and angularity, shall be indicated by the Geometric Characteristic Symbols as shown in the applicable ASME Y14.5 standard and on the engineering drawing. See also paragraphs 5.1.4, 5.1.5, 5.1.6 and 5.1.7 for definitions of flatness, roundness, parallelism, and angularity, respectively.

3.5.1.1.2 **Positional Tolerance**. Positional tolerance shall apply as specified in this specification unless a closer tolerance is required by the drawing and is so indicated by one of the Geometric Characteristic Symbols, as shown in the applicable ASME Y14.5 standard and on the engineering drawing.

3.5.1.1.3 **Block Angular Tolerance**. The block angular tolerance of $\pm 2^\circ$ shall apply to all implied (nondimensioned) angles as well as all specified angles having no tolerance called out on the drawing (see paragraph 5.1.8 for definition of block tolerance).

3.5.1.2 **Centerline deviation**. Holes, slots, and tangs presented on the true centerline of a part, but not dimensioned, shall be permitted to deviate from the centerline as shown in Table I. The allowable deviation shall be a function of the tolerance of the overall width of the part containing the feature (see paragraph 5.1.9 for definition of centerline).

3.5.1.3 **Concentricity**. Cylindrical surfaces having a common axis shall be concentric as specified in paragraphs 3.5.1.3.1 through 3.5.1.3.4 (see paragraph 5.1.10 for definition of concentricity).

3.5.1.3.1 **Two Cylindrical Surfaces**. When two cylindrical surfaces having a common axis are machined, they shall be concentric within a total indicator reading (TIR) or 0.010 inch (see paragraphs 5.1.11 and 5.1.12 for definitions of cylindricity and TIR).

3.5.1.3.2 **Three or More Cylindrical Surfaces**. When more than two cylindrical surfaces having a common axis are machined, the concentricities shall be measured using the diameter with the closest diametrical tolerance as a reference. The requirement specified in paragraph 3.5.1.3.1 shall then be followed.

3.5.1.3.3 **Stock Diameter and Machined Surfaces**. When one surface is specified as "stock diameter" and one or more surfaces are machined, each machined surface shall be concentric to the stock diameter, as specified in Table II.

3.5.1.3.4 **Hole Runout.** The runout of deep drilled holes (depth of drilled holes six or more times the drill diameter) shall be within 0.030 inch TIR concentricity of the adjacent diameter on center drilled parts. The runout of other holes shall be within the limits of Table III (see paragraphs 5.1.13, 5.1.13.1 and 5.1.13.2 for definitions of runout, circular runout, and total runout).

3.5.1.4 **Equal Spacing.** An implied dimension and tolerance shall be considered to exist between any two holes or other features of a group governed by an applicable note or symbol for equal spacing. The tolerance on the overall dimension shall apply to holes or individual features, adjacent as well as non-adjacent (non-accumulative) (see Figure 2). For exceptions to the angular tolerance, see paragraph 3.5.1.1.3.

3.5.1.5 **Surface Finish-Transition Areas.** Surface finish in areas of transition, such as chamfers and fillets, shall conform to the roughest of the adjacent areas unless otherwise indicated (see Figure 3). See paragraph 5.1.14 for definition of surface.

3.5.1.6 **Flatness and Straightness.**

3.5.1.6.1 **Flatness.** If the flatness is specified and surface roughness or waviness height is not specified, the values of surface roughness and waviness height which correspond to the flatness requirement as described in paragraph 3.5.1.13 and shown in Table IV shall apply, subject to the limitations of 3.5.1.12.

3.5.1.6.2 **Straightness.** All linear features shall be straight within the total envelope tolerance, e.g., if a feature is shown to have a ± 0.010 tolerance on size, that feature shall be straight within 0.020 inch (see paragraph 5.1.15 for definition of straightness).

3.5.1.7 **Centerline of Holes or Other Features Governed by a Single Centerline.** The centerline of holes or other features governed by a single centerline shall lie within the tolerance specified for the location of the centerline of the part (see Table I).

3.5.1.8 **In-Line Holes (pertaining to holes on the same axis).** All holes thus specified shall meet the required diametrical tolerance individually. In addition, all holes so

specified shall simultaneously accept a single cylindrical gauge of a diameter, or diameters, equal to the minimum specified for each hole.

3.5.1.9 **Perpendicularity**. When a plane surface is shown perpendicular to an axis or other plane surface or surfaces, and a tolerance is not specified on the drawing, the implied tolerance shall be the block angular tolerance (see paragraph 3.5.1.1.3) when normality is specified in terms of TIR (see paragraph 5.1.1.6 for definition of perpendicularity).

3.5.1.10 **Parallelism**. When parallelism is not specified, the distance between the entire two surfaces in question shall be within the dimensional tolerance specified on the drawing. (Dimensions apply for the full surface which they indicate.)

3.5.1.11 **Roundness/Cylindricity**. To isolate roundness as an individual function and because roundness may be confused with cylindricity or concentricity by use of some gauging methods, roundness shall be checked at numerous points around the diameter perpendicular to the common axis. Cylindricity shall be checked in the same manner along the entire length; however, cylindricity checks roundness, straightness and parallelism.

3.5.1.12 **Surface Finish and Tolerance**.

3.5.1.12.1 The surface finish of any machined surface shall be governed by the closest tolerance given for any dimension of that surface.

3.5.1.12.2 Table V shall be used to determine the maximum surface roughness permitted for a specified tolerance. See Figure 4 for lay symbols. Surfaces shall contain no discontinuities (e.g., scratches, nicks or gouges) with a depth greater than 10 times the RHR callout expressed in millionths of an inch, when the width is less than 40 times the RHR callout, expressed in millionths. Discontinuities shall not exceed 1 per square inch of surface; e.g., a surface area of five square inches is allowed to have a maximum of five discontinuities.

EXAMPLE:

For a surface finish of 63 RHR, $D = 0.000063$
 $X_{10} = 0.0006$ inch; $W = 0.000063$ $X_{40} =$
 0.0025 inch.

3.5.1.12.3 **Nicks and Dings on Body Blocks**. It is not necessary to reject blank body blocks (identified as "Block-XX", where XX is any number) for any minor nicks and dings that occur along the corners for the following reasons:

3.5.1.12.3.1 Prior to machining, the machinist breaks the corners with a file or equivalent.

3.5.1.12.3.2 Normal handling of these blocks may cause additional nicks and dings. It is not necessary to handle these blocks in a manner that would completely eliminate the nicks and dings.

3.5.1.12.3.3 Neither VACCO nor the customer use the corners for indicating or assembly. Any nicks and dings are cosmetic only.

3.5.1.12.3.4 Any nicks and dings which have occurred during manufacturing will be blended out during final debur.

3.5.1.12.4 Any gouges on the corner of the block deeper than .060 or upset metal over .030 above the surface should be forwarded to Engineering for disposition.

3.5.1.13 **Waviness Height, Cut-Off and Flatness**. Machined surfaces designated as flat shall have a waviness height not greater than and a surface finish within the limits listed in Table IV, depending upon the required flatness. Waviness height shall not be cumulative and applies only to a one-half inch increment on any portion of a surface. The full waviness height tolerance shall apply for the extent of any surface which is less than 0.500 inch long. A 0.030 inch cut-off shall be used (see Figure 3).

3.5.1.14 **Free State Variation**. Free state variation, unless otherwise specified, shall be within an elastic range that will allow the part to be brought within drawing tolerances by forces equivalent to those that can be exerted by employing the expected method of assembly (see paragraph 5.1.17 for definition of free state variation).

3.5.2 Operations.

3.5.2.1 Chamfer. The tolerances specified in Table VI shall apply to chamfer angles (see paragraph 5.1.18 for definition of chamfer).

3.5.2.2 Counterbore and Spottace. For counterboring and spottacing operation the block angular tolerance (paragraph 3.5.1.1.3) shall apply and the surface roughness shall be 125 maximum.

3.5.2.3 Countersink. For countersinking operation the surface roughness shall be 125 maximum. Pilot drilled holes may be oversized if the material thickness is less than the full contour of the countersink.

3.5.2.4 Deburring. All parts shall be deburred (see paragraph 5.1.19 for definition of burr and 5.1.19.1, 5.1.19.2 and 5.1.19.3 for type of burrs). Appendix 1 contains more explanation and the removal of burrs.

3.5.2.4.1 Breaking of Edges. The size of a break resulting from deburring an edge shall be determined from the surface finish specified for the two adjacent surfaces. The coarser of these two surfaces shall determine the size of the break. A broken edge shall signify that either a radius or a chamfer is acceptable as the result of the deburring process. All edges shall be broken as follows.

- a) For edges specified as sharp, the edges shall be broken 0.000 to 0.005 inch.
- b) For finishes 32 or finer, break edge 0.003 to 0.010 inch.
- c) For finishes 33 or coarser, break edge 0.005 to 0.015 inch.

3.5.2.4.2 Burrs. Acceptance of burrs shall depend upon the surface finish required for the surfaces, the type, size (protrusion) and position. The size of the burr shall be determined by visual inspection and magnification level per Table VII and paragraph 4.3.2. All levels of inspection shall be conducted using an illumination level of 100 ± 10 foot candles and 20/20 to 20/30 vision. The maximum acceptable protrusion shall be that size

of burr which does not protrude discernibly above a surface under the conditions specified in Table VII.

3.5.3 **Drilling.** The specified hole shall be made by any process that maintains the block tolerance and provides a surface roughness of 125 maximum. The diametrical tolerance of holes of greater than four but less than 10 drill diameters deep shall be within twice the normal tolerance for that diameter.

3.5.3.1 **Drill Breakthrough.** A part shall be acceptable if drilling causes a protuberance or breakthrough providing all features, i.e., size depth, drill point angle, and related dimensions, are within specified tolerances.

3.5.4 **Knurling.** The circular pitch of the knurl for use with the corresponding diameters shall be as shown in Table VIII. The tooth angle of the knurl of hard materials shall be 60 ± 5 degrees and for soft materials (150 BHN or less) it shall be 90 ± 5 degrees.

3.5.5 **Machined Surface Deviations.**

3.5.5.1 **Single Flat or Curved Surfaces.** Where two or more machined cuts (Figure 6a) are required to produce a single surface, the maximum misalignment of adjacent cuts shall not exceed 0.003 inch on parts less than 12 X 12 inches (144 square inches) in area and 0.006 inch on parts greater than 12 X 12 inches in area, unless otherwise specified. The minimum cutter radius shall be 0.063 inch.

3.5.5.2 **Intersecting Surfaces (one surface not machined).** When two or more surfaces intersect and one of the surfaces is not machined (Figure 6b), or where an unmachined and a machined surface are in the same plane (Figure 6c), the misalignment of the surfaces shall not exceed 0.030 inch with a 0.063 inch minimum fillet radius produced by the cutter.

3.5.5.3 **Intersecting Surfaces (both surfaces machined).** Where two or more machined surfaces intersect, the misalignment between any of the surfaces shall not ex-