MOOG

WORKMANSHIP STANDARDS

FOR MACHINED METALLIC PARTS

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<table>
<thead>
<tr>
<th>Moog Model Number</th>
<th>N/A</th>
<th>© Moog Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moog Part Number</td>
<td>N/A</td>
<td>AUTHOR: Will Brady</td>
</tr>
<tr>
<td>Customer Part Number</td>
<td>Various</td>
<td>REV</td>
</tr>
<tr>
<td>Data Item Number</td>
<td>Various</td>
<td>-</td>
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1.0 INTRODUCTION
Supported by our suppliers, Moog has developed a reputation for quality, performance and delivery that has helped us to become a leading supplier of aircraft flight control systems and components. Achieving a satisfactory and repeatable standard of workmanship for machined metallic parts is vital to Moog’s continuing ability to meet and exceed our customers’ expectations, leading to continued growth and mutual success in the marketplace.

2.0 PURPOSE

2.1 SCOPE & INTENT
Moog continually strives to deliver the highest quality products that meet performance, cost and on-time delivery goals. However, many visible irregularities, although not aesthetically perfect, conform to the drawing requirements and do not adversely affect the design intent. This document will assist in the judgment of whether a machined metallic part for Moog Aircraft Group orders is deemed Non-Conforming. The standards, guidelines and instructions within this document are intended to apply to machined metallic parts and assemblies, and associated special processes.

This document supplements engineering drawings and purchase order requirements for make-to-print machined metallic parts. In all cases, reference must be made to the order of precedence presented below:

Drawing >> PO (including S-Clauses) >> Workmanship Standard >> SQR-1

Given the order of precedence, nothing in this standard can override a requirement or specification called out on the drawing or PO.

The primary intent of this document is to align suppliers and Moog as to criteria and methods for judging whether parts are non-conforming. It is therefore expected that both suppliers’ and Moog Quality & Product Engineers will use this document as the basis for process optimization, control plans, inspection plans, and accept/reject criteria when dispositioning parts with visual irregularities.

2.2 GENERAL GUIDELINE NOTES

2.2.1 Procedures, Training and Inspection Records: Suppliers must develop inspection/operating procedures, and provide regular training to inspectors/operators, based on this workmanship standard. Inspections must take place in an area with a minimum light level of 750 LUX (70 foot-candles). Suppliers are expected to retain training records, and record the results of all inspections.

2.2.2 Dimensions: Applicable dimensions within this workmanship standard are presented in U.S. inches. Metric equivalents are presented in parentheses for general guidance to those organizations using these units of measure; e.g., .25” (6.3mm), .0003” (0.008mm), etc.

2.2.3 Foreign Object Debris/Damage: Moog requires that all parts are free from FOD and contamination at 10x magnification. Suppliers shall adopt FOD control and inspection methods to assure this requirement, and the requirements of AS9146. FOD which is
isolated and potentially introduced from packing/unpacking, and/or is airborne and can be removed with slight airflow, shall not be cause for rejection.

2.2.4 Part Handling, Packing, & Preservation:
Packaging shall be adequate to protect the components during transportation, handling, and storage at all stages including provisions for the protection of corrosion sensitive materials. Packaging containers shall be appropriate for the size, weight, and fragility of the components being packed. To prevent many of the types of defects and irregularities described in this document, part-to-part contact shall be avoided at all stages, including manufacturing, inspection, handling, storage and shipping.

2.2.5 MRB Authority & Rework:
This document is not a delegation by Moog to suppliers of make-to-print machined parts for MRB (Material Review Board) authority. MRB is the formal disposition of non-conformities to drawing (or other design technical data) requirements and can only be performed by Moog or its customers. This document is intended solely as a guide to determine when a feature should be considered non-conforming. Where doubt exists over the interpretation of an irregularity, including whether rework-to-print is allowable, it should be considered non-conforming and additional advice sought from Moog engineering via an SR-type NC (SRID). Whenever an irregularity is caused by an event that may cause an over-stress condition, such as dents caused by dropping a part, it shall be considered non-conforming and advice sought from Moog engineering via an SR-type NC (SRID).

2.2.6 Examples:
Throughout this document, examples of typical irregularities found with Moog parts are included to provide clarity on disposition criteria and methods. Wherever specific part numbers are used, the intent is not to indicate the subject irregularities are unique to those specific parts, but rather to always refer the reader to the drawing and all associated specifications in order to disposition whether the part is Non-Conforming.
2.3 MAGNIFICATION REQUIREMENTS

The table below summarizes the magnification needed to inspect and verify each type of irregularity. Where a higher magnification level is deemed necessary, based on criticality of parts or tolerances specified on the drawing for example, this is specified in the appropriate Appendix of this document.

<table>
<thead>
<tr>
<th>Irregularity Type</th>
<th>Magnification Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Surface Corrosion and Pitting</td>
<td>Visual check (1X); if Non-Conforming, inspect at up to 10X to validate</td>
</tr>
<tr>
<td>B. Cosmetic Irregularities</td>
<td>Visual check only (1X)</td>
</tr>
<tr>
<td>C. Burrs</td>
<td>No burrs visible at 10X (maximum)</td>
</tr>
<tr>
<td>D. External Contouring</td>
<td>Visual check only (1X)</td>
</tr>
<tr>
<td>E. Special Processes</td>
<td>Visual check only (1X); up to 10X in certain limited cases</td>
</tr>
</tbody>
</table>
### 3.0 Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part-to-Print</td>
<td>A Part-to-Print irregularity indicates that the part meets the requirements of the drawing. When this applies to images within this document, images will be bordered in green.</td>
</tr>
<tr>
<td>Non-Conforming</td>
<td>A Non-Conforming irregularity indicates that the part does not meet the requirements of the drawing. Non-Conforming parts will be entered into Moog’s TIP QA quality system and dispositioned by the relevant MRB authority, i.e. Use, Return to Vendor etc. This includes SR-type NCs (SRIDs) submitted by suppliers.</td>
</tr>
<tr>
<td>Irregularity</td>
<td>Any area that is visibly different from the surrounding surface of the same material, verified at 1X.</td>
</tr>
<tr>
<td>Smooth</td>
<td>Meeting the drawing surface finish requirement and any drawing mismatch allowance or, when there is no mismatch allowance, exhibiting no surface discontinuity detectable with a plastic pick.</td>
</tr>
<tr>
<td>Rework</td>
<td>Localized area on a surface where an irregularity has been removed or touched up. Reworked areas can show evidence of mechanical blending. A Part-to-Print rework must conform to all GD&amp;T callouts on the drawing. Surface Finish, Flatness, Perpendicularity, Parallelism etc.</td>
</tr>
<tr>
<td>Shall</td>
<td>Shall denotes an intended mandatory requirement. Each shall hereafter requires a verification process. Where not already indication in the matrix, the supplier is required to state how the requirement of each shall is to be verified.</td>
</tr>
<tr>
<td>Will</td>
<td>Will denotes an intended mandatory requirement. It is synonymous with shall, but does not require verification.</td>
</tr>
<tr>
<td>Should &amp; May</td>
<td>Should &amp; May both denote non-mandatory provisions and are used to show guidelines.</td>
</tr>
</tbody>
</table>
## 4.0 ABREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TipQA</td>
<td>Tip Technologies Quality Assurance</td>
<td>A computer program used for quality assurance within Moog; primarily used for non-conformance documentation and corrective action management.</td>
</tr>
<tr>
<td>SR type NC</td>
<td>Supplier Request type Non conformance</td>
<td>Supplier deviation request or clarification request via the Moog portal.</td>
</tr>
<tr>
<td>MRB</td>
<td>Management/Materials Review Board</td>
<td>A group and process in which deviating parts are dispositioned.</td>
</tr>
<tr>
<td>GD&amp;T</td>
<td>Geometric Dimensioning &amp; Tolerancing</td>
<td>A system for defining and communicating engineering tolerances. It uses a symbolic language on engineering drawings and computer-generated three-dimensional solid models that explicitly describes nominal geometry and its allowable variation.</td>
</tr>
<tr>
<td>FOD</td>
<td>Foreign Object Debris/Damage</td>
<td>Any substance, debris, or article alien to a part or system which could potentially cause damage or improper function. The acronym FOD is used to describe both the foreign objects themselves, and any foreign object damage attributed to them.</td>
</tr>
<tr>
<td>PO</td>
<td>Purchase Order</td>
<td>A defined contract for purchase of goods between Moog and a supplier.</td>
</tr>
<tr>
<td>Ra</td>
<td>Roughness Average</td>
<td>The roughness average or mean roughness is the arithmetic average of the absolute values of the roughness profile ordinates. Ra is one of the most effective surface roughness measures commonly adopted in general engineering practice. It gives a good general description of the height variations in the surface.</td>
</tr>
<tr>
<td>Rt</td>
<td>Total Profile Height</td>
<td>The distance from the highest peak to the deepest valley within the evaluation length.</td>
</tr>
<tr>
<td>DWG</td>
<td>Drawing</td>
<td>A representation of Moog’s part manufacturing requirements - Interchangeable terms include print, blueprint or part technical drawing.</td>
</tr>
<tr>
<td>IPA</td>
<td>Isopropyl Alcohol</td>
<td>A colorless, flammable hydrocarbon liquid which can be used for cleaning parts.</td>
</tr>
<tr>
<td>IVD</td>
<td>Ion Vapor Deposit</td>
<td>Ion Vapor Deposition, known as IVD or Ivadizing, is a physical Vacuum deposition process which is used to apply a pure aluminum coating to various substrates, to improve the resistance to atmospheric and bi-metallic corrosion.</td>
</tr>
<tr>
<td>OD</td>
<td>Outer Diameter</td>
<td>The length of a line that bisects a circle which begins and ends on the outer surface of a feature or part.</td>
</tr>
<tr>
<td>ID</td>
<td>Inner Diameter</td>
<td>The length of a line that bisects a circle which begins and ends on the inner surface of a feature or part.</td>
</tr>
<tr>
<td>NC</td>
<td>Non-Conformance</td>
<td>A part or assembly which deviates from the specification of its part technical drawing or any standards applicable to it. This includes dimensioning and aesthetic appearances.</td>
</tr>
<tr>
<td>TLO</td>
<td>Tool Length Offset</td>
<td>An offset used to account for variations in tool length.</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
<td>Using computer software, 3D models of parts can be made. This can help with product design and visualization.</td>
</tr>
<tr>
<td>CAM</td>
<td>Computer Aided Manufacture</td>
<td>Using software to manufacture parts from data, using it to program instructions into manufacturing tools such as CNC.</td>
</tr>
</tbody>
</table>
5.0 REFERENCE DOCUMENTS:

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQR-1/1A</td>
<td>Moog Supplier Quality Requirements.</td>
</tr>
<tr>
<td>AS 9146</td>
<td>Foreign Object Damage/Foreign Object Debris (FOD) Prevention.</td>
</tr>
<tr>
<td>ASME Y14.5-2009</td>
<td>Dimensioning &amp; Tolerancing.</td>
</tr>
<tr>
<td>MIL-DTL-83488</td>
<td>Aluminum Coatings.</td>
</tr>
<tr>
<td>MIL-DTL-5541</td>
<td>Chemical conversions and coatings.</td>
</tr>
<tr>
<td>MIL-A-8625</td>
<td>Anodizing.</td>
</tr>
<tr>
<td>SAE-ASS272</td>
<td>Lubricant, solid film, heat cure and corrosion inhibition.</td>
</tr>
<tr>
<td>MIL-PRF-46010</td>
<td></td>
</tr>
<tr>
<td>AMS QQ-P-416</td>
<td>Cadmium plating.</td>
</tr>
<tr>
<td>AMS-C-8837</td>
<td>Cadmium coating.</td>
</tr>
</tbody>
</table>

This is not a complete list of documents and specifications referenced on Moog drawings. As stated above, this workmanship standard does not supersede requirements referenced on Moog drawings.
APPENDIX A:
SURFACE CORROSION AND PITTING
1.0 SURFACE CORROSION AND PITTING

This appendix defines what constitutes a non-conformance or otherwise against Moog requirements in the area of surface pitting and corrosion. In all cases, reference must be made to the order of precedence laid out in Section 2.1 of the main body of the document and repeated here:

Drawing >> PO (including S-Clauses) >> Workmanship Standard >> SQR-1

2.0 DEFINITIONS

<table>
<thead>
<tr>
<th>Corrosion</th>
<th>Gradual destruction of a metal surface caused by electrochemical interaction with the environment resulting in oxidation where the passive layer is compromised (by inclusion, scratches, dents, etc.).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitting</td>
<td>Formation of small areas of deep material removal, indicating localized surface attack where the passive layer is compromised (by inclusion, scratch, dent, etc.). Usually such pitting is caused by a chemical attack comprised of zones with anode, cathode and electrolyte (oxidation) properties. For instance, Chlorine dissolved in water can interact with a weak Chrome-Oxide layer on a 440C part. Increased temperature or increased PH can accelerate pitting. Pits, wide or narrow, deep or shallow (with many shapes) usually are covered with corrosion by-products that hide the hole. More resistance materials with Chromium, Molybdenum or Nickel or polished surfaces or environmental control can reduce and even prevent pitting.</td>
</tr>
<tr>
<td>Passive Layer</td>
<td>Spontaneous thin (&lt; 10 nanometer) film created on a part surface that acts as a barrier to oxidation (corrosion pitting).</td>
</tr>
</tbody>
</table>

3.0 BACKGROUND

Pitting corrosion results in weakened material properties for both wear and fatigue, therefore such conditions are Non-Conforming. Materials with low amounts of Chrome, Molybdenum and Nickel with rougher surfaces are more susceptible.

3.1 Detection Method

3.1.1 Visual Detection

Corrosion is usually detectable with normal unaided 1X vision. However, magnification up to 10X may be required to differentiate corrosion from watermarks, FOD, heat tint, scale or some other discoloration. Corrosion of steels is usually due to free iron from an improperly controlled process where spots (freckles) exist on the surface with rings around them and a pit in the middle. For steel, the spot color is brownish red due to iron oxide formation, but the spots may appear black if very small. Residue that wipes off with a damp cloth, IPA or another appropriate solvent is not considered corrosion unless there are pits visible at 10X. Corrosion of aluminum involves the generation of a uniform protective aluminum oxide layer that is usually dull gray to powdery white, but chlorine induced corrosion results in black spots with pitting. Note that other non-
corrosive stain types (colors and shapes) exist without pitting that may result from material or electro-chemical process variation or impurities.

3.2 Definition of Part-to-Print and Non-Conforming

Refer to Section 3.0 of the main body for definitions on Part-to-Print and Non-Conforming.
4.0  PITTING CORROSION

4.1  Examples

![Mild Pitting and corrosion]

Figure A1 – Mild Pitting Corrosion, Non-Conforming

Part is Non-Conforming for the following reasons:

- The part has confirmed pits. They were initially visible at 1X and confirmed to be pitted with the aid of magnification up to 10X.
- Per paragraph 3.1.1 above pitting corrosion constitutes a Non-Conformance.
Figure A2 – Severe pitting Corrosion, Non-Conforming

Part is Non-Conforming for the following reasons:

- The part is corroded. Corrosion was visible at 1X. Confirmed to be corrosion by the presence of flakes and pits visible without magnification.
- Per paragraph 3.1.1 above pitting corrosion constitutes a Non-Conformance.
FLOW CHART (FOR SURFACE CORROSION ON STEEL PARTS)

Start

Are Brown or Black Spots Visible at 1X?

No → Part to Print

Yes → Clean the part with IPA or similar to confirm that other contaminants (i.e. not corrosion) have been removed

Can a Pit be seen at 10X in the middle of the discoloration? (ring optional)

No → Part to Print

Yes → Part Non-Conforming

End
APPENDIX B: COSMETIC IRREGULARITIES
1.0 INTRODUCTION

This appendix defines what constitutes a non-conformance or otherwise against Moog requirements in the area of cosmetic irregularities. In all cases, reference must be made to the order of precedence laid out in Section 2.1 of the main body of the document and repeated here:

Drawing >> PO (including S-Clausess) >> Workmanship Standard >> SQR-1

2.0 DEFINITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracks</td>
<td>A tear or fracture in the material surface or edge.</td>
</tr>
<tr>
<td>Dent</td>
<td>Depression in a part surface. Smooth transition with surrounding areas and free from creases, folds, gouges or cracks.</td>
</tr>
<tr>
<td>Discontinuity</td>
<td>An irregularity with a sharp edge that is detectable with a pick specifically providing resistance to motion when the pick is run across the irregularity.</td>
</tr>
<tr>
<td>Scratches, Gouges, Abrasions, Grooves or Scrapes</td>
<td>Irregularities resulting from material removal by a sharp object. Typically with elongated shape and not following the normal machining marks of the surrounding surface.</td>
</tr>
<tr>
<td>Nicks and Dings</td>
<td>Surface impressions having sharp edges or corners caused by impact of a sharp object.</td>
</tr>
<tr>
<td>Raised Material</td>
<td>Displaced base material extending above the object surface plane as a result of a scratch, gouge, nick, ding or dent.</td>
</tr>
<tr>
<td>Chatter (machining tool mark)</td>
<td>Recurring irregularities on the surface that the result from vibration or jumping of a machining cutting tool.</td>
</tr>
<tr>
<td>Rifling (Machining tool mark)</td>
<td>Helical grooves or scratches on a bore that are typically caused after machining when the machining tool is removed.</td>
</tr>
<tr>
<td>Machining Tool Mark</td>
<td>Visible mark left in the machined surface of a part by the machining process. The use of this term in this document applies to marks that are irregular (visibly different from the surrounding surface of the same material) and not a normally expected surface finish.</td>
</tr>
</tbody>
</table>
3.0 BACKGROUND

Visible irregularities on surfaces, edges of parts and assemblies may be caused by inherent material geometry, processing operations, rework performed and mishandling of the part.

3.1 Detection Method

3.1.1 Tactile Detection

Irregularities that have a discontinuity or change in profile detectable with a plastic pick are considered to be tactile. In some cases (refer Table B2), tactile irregularities may already be Smooth or may be reworked until Smooth, allowing the part to conform to the requirements of the drawing and this workmanship standard.

![Plastic Pick to assist with detection of Tactile Irregularities](image)

Figure B1 – Plastic Pick to assist with detection of Tactile Irregularities

Area A: Point End

Area R: Radius End

NOTE: The precise manufacturer and dimensions of the plastic pick are not explicitly defined in this standard, but should be suitable for the type of parts and features being inspected. However, the use of a plastic pick for tactile detection is a requirement. Other tools or picks of any other material are not suitable and should not be used.

3.1.1 Visual Detection

Irregularities that are not tactile but still detectable by visual inspection are considered to be visual only. In some cases (refer Table B2) visual only irregularities will already conform to the requirements of the drawing and this workmanship standard. In other cases, e.g. sealing surfaces, these visual only irregularities violate the requirements of this workmanship standard and will not be Part-to-Print.

3.1.2 Measuring the Depth of Irregularities

It may be necessary to measure the depth of an irregularity to determine whether the part is conforming to the GD&T requirements on the drawing. This section defines the method for using Roughness Average requirements to define the allowable limits for the depth of an irregularity.

A surface roughness tester or profilometer can be used to provide a trace of the surface profile of a part. Most surface roughness testers will provide a Roughness Average (Ra) and Total Profile Height (Rt) value with the trace.

Table B1 below shows the maximum allowable Total Profile Height (Rt) for irregularities on surfaces for typical Roughness Average requirements.
Table B1 – Maximum Allowable Irregularity Depths for Different Surface Finish Requirements.

<table>
<thead>
<tr>
<th>Drawing Surface Finish Requirement (Ra)</th>
<th>Multiple of Ra Allowed</th>
<th>Maximum Allowable Irregularity Depth (Rt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 8Ra</td>
<td>Max. 3 times</td>
<td>≤ 24µin (.000024”)</td>
</tr>
<tr>
<td>≤ 16Ra</td>
<td>Max. 3 times</td>
<td>≤ 48µin (.000048”)</td>
</tr>
<tr>
<td>≤ 32Ra</td>
<td>Max. 3 times</td>
<td>≤ 96µin (.000096”)</td>
</tr>
<tr>
<td>≤ 63Ra</td>
<td>Max. 4 times</td>
<td>≤ 252µin (.000252”)</td>
</tr>
<tr>
<td>≤ 125Ra</td>
<td>Max. 4 times</td>
<td>≤ 500µin (.000500”)</td>
</tr>
</tbody>
</table>

Table B2 below shows the maximum allowable Total Profile Height (Rt) for regular machined surfaces (i.e. free of irregularities) with typical Roughness Average requirements.

Table B2 – Maximum Allowable Machining Mark Depths for Different Surface Finish Requirements.

<table>
<thead>
<tr>
<th>Drawing Surface Finish Requirement (Ra)</th>
<th>Multiple of Ra Allowed</th>
<th>Maximum Allowable Total Profile Height (Rt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 8Ra</td>
<td>Max. 4 times</td>
<td>≤ 32µin (.000032”)</td>
</tr>
<tr>
<td>≤ 16Ra</td>
<td>Max. 4 times</td>
<td>≤ 64µin (.000048”)</td>
</tr>
<tr>
<td>≤ 32Ra</td>
<td>Max. 4 times</td>
<td>≤ 128µin (.000128”)</td>
</tr>
<tr>
<td>≤ 63Ra</td>
<td>Max. 4 times</td>
<td>≤ 252µin (.000252”)</td>
</tr>
<tr>
<td>≤ 125Ra</td>
<td>Max. 4 times</td>
<td>≤ 500µin (.000500”)</td>
</tr>
</tbody>
</table>

In summary:

A surface with an irregularity must:

- Have a Roughness Average (Ra) that is equal to or less than the requirement on the drawing AND
- Have a Total Profile Height (Rt) that is equal to or less than the limits defined in Table B1 above when the profile of the surface in the area of the irregularity is evaluated

A surface with no visible irregularities at 1X must:

- Have a Roughness Average (Ra) that is equal to or less than the requirement on the drawing AND
- Have a Total Profile Height (Rt) that is equal to or less than the limits defined in Table B2.
Figure B2 – Typical Profilometer Report with multiple peaks/valleys.

**Note:** Even if the irregularity meets the above Ra and Rt requirements, Moog may still reject the part if the irregularity is on a seal groove or similarly important functional surface. Suppliers are not assumed to have such knowledge of critical part features, but such cases will likely be rare as most if not all irregularities rejected by Moog would fail to meet the above requirements.

**Note:** Machining steps/mismatch are not allowed. Table B1 and Table B2 shall not be used as a rationale to accept such features.
4.0 COSMETIC IRREGULARITIES

4.1.1 Part-to-Print Decision for Cosmetic Irregularities

*Table B3* below defines the Part-to-Print decision of surface irregularities against surface types.

Y = Yes (Part-to-Print)

N = No (Non-Conforming)

<table>
<thead>
<tr>
<th>Surface Irregularity</th>
<th>Machined Surface ***</th>
<th>Irregularity meets all drawing GD&amp;T requirements including Ra/Rt per Table B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Dent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discontinuity</td>
<td>Visual only: N</td>
<td>Visual only: Y*</td>
</tr>
<tr>
<td>Nick / Ding</td>
<td>Tactile, not Smooth: N</td>
<td>Tactile, Smooth: Y*</td>
</tr>
<tr>
<td>Scratch</td>
<td></td>
<td>Reworked to Print: Y**</td>
</tr>
<tr>
<td>Machining Tool Marks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raised Material</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

*Additional Requirements:

- Irregularity must not cover more than 5% of the part feature surface. Even if the irregularity satisfies the less than 5% of the surface allowance, it may still be unacceptable for cosmetic/aesthetic reasons, such as with an externally visible or larger surface. Moog may reject any visual irregularities based on quality expectations and aesthetic requirements flowed down by customers.

- Irregularities must conform to all GD&T callouts on the drawing. This includes Surface Finish per *Table B1* and *Table B2*, Flatness, Perpendicularity, Parallelism, Edge-break dimensions etc. Even if an irregularity meets the drawing GD&T requirements and meets the definition of *Smooth*, Moog may still reject the part if the irregularity is on a seal groove or similarly important functional surface.

*Additional Requirements:
• All rework must generate a Smooth surface. Where doubt exists over the interpretation of an irregularity, including whether rework-to-print is allowable, it should be considered non-conforming and additional advice sought from Moog engineering via an SR-type NC (SRID).

• Whenever an irregularity is caused by an event that may cause an over-stress condition, such as dents caused by dropping a part, it shall be considered non-conforming and advice sought from Moog engineering via an SR-type NC (SRID).

***Additional requirements: For as-forged and as-cast surfaces, refer to the drawing requirements for acceptability of any irregularities.
4.1.2 Examples

Part is to-Print for the following reasons:

- The scratch has been reworked (buffed) such that when a pick is run across the scratch, there is no detectable resistance to motion, i.e. no detectable discontinuity. This meets the definition of Smooth.

- Table B3 allows the presence of Smooth irregularities as long as all GD&T requirements are met.

- A profilometer reading taken across the scratch shows the average roughness to be 40µin and the Total Profile Height to be .0003”. Per Table B1, defects that have an average roughness of less than or equal to the 125 Ra surface finish requirement AND have an Rt ≤ 500µin (.0005”) in the area of the irregularity, meet the 125 Ra surface finish requirement and are therefore considered Part to Print.

- With Datum M located on an angle plate, the perpendicularity of the face in question measured less than .001, when an indicator was run across the entire face including the defect.
Part is Non-Conforming for the following reasons:

- A dial indicator reading taken across the dent shows the Total Profile Height (Rt) to be .035". Per Table B1, defects that are > 96µin (.000096") do not meet the 32 Ra surface finish requirement and are therefore considered Non-Conforming.

- The countersink angle is less than 58° in the area of the irregularity. Therefore the 60° ±2° requirement is not met and the part is considered Non-Conforming.

- When a pick is run across the edge of the dent, there is a noticeable resistance to motion, i.e. a detectable discontinuity. This does NOT meet the definition of Smooth. Per Table B3 irregularities that are not smooth are considered Non-Conforming.
Part is Non-Conforming for the following reasons:

- A dial indicator reading taken across the dent shows the depth of the irregularity to be .043". Per Table B2, irregularities must conform to all GD&T callouts on the drawing. The dent is significantly deeper than the .002 -.018 break edge requirement and is therefore considered Non-Conforming.

- When a pick is run across the edge of the dent, there is a noticeable resistance to motion, i.e. a detectable discontinuity. This does NOT meet the definition of Smooth. Per Table B3 irregularities that are not smooth are considered Non-Conforming.
Part is Non-Conforming for the following reasons:

- A dial indicator reading taken across the dent shows the depth of the irregularity to be .006”. Per Table B2, irregularities must conform to all GD&T callouts on the drawing. The dent is within the break edge requirement with no raised material and would be considered Part to Print, however...

- When a pick is run across the edge of the dent, there is a noticeable resistance to motion, i.e. a detectable discontinuity. This does NOT meet the definition of Smooth. Per Table B3 irregularities that are not smooth are considered Non-Conforming.
Part is Non-Conforming for the following reasons:

- A profilometer reading taken across the scratch shows the total profile height (Rt) to be .00025". Per Table B1, defects that are > 96µin (.000096") do not meet the 32 Ra surface finish requirement and are therefore considered Non-Conforming.
Figure B8 - CA54389-001, Machining Mark (Chatter), Non-Conforming

Part is Non-Conforming for the following reasons:

- A profilometer reading taken across the area with the chatter shows the average roughness to be 26μin and the Total Profile Height (Rt) measurement is 0.0002”. Per Table B1, defects that have an average roughness of greater than the 32 Ra surface finish requirement OR have Total Profile Height (Rt) measurement of > 96μin (.000096”), do not meet the surface finish requirement and are therefore considered Non-Conforming.

Drawing Requirements:

- .001 flatness across the face
- 32 Ra Surface Finish
FLOW CHART (FOR COSMETIC IRREGULARITIES)

Start

Is irregularity Tactile?

No (Visual Only)

Yes

Is irregularity Smooth?

No

Yes

Does irregularity meet all GD&T requirements including Ra per Table B1?

No

Yes

Does the irregularity cover <5% of the surface area?

No

Yes

Preliminary decision: Part Non-Conforming

Do dwg requirements contradict preliminary decision?

No

Part Non-Conforming

End

Yes

Part to Print

End

Preliminary decision: Part to Print

Do dwg requirements contradict preliminary decision?

No

Part to Print

End

Yes

Part Non-Conforming

End
APPENDIX C: BURRS
1.0 INTRODUCTION

This appendix defines Moog's deburr criteria for inspecting and deburring edge breaks, cross holes, wire-ways, intersecting passages, threads, profiles and general knowledge of burr removal. In all cases, reference must be made to the order of precedence laid out in Section 2.1 of the main body of the document and repeated here:

- Drawing >> PO (including S-Clauses) >> Workmanship Standard >> SQR-1

2.0 DEFINITIONS

<table>
<thead>
<tr>
<th>Burr</th>
<th>A burr is a raised edge or small piece of residual material attached to a workpiece after a machining process. Unless otherwise specified, required to be removed with a tool in a process called 'deburring'.</th>
</tr>
</thead>
</table>
3.0 BACKGROUND

Edges should comply with drawing edge break requirements and be free of burrs. When dislodged, burrs may cause product failures, adversely affect subsequent machining and dimensional inspections, and damage other parts. While ultimate acceptance criteria depends upon factors including product application, burrs that are visible at 10X magnification are considered non-conforming.

3.1 Detection Method

Consideration for the following may simplify the burr detection process:

**Part cleanliness** - Cleanliness may be essential for efficiently detecting burrs. Confused with dirt or other contaminants, burrs may be overlooked.

**Viewing angle** - Frequently, easily detectable burrs are overlooked when viewing a part from a single direction. It is good practice to view from varying directions and angles. In general, parts should be viewed with the line of sight between 30° to 60° to the edge or surface being inspected.

![Burr](image)

*Figure C1 – Burr, Non-Conforming*

Part is Non-Conforming due to the following reasons:

- Burr is visible at 10x magnification with a viewing angle looking through the diameter.
Figure C2 – Burr, Non-Conforming

Part is Non-Conforming for the following reasons:

- Burrs present at 10x magnification with a viewing angle looking through the diameter.
**Backlighting** – The use of a light source shining behind a feature helps shadow the burr that may not be seen with the use of front lighting from just a microscope alone.

Figure C3 – Lighting assistance for inspections within bores

![Backlighting Image]

Figure C4 – Burrs, Non-Conforming

Part is Non-Conforming due to the following reasons:

- Burr present at 10x magnification using backlighting.
3.2 Visual Detection

**Inspection Aids** – Microscope, eye loupe, otoscope, fiber optic back lighting, endoscope and dental mirrors aid in detecting burrs. A magnification power of 10x are ideal for detecting and removing burrs. Higher magnification can be used if desired for removing burrs. The following examples are not a requirement but are recommended for the use of inspection and burr removal.

![Microscope with variable zoom](image)

*Figure C5 – Microscope with variable zoom*

![Fiber optic box used for backlighting](image)

*Figure C6 – Fiber optic box used for backlighting*
Figure C7 – Otoscope used as eye loupe with light source

Figure C8 – inspection mirrors
Figure C9 – Borescope used for hole intersections, bores and scallop inspection

Figure C10 – Endoscope used for hole intersections, bores and scallop inspection
3.3 Deburring / Over Deburr

**Deburring:** This is a critical post-machining operation for ensuring the functionality and safe handling of the part. Edges should comply with drawing edge break requirements and be free of burrs. Care must be taken not to damage the part or introduce new defects or contamination during the deburring operation.

**Over-Deburring:** Functional surfaces such as sealing surfaces on Moog parts will have carefully specified land lengths and surface finish requirements, and so all specified drawing tolerances for edge conditions must be adhered to and special care must be taken not to over-deburr these features. Over-deburring of the ends of spline teeth, especially on internal splines, is also a common cause for non-conformances and rejection – care to be taken while deburring such features.
4.0 FLOW HOLES

4.1 Feature Description
These features are hydraulic passages. Burr free conditions are required on these areas. Edge break requirements are to drawing specifications. Dependent upon the material, machining process, and dimensions, difficult to detect burrs and other imperfections may be created.

![Figure C11 – Examples of flow holes](image)

4.2 Examples

![Figure C12 – Internal Flow Hole Magnified, Burr, Non-Conforming](image)

Part is Non-Conforming for the following reasons:

- Burr is detectable at 10x or less magnification using backlighting.
Part is Non-Conforming for the following reasons:

- Burr is detectable at 10x or less magnification using backlighting.
5.0 SCALLOPPED RECESSES

5.1 Feature Description

These features are bore intersections that play a vital role in assemblies. Burrs and contaminants may be hidden from view. Burr free conditions are required. Top edges of scallops are to be *smooth* while still meeting drawing specifications.

*Note: Sectioned parts are used for clarity purposes of this document. For proper inspection use mirror, borescope and/or endoscope.*
5.2 Examples

Figure C16 – Burr, Non-Conforming

Part is Non-Conforming for the following reasons:

- Burr is present at 10x magnification, using mirror and/or fiber optics.
Figure C17 – Burrs and sharp edges, Non-Conforming

This part is Non-Conforming for the following reasons:

- Burrs on scallops
- Sharp edges
- Noticeable at 10x magnification using mirror down the bore.

Figure C18 – Deburred scallop, Part-to-Print

Part is to-Print for the following reasons:

- Edge breaks comply with drawing
- No burrs present on feature
6.0 INTERSECTING PASSAGES

6.1 Feature Description

Form essential flow paths that must be free of restrictions and debris. Intersections should be verified, and passages should be free of chips and burrs.

![Intersecting passage of bore and flow hole](image)

Figure C19 – Example of intersecting flow passage
6.2 Examples

Figure C20 – Before and after deburr in intersecting flow passages
7.0 INTERNAL AND EXTERNAL THREADS

7.1 Feature Description

These features are high stress areas and are critical to the assembly of the part. Deburr first and last thread and blend all chamfers that are present on bores. Burr free conditions are essential on these features.

7.2 Examples

Figure C21 – examples of internal and external threads

Figure C22 – Before and after deburr of internal threads
There is a burr found on the first thread. You can see the roughness before it has been removed.

After deburr you can see the first thread is smooth and conforming to the drawing.

Figure C23 – Before and after deburr of internal thread bore
8.0 BLIND TAPPED HOLES

8.1 Feature Description

Generally low stress areas. Be sure to remove any FOD such as packed chips and other debris. No extruded material is allowed on mating surfaces. Deburr the first thread and make sure last thread is clean without hanging material.

![Blind Tapped Holes](image)

Figure C24 – Example of blind thread bores

8.2 Examples

![Burr, Nonconforming](image)

Figure C25 – Burr, Nonconforming

Part is Non-Conforming due to the following reasons:

- Burr on lead thread is visible at 10x magnification
Figure C26 – Examples of Part-to-Print and Non-Conforming in blind threaded bores - FOD

Figure C27 – Hanging burr, Non-Conforming

Part is Non-Conforming for the following reasons:

- Hanging burr on last thread
9.0 SPLINES AND SERRATIONS

9.1 Feature Description

Ridges or teeth on a drive shaft that mesh with grooves in a mating piece and transfer torque to it, maintaining the angular correspondence between them. Burrs are usually large on one side of spline. Remove all burrs while maintaining drawing requirements.

![Image of internal and external splines](image1.png)

**Figure C28 – Examples of internal and external splines**

9.2 Examples

![Image of before and after deburr of external splines](image2.png)

**Figure C29 – Before and after deburr of external splines**
10.0 WIREWAYS

10.1 Feature Description
These features are generally low stress, dry areas. Edges must be blended and smooth to prevent damage to wires during installation. Edge break requirements are to drawing specification.

10.2 Examples

Figure C30 – Sharp edge, Non-Conforming

Part is Non-Conforming for the following reasons:

- The wireway has been deburred but the edge is still sharp.
- Needs to be refined to a radius.
Figure C31 – Part-to-Print

Part is to-Print due to the following reasons:

- Smooth and uniform radius around all edges of diameter.
Figure C32 – Part-to-Print

Part is to-Print due to the following reasons:

- Smooth and uniform radius around all edges of diameters and features where wires will be pulled through.
**11.0 TIE WIRE HOLES**

**11.1 Feature Description**

These features are non-stress diameters used to lock a part in place in the assembly. Burr free condition is essential on these features to ensure no cross-contamination at assembly.

![Before Deburr](image1.png) ![After Deburr](image2.png)

*Figure C33 – Before and after deburr of wireway*

Although the edge break is conforming, there is a burr pushed into the hole which can be seen when looking through to the exit of the diameter.

![Before Deburr](image3.png) ![After Deburr](image4.png)

*Figure C34 – Before and after deburr of wireway*

**12.0 MISCELLANEOUS FEATURE PICTURES**
Figure C37

Before Deburr

After Deburr
APPENDIX D:
EXTERNAL CONTOURING
1.0 INTRODUCTION

This appendix defines what constitutes a non-conformance or otherwise against Moog requirements in the area of external contouring. Specifically, this includes fillets and radii created during machining operations. In all cases, reference must be made to the order of precedence laid out in Section 2.1 of the main body of the document and repeated here:

Drawing >> PO (including S-Clauses) >> Workmanship Standard >> SQR-1

2.0 DEFINITIONS

<table>
<thead>
<tr>
<th>Drawing Border Tolerance</th>
<th>The tolerances called out on the drawing border, which state “unless otherwise specified…”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge radius</td>
<td>A corner radius between the junction of 2 surfaces where the material is on the inside of the radius, lying on and external corner</td>
</tr>
</tbody>
</table>

![Edge Radius Diagram]

<table>
<thead>
<tr>
<th>Fillet</th>
<th>A corner radius between the junction of 2 surfaces where the material is on the outside of the radius, lying on an internal corner</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>![Fillet Diagram]</td>
</tr>
</tbody>
</table>
3.0 External Contouring

The following requirements are applicable to all fillets and radii created during external part contouring. These features are typically defined on the drawing with a note similar to “Unless otherwise specified, Contour fillets are to be R.250” or “Unless otherwise specified, Contour fillets are to be R.375”.

- The radii must fall within the criteria established in Section 3.4.

- Fillets not defined or shown on the drawing shall be compliant to the drawing note. They must be uniform in shape and can be generated via milling or turning but must be Smooth.

- Radii should be tangential to adjacent surfaces and bisect corners that they cannot be tangent to due to space constraints. These radii commonly create contour bridging between the bosses and features.

- Surfaces between faces should not be created in an attempt to fill in the solid model. They should have a fillet radius between the faces and bisecting the corners of the adjacent faces, but not necessarily tangential to the adjacent faces (i.e. not necessarily a full radius). Imagine a ball with a radius matching the fillet radius note rolling around the part. Any place it will not fit gets a radius from the ball while contacting the two adjacent surfaces or edges. The remaining material is referred to as contour bridging and is acceptable.

4.0 Contouring Examples

Figure D6 – Contour Bridging in between bosses where ball end mill won’t fit
Figure D7 – Contour Fillet Radii in Corners not defined on solid model

Figure D8 – Contour Fillet Radii in Corners not defined on solid model
APPENDIX E:
SPECIAL PROCESSES
(PLATING, COATING, HEAT TREATMENT)
1.0 INTRODUCTION

This appendix defines what constitutes a non-conformance or otherwise against Moog requirements in the area of visual defects of special process. In all cases, reference must be made to the order of precedence laid out in Section 2.1 of the main body of the document and repeated here:

Drawing >> PO (including S-Clauses) >> Workmanship Standard >> SQR-1

2.0 DEFINITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jig Marks</td>
<td>Electrode contact points during any electro plating process.</td>
</tr>
<tr>
<td>Special Process Damage</td>
<td>Damage to the finish or coating that is applied to the part. Could be chipping, scratches, smearing etc.</td>
</tr>
<tr>
<td>Discoloration</td>
<td>Localized change in visual appearance of the part.</td>
</tr>
</tbody>
</table>

3.0 BACKGROUND

Visible irregularities on parts that have been specially treated or processed may adversely impact the process intent. In addition, such irregularities create an aesthetic impression of poor manufacturing quality.

3.1 Detection Method

3.1.1 Visual Detection

Surface irregularities that are detectable with normal unaided 1X vision are subjected to the requirements of this standard, and every effort should be made to inspect at 1X. In certain limited cases however, it may not be possible to visually inspect plated/coated features without greater levels of magnification, e.g. down blind bores. In these exceptional and limited cases, magnification up to 10X may be used to inspect the feature.

3.2 Definition of Part-to-Print and Non-Conforming

Refer to Section 3.0 of the main body for definitions on Part-to-Print and Non-Conforming. The acceptability criteria for cosmetic irregularities outlined in Appendix B of this document are also applicable to parts subjected to the special processes described in this section.
4.0 DRY PROCESS

4.1 Ion Vapor Deposition (IVD)

The requirements for coating parts with high purity aluminum are detailed in MIL DTL 83488 or equivalent and should be referenced on the drawing. This section only clarifies those requirements that may be ambiguous on the drawing or the industry standard specification. Per the MIL DTL 83488 specification there are two types of Ion Vapor Deposition; Type I and Type II.

Type I: As coated (i.e. ion vapor deposition aluminum coating only)

Type II or omitted: With supplementary chromate treatment per MIL-C-5541

The wording related to workmanship in MIL DTL 83488 implies that there must be no gap in coverage of the deposited aluminum or the chemical conversion coating (Type II only). The only concession is that contact points and hard to reach areas are not subject to the same thickness requirements as the rest of the part.

MIL DTL 83488 Rev D Paragraph 3.5.4:

“Fixture contact points, holes, recesses, internal threads, and other areas where a controlled deposit cannot be obtained shall not be subject to a thickness requirement. However, there shall be visual evidence of coating in holes and recesses down to a depth of at least the diameter of the hole or recess. Fastener areas that cannot be touched with a 0.020-inch diameter ball shall not be subject to thickness requirement.”

MIL DTL 83488 Rev D Paragraph 3.9.2:

“The high purity aluminum coating shall be smooth, fine grained, adherent, uniform in appearance, free from staining, pitting and other defects. The coating shall show no indication of contamination or improper operation of equipment used to produce the deposit, such as excessively powdered or darkened coatings. Type II parts processed in accordance with MIL-C-5541 requirements shall have a continuous, distinctly colored protective film ranging in color from yellow and iridescent bronze through olive drab and brown.”
4.1.1 Part-to-Print Decision for Jig Marks, Damage and Color Variation

Table E1 below defines the Part-to-Print decision for irregularities on surfaces with ion vapor deposition aluminum coating.

Y = Yes (Part-to-Print), N = No (Part is Non-Conforming)

<table>
<thead>
<tr>
<th>Surface Irregularity</th>
<th>Acceptability for Surfaces Finished with Ion Vapor Deposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRICAL CONTACT MARKS OR JIG MARKS</td>
<td>N</td>
</tr>
<tr>
<td>LOOSE COATING</td>
<td>N</td>
</tr>
<tr>
<td>VOIDS</td>
<td>N</td>
</tr>
<tr>
<td>TACTILE FLAWS</td>
<td>N</td>
</tr>
<tr>
<td>FLAWS PENETRATE THROUGH COATING</td>
<td>N</td>
</tr>
<tr>
<td>May be detected by change in color or reflectivity</td>
<td></td>
</tr>
<tr>
<td>VISUAL ONLY FLAWS</td>
<td>Y</td>
</tr>
<tr>
<td>NOT tactile</td>
<td></td>
</tr>
<tr>
<td>Do NOT penetrate through coating</td>
<td></td>
</tr>
<tr>
<td>COLOR VARIATION OF CHEMICAL CONVERSION COATING (TYPE II ONLY)</td>
<td>Y*</td>
</tr>
</tbody>
</table>

*Note: Per the MIL-DTL-83488 specification, paragraph 3.9.2 “Type II parts processed in accordance with MIL-C-5541 requirements shall have a continuous, distinctly colored protective film ranging in color from yellow and iridescent bronze through olive drab and brown.”
4.1.2 Examples

Figure E1 – A24961-001, Damage to Chemical Conversion Coating caused during Jig Removal, Non-Conforming

Part is Non-Conforming for the following reasons:

- The ID of the hole has jigging damage that penetrates through the Chemical Conversion Coating. This is detectable at 1X by the change in color.

- Per Table E1, parts with flaws that penetrate through the coating are considered Non-Conforming.
Part is Non-Conforming for the following reasons:

- The break edge around the hole has a jig mark (it was an electrode contact point) that penetrates through the chemical conversion coating only. This is detectable at 1X by the change in color. Per Table E1, parts with flaws that penetrate through the coating are considered Non-Conforming.

**Figure E2 – A24691-001, Jig Marks, Non-Conforming**
Figure E3 – A24691-001, Damage to Chemical Conversion Coating, Non-Conforming

Part is Non-Conforming for the following reasons:

- There is a scratch that penetrates through the chemical conversion coating. This is detectable at 1X by the change in color. Per Table E1, parts with flaws that penetrate through the coating are considered Non-Conforming.

Drawing Requirements:

- 63 Ra Surface Finish (Block Tolerance)
- IVD Aluminum Coating per MIL DTL 83488, Class I, Type II
Figure E4 & E5 – A24691-001, Chemical Conversion Coating Gray & Olive Drab Color Variation, Part-to-Print

Part is to-Print for the following reasons:

- Two different examples of the same part number are shown above. The first is colored grey, the second olive drab.

- Per Table E1, Type II chromate coated parts with color variation shall be considered Part-to-Print. MIL DTL 83488, paragraph 3.9.2 states “Type II parts processed in accordance with MIL-C-5541 requirements shall have a continuous, distinctly colored protective film ranging in color from yellow and iridescent bronze through olive drab and brown.” The colors shown in the images above fall within the color range allowed by Table E1 and the specification, therefore the parts are designated Part-to-Print.
5.0 Heat Treatment

5.1 Background

There are many different industry standard specifications that cover heat treatment. All the heat treatment processes alter the physical properties of the material. Typically this involves exposure of the material to temperature extremes with the aim of hardening or softening that material. Many industry standard specifications call for a hardness check on a sample part, or in some cases every part, from the heat lot to verify that the physical properties of the material have been correctly altered.

There are two types of irregularities frequently witnessed on Moog parts.

- Heat Tint: A thin adherent film of oxides resulting from extreme heating of stainless steels in the presence of oxygen. It ranges in color from light straw yellow to a deep blue.

- Hardness Indentation: An impression made in the material to determine hardness.

This section clarifies the Part-to-Print designation of the above two types of irregularities for the cases where the drawing and/or the industry standard specifications are lacking in clarity.
5.2 Part-to-Print Decision for Heat Tint and Hardness Indentations

Table E2 below defines the Part-to-Print decision for heat tint and hardness indentations on parts that have been heat treated.

\[ Y = \text{Yes (Part-to-Print), } N = \text{No (Part is Non-Conforming)} \]

**Table E2 - Part-to-Print Decision, Heat Tint & Hardness Indentations**

<table>
<thead>
<tr>
<th>Surface Irregularity</th>
<th>Surface finish on hardened surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface Finish ≤ 63 Ra</td>
</tr>
<tr>
<td>Heat Tint, Yellowish White to Deep Straw</td>
<td>Y*</td>
</tr>
<tr>
<td>Heat Tint, Yellowish Brown through Purple, Blue and Gray</td>
<td>N*</td>
</tr>
<tr>
<td>Indentation Mark (location not specified by drawing or op sheet)</td>
<td>N**</td>
</tr>
<tr>
<td>Indentation Mark (location specified by drawing or op sheet)</td>
<td>Y***</td>
</tr>
</tbody>
</table>

*Note: For clarification of color range, refer to Figure E6 below:

**Note: Per Appendix B, all irregularities with raised material are deemed to be Non-Conforming.

***Note: Indentation marks including those with raised material are allowed whenever the hardness test location is consistent with the location specified on the drawing or by a Moog approved operating instruction.
5.3 Examples

Part is Non-Conforming for the following reasons:

- The part displays a purple/grey heat tint.
- Per Table E2, parts with heat tint that is yellowish brown through purple, blue or gray are deemed to be Non-Conforming.
Figure E8 – CB83719-001, Part-to-Print

Part is to-Print for the following reasons:

• The part displays no heat tint.

Figure E9 – A24961-001, Hardness Indentation, Part-to-Print

Part is to-Print for the following reasons:

• Per Table E2 & Appendix B Table B2, hardness indentations without raised material on a surface with a finish requirement called out by the drawing block tolerance are deemed Part-to-Print.
6.0 WET PROCESS

6.1 Anodizing

Anodizing is an electrolytic passivation process used to increase the corrosion resistance of predominantly aluminum alloy parts but can be used on titanium and other metals as well. During the process, the microscopic structures of the surface is altered to increase the thickness of the natural oxide layer. Anodizing requirements are detailed in MIL-A-8625 or equivalent and should be referenced on the drawing.

MIL-A-8625 contains statements regarding workmanship and contact marks.

MIL-A-8625 Rev F Paragraph 3.3.4:

“Unless otherwise specified, mechanically damaged areas from which the anodic coating has been removed without damage to the part may be touched up using chemical conversion materials approved on QPL-81706 for Class 1A coating and the applicable method of application. ...The mechanically damaged area(s) shall not exceed 5 percent of the total anodized area of the item or touch up shall not be permitted. When specified in the contract or purchase order, contact marks shall be touched up using the above method required for mechanical damage.”

MIL-A-8625 Rev F Paragraph 3.13:

“Except for touch up areas in accordance with 3.3.4 and as noted below, the applied anodic coating shall be continuous, smooth, adherent, uniform in appearance, free from powdery areas, loose films, breaks, scratched and other defects which will reduce the serviceability of anodized parts or assemblies.”

MIL-A-8625 Rev F Paragraph 3.13.1

“The size and number of contact marks shall be at a minimum consistent with good practice. If a specific location for contact marks is desired, the location shall be specified on the contract or purchase order.”
6.1.1 Part-to-Print Decision for Jig Marks and Damage

Table E3 below defines the Part-to-Print decision for Jig mark and jigging damage on anodized part.

Y = Yes (Part-to-Print), N = No (Part is Non-Conforming)

<table>
<thead>
<tr>
<th>Surface Irregularity</th>
<th>Acceptability for Surfaces Finished with Anodize</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface Finish ≤ 63 Ra</td>
</tr>
<tr>
<td>ELECTRICAL CONTACT</td>
<td>N</td>
</tr>
<tr>
<td>With or without chemical conversion touch up</td>
<td></td>
</tr>
<tr>
<td>LOOSE COATING</td>
<td>N</td>
</tr>
<tr>
<td>VOIDS</td>
<td>N</td>
</tr>
<tr>
<td>TACTILE FLAWS</td>
<td>N</td>
</tr>
<tr>
<td>FLAWS PENETRATE THROUGH COATING</td>
<td>N</td>
</tr>
<tr>
<td>May be detected by change in color or reflectivity</td>
<td></td>
</tr>
<tr>
<td>GRAIN MARKS</td>
<td>Y</td>
</tr>
<tr>
<td>FLAWS PENETRATE THROUGH COATING AND TOUCHED UP WITH CHEMICAL CONVERSION COATING</td>
<td>Y**</td>
</tr>
<tr>
<td>VISUAL ONLY FLAWS</td>
<td>Y</td>
</tr>
<tr>
<td>NOT tactile</td>
<td></td>
</tr>
<tr>
<td>Do NOT penetrate through coating</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Per MIL-A-8625, a requirement to touch up electrical contact marks with chemical conversion coat shall be specifically called out in the contract or purchase order (i.e. on the drawing).

**Note: The touched up areas must not exceed 5 percent of the total anodized area.
6.1.2 Part-to-Print Decision for Anodize Runout

*Table E4* below defines the Part-to-Print decision for runout of Anodize coating.

Y = Yes (Part-to-Print), N = No (Part is Non-Conforming)

**Table E4 – Part-to-Print Decision, Anodize Runout**

<table>
<thead>
<tr>
<th>Surface</th>
<th>Presence of Anodize Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface with Anodize Requirement</td>
<td>Y</td>
</tr>
<tr>
<td>Fillet, Chamfer or Edge Break between Anodized Surface and Adjacent Surface</td>
<td>Y**</td>
</tr>
<tr>
<td>Adjacent Surface to Anodized Surface</td>
<td>N</td>
</tr>
<tr>
<td>Lead In and Runout Chamfers for Threads that are Adjacent to Anodized Surface</td>
<td>Y</td>
</tr>
<tr>
<td>Threads that are Adjacent to Anodized Surface</td>
<td>N*</td>
</tr>
</tbody>
</table>

*Note: It is difficult to fully mask threads on aluminum bodies, and a special note is usually added to the drawing to address anodize runout onto threads. In the event that no special drawing note exists, this table forms the requirement.

**Note: Anodize is typically added as a requirement to Moog parts to improve corrosion resistance. If there are features or surfaces on a part that do NOT have anodize requirements, it is likely that those features have requirements for some other corrosion preventative finish such as chemical conversion coating per MIL-DTL-5541. In the scenario where two finishes are called out on a part, care must be taken to ensure that bare base metal does NOT exist on any features.*
Figure E10 – CA82771-001, Example Clarification of Requirements for Part with 2 Coating/Finish Requirements

White colour - Chemical Conversion Coating required
Gray (dark) colour (not including fillet) - Anodize Coating required
Fillet - Anodize Coating or Chemical Conversion Coating or transition of both. BARE METAL IS A NON-CONFORMANCE
6.1.3 Examples

Part is to-Print for the following reasons:

- There is anodize and chemical conversion coating present on the fillet between the surfaces with the different finish requirements.

- Per Table E4, the presence of anodize on the fillet between an anodized surface and the adjacent surface is deemed to be Part-to-Print.

- The note underneath Table E4 explains that in the scenario where two finishes are called out on a part, care must be taken to ensure that bare base metal does NOT exist on any features. In the example image, the remaining area of the fillet that is not anodized has full chemical conversion treatment.

- Given the above, the part is deemed Part-to-Print.
Figure E12 – C29712-001, Damage to Anodize Coating, Non-Conforming

Part is Non-Conforming for the following reasons:

- There is damage (flaw) to the anodize coating that penetrates through to the base metal. There is no chemical conversion coating to touch up the area of damage.

- Per Table E3 above, a part with anodic coating that has been removed will be deemed Non-Conforming if the damage has not been touched up with chemical conversion coating.

- Note: This example also illustrates a grain structure that can appear after anodizing. Although this part is non-conforming due to damage to anodize coating, the ‘grain mark’ type of irregularity is Part-to-Print as per Table E3 above.

Drawing Requirements:
Anodize per MIL-A-8625, Type I, Class 1
6.2 DFL (Dry/Solid Film Lubricants)

6.2.1 Background

DFL is a material which, although solid, reduces friction between two sliding surfaces without the need for additional oil or greases. Typically, this is used on threads and splines to aid the installation process and prevent galling. The requirements for DFL are detailed in SAE AS5272, MIL-PRF-46010 or equivalent and should be referenced on the drawing.

Both SAE AS5272 and MIL-PRF-46010 provide adequate clarity with regards to what constitutes a non-conformance in the area of visual irregularities (cracks, scratches, pinholes, blisters etc.) and as Moog do not see a significant volume of Non-Conforming parts due to visual irregularities, the topic has not been specifically addressed in this section.

The remaining issue that frequently causes non-conformances on Moog parts is overspray. Moog drawings do not consistently detail the allowable overspray of DFL and this leads to either significant numbers of non-conformances or parts that are very difficult to produce. This section clarifies the Part-to-Print designation of DFL overspray for the cases where the drawing has omitted this requirement.

6.2.2 Part-to-Print Decision for DFL Overspray / Seepage

Table E5 below defines the Part-to-Print decision for overspray of DFL.

\[ Y = \text{Yes (Part-to-Print)}, N = \text{No (Part is Non-Conforming)} \]

<table>
<thead>
<tr>
<th>Surface</th>
<th>Presence of DFL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threads &amp; Splines with DFL Requirement</td>
<td>Y</td>
</tr>
<tr>
<td>Lead In and Runout Chamfers for Threads/Splines with DFL Requirement</td>
<td>Y</td>
</tr>
<tr>
<td>Adjacent Surface to Lead In and Runout Chamfers for Threads/Splines with DFL Requirement</td>
<td>N</td>
</tr>
</tbody>
</table>
6.2.3 Examples

Figure E13 – CB08866-001, DFL seepage, Non-Conforming

Part is Non-Conforming for the following reasons:

- DFL is present on the threads, the lead in chamfer for the thread and 0.015 into the surface adjacent to the lead in chamfer.

- Per Table E5, parts that have DFL on the lead in chamfer shall be considered Part to Print. However...

- Per Table E5, parts that have DFL any distance onto the adjacent surface shall be deemed Non-Conforming.
6.3 Cadmium Coating/Plating

6.3.1 CAD Plating

This process involves the electrodepositing of 99% pure cadmium plate to a base metal. The requirements are detailed in AMS-C-8837 (coating) and AMS QQ-P-416 (plating) or equivalent and should be referenced on the drawing. This section only clarifies those requirements that may be ambiguous on the drawing or the industry standard specifications.

Per the AMS-C-8837 and AMS QQ-P-416 specifications there are three types of Cadmium Plating; Type I, Type II and Type III.

Type I: As plated (i.e. electrodeposited cadmium plate only)

Type II: With supplementary chemical conversion coating

Type III: With supplementary phosphate treatment

The wording related to workmanship in AMS QQ-P-416 implies that there must be no gap in coverage of the deposited cadmium, the chemical conversion coating (Type II) or phosphate treatment (Type III).

AMS QQ-P-416 Rev E Paragraph 3.5.2:

“The cadmium plating shall be smooth, adherent, uniform in appearance, free from blisters, pits, nodules, burning, and other defects when examined visually without magnification. The plating shall show no indication of contamination or improper operation of equipment used to produce the cadmium deposit, such as excessively powdered or darkened plating. Superficial staining, which has been demonstrated as resulting from rinsing, or slight discoloration resulting from any drying or baking operations as specified shall not be cause for rejection.”

AMS QQ-P-416 Rev E Paragraph 3.2.8.1:

“The plating shall cover all surfaces as stated in 3.3.1, including roots of threads, corners and recesses.”

AMS QQ-P-416 Rev E Paragraph 3.3.1:

“For surfaces that cannot be touched by a 0.75 inch sphere, including internal threads, no thickness requirements are established, but such areas shall show evidence of coating. There shall be no bare areas, except for areas beyond a hole depth of 2.5 times the hole diameter.”

AMS QQ-P-416 Rev E Paragraph 3.2.8.2:

“The chromate treatment required for conversion to Type II shall be a treatment in or with an aqueous solution of salts, acids, or both, to produce a continuous smooth, distinctive protective film, distinctly colored iridescent bronze to brown including olive drab, yellow and forest green.”

AMS QQ-P-416 Rev E Paragraph 3.2.8.2:

“The phosphate treatment required for conversion to Type III shall produce a tightly adherent film conforming to Type I or TT-C-490.”
6.3.2 Part-to-Print Decision for Jig Marks, Damage and Color Variation

Table E6 below defines the Part-to-Print decision for jig marks, damage and color variation on surfaces with electrodeposited cadmium plating.

Y = Yes (Part-to-Print), N = No (Part is Non-Conforming)

### Table E6 - Part-to-Print Decision, Jig Marks, Damage & Color Variation

<table>
<thead>
<tr>
<th>Surface Irregularity</th>
<th>Acceptability for Surfaces Finished with Cadmium Plating</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRICAL CONTACT MARKS OR JIG MARKS</td>
<td>N</td>
</tr>
<tr>
<td>LOOSE COATING</td>
<td>N</td>
</tr>
<tr>
<td>VOIDS</td>
<td>N</td>
</tr>
<tr>
<td>TACTILE FLAWS</td>
<td>N</td>
</tr>
<tr>
<td>FLAWS PENETRATE THROUGH COATING</td>
<td>N</td>
</tr>
<tr>
<td>May be detected by change in color or reflectivity</td>
<td></td>
</tr>
<tr>
<td>VISUAL ONLY FLAWS</td>
<td>Y</td>
</tr>
<tr>
<td>NOT tactile</td>
<td></td>
</tr>
<tr>
<td>Do NOT penetrate through coating</td>
<td></td>
</tr>
<tr>
<td>COLOR VARIATION OF CHEMICAL CONVERSION COATING (TYPE II ONLY)</td>
<td>Y*</td>
</tr>
</tbody>
</table>

*Note: Per the AMS-C-8837 and AMS QQ-P-416 specifications, “The chromate treatment required for conversion to Type II shall... ...produce a continuous smooth, distinct protective film, distinctly colored iridescent bronze to brown including olive drab and yellow.”

6.3.3 Part-to-Print Decision for Cadmium Plate Runout

Table E7 below defines the Part-to-Print decision for runout of Cadmium Plating.

Y = Yes (Part-to-Print), N = No (Part is Non-Conforming)

### Table E7 – Part-to-Print Decision, Cadmium Coating/Plating Runout
<table>
<thead>
<tr>
<th>Surface</th>
<th>Presence of Cadmium Plating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface with Cadmium Coating/Plating Requirement</td>
<td>Y</td>
</tr>
<tr>
<td>Fillet, Chamfer or Edge Break between Cadmium Coated/Plated Surface and Adjacent Surface</td>
<td>Y</td>
</tr>
<tr>
<td>Adjacent Surface to Cadmium Coated/Plated Surface</td>
<td>N</td>
</tr>
</tbody>
</table>
6.3.4 Examples

**Drawing Requirements:**
Apply Cadmium per AMS QQ-P-416 Type II

**Figure E14 – B43945-002, Cadmium Runout, Non-Conforming**

Part is Non-Conforming for the following reasons:

- Cadmium is present on the surfaces designated by the drawing and is present on the fillet between the cadmium plated surface and the adjacent surface (i.e. to Part-to-Print per Table E7). However...
  - Cadmium extends 1mm (0.061") onto the adjacent surface, i.e. 1mm beyond where the fillet transitions into the OD.
  - Per Table E7 parts that have cadmium present any distance onto the adjacent surface shall be considered Non-Conforming.
Part is Non-Conforming for the following reasons:

- The chemical conversion coating has been removed in places due to part to part contact. This is detectable at 1X by the change in color.

- Per Table E6, parts with flaws that penetrate through the coating are considered Non-Conforming.
Part is Non-Conforming for the following reasons:

- The cadmium coating is chipped to the extent that cadmium is missing and the base material is exposed. This is detectable at 1X.

- Per Table E6 damage to the cadmium must NOT penetrate through the coating. Therefore the part is Non-Conforming.