VALVE RESEARCH & MANUFACTURING CO.
OPERATING PROCEDURE

GP- 008

REV: N/C

WORKMANSHIP REQUIREMENTS
FOR
VR SUPPLIERS

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REVISIONS

LETTER	DESCRIPTION	DATE
N/C	INITIAL RELEASE	8/1/23

1. SCOPE

This document defines and establishes supplemental criteria to be used in conjunction with VRM engineering drawings and specifications, which are not subjected to customer control. This document shall be used, when required by drawings or Purchase Order, to establish acceptable standards of quality, good workmanship, and accepted shop practice when a specific designation covered herein is not specified or is incompletely defined in the applicable drawing or specification.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent applied herein. Unless otherwise specified, the latest issue of the document shall apply. All documents listed below shall reference the latest revision available.

ASME Y14.5	Dimensioning and Tolerance Standard
ASME B46.1	Surface Texture

3. DEFINITIONS

Imperfection: An interruption (non-uniformity) in the normal surface condition of a part configuration which shall be evaluated for acceptance to the applicable standard.

Lay: The direction of the predominant surface pattern.

Smooth: A surface that is continuously even, free of irregularities, presenting no resistance to the sliding of a finger or probe.

Referee Magnification: A level of magnification higher than what normal inspection/evaluation would be done at. This level of magnification is only used to verify or confirm what is identified using the standard level of magnification.

Superficial Imperfection: An imperfection on a surface which although appears to penetrate the surface finish texture, does not have a dark bottom, and would not cause a probe to hesitate (catch) when passed over it.

Surface Roughness: Marks left on the surface of a part by the action of machined tools.

Visual Inspection: Visual inspection is one of the most important elements of product evaluation.

Tin Soldier Inspection: The tin soldier inspection method compares a known good unit against other parts in the production lot. This method is very useful to detect missing or incorrect operations.

Contamination: Contamination is defined as burrs, chips, dirt, machining oil or coolant, grinding, honing, or lapping grit, excessive corrosion or discoloration or any other substance foreign to the base materials of a component or assembly.

4. GENERAL REQUIREMENTS

4.1. Parts being processed through production operations shall be stored in suitable containers that are adequate to protect the parts from physical damage / contamination.

4.2. All parts or components shall be visually inspected by personnel for evidence of handling damage before each operation.

4.3. All workstations, tooling, fixtures, and inspection equipment shall be kept free of dirt, excess oil fluids, rags, loose metal chips, burrs, any foreign materials that can damage or become potential F.O.D.

4.4. All deburring personnel shall ensure parts are burr free before stamping off of router.

4.5. All deburring personnel shall verify burr removal by 5X microscope magnification or better. Note: specific detailed components may require higher microscope magnification (i.e., 10X or greater) for burr detection.

4.6. All CNC personnel shall monitor tool life as needed for evidence of excessive wear. Tooling shall be replaced as needed or before tool failure results.

4.7. All CNC personnel shall make sure parts are free of tool chatter on all applicable machined surfaces of parts.

4.8. Below is a list workmanship requirement for components or common part features. These descriptions shall aid in the understanding of a defined part feature. All personnel shall follow these requirements for a given part feature. The VRM drawing shall always apply before the following below:

a. Blending Surface
Connecting curved surfaces or curved and plain surfaces shown as a tangent must blend smoothly. Attention to the general note on the blueprint as this shall specify tolerances.

b. Mismatch of Machined Surfaces
When two or more machining cuts are required to produce a surface delineated on the drawing as being a theoretical single surface, the maximum misalignment between intersecting or adjacent surfaces shall not exceed 0.005 inch or must be contained within the limits of dimensional size, whichever is the smaller.

c. Breaking Sharp Edges
Unless otherwise stated on the drawing, the standard to which sharp edges must be broken is from 0.003 to 0.010 inch. Any method may be used to break such edges, provided a radius or a flat without sharp corners is produced within the tolerance given.

d. Chamfers for Internal Thread Ends
Unless otherwise noted on the drawing, a chamfer with an included angle of 80 to 120 degrees shall be used at internal thread start. The minimum diameter of the chamfer shall be the major diameter of the thread. The maximum diameter of the chamfer shall be the major diameter of the thread plus 0.030 inch.

e. Chamfers for External Thread Ends
Chamfers shall be provided at the ends of externally threaded parts. The chamfer shall extend to the minor diameter of the thread. The angle of the chamfer shall be 45 plus or minus 5 degrees. The minimum length of the chamfer shall be the height of the external thread.

f. Thread Length
The thread length dimensions indicated on the drawing are the gaging length or the length of threads having full form. Three perfect or imperfect threads are allowable beyond such limit for lead of tap where hole depth permits.

5. VISUAL INSPECTION REQUIREMENTS

5.1. Parts shall be 100% visually inspected to assure they are free from nicks, dents and other visual anomalies. The use of magnification with supplemental illumination may be required if specifically stated on the PO/Drawing or depending on the physical size or configuration of the part. Additional magnification may also be required for referee inspection to verify a condition.

5.2. Visual imperfections which will be removed by subsequent machining or process operations may be disregarded.

5.3. General Appearance
When visually inspecting a group of parts, the "Tin Soldier Method" may be used. Establish a "Master" part from the manufacturing lot and verify that it meets the drawing requirements. Line up the remaining parts from the manufacturing lot such that they are all in the same orientation. Visually inspect the remaining parts against the "Master" checking for the following:

a. Proper geometry (i.e., no missing features such as holes, threads, chamfers, radii, etc.)
b. For an assembly, presence and proper installation of all components (including inserts, bushings, hardware, lock-wire, etc.)
c. Presence of required surface treatment (e.g., shot peen, plating, anodize, paint, etc.)
d. Correct, legible and properly located marking and no visible damage.

5.4. Surface Condition

Visually inspect surfaces of the parts to identify any surface imperfections or flaws. Use a probe, magnification and other special aids as required to assist in the detection of any imperfections. Comparison with similar parts or photographs may be used to gauge against any observed conditions.

5.5. Machined Parts

Typical surface imperfections for machined parts are listed in Table 2. Table 2 also includes imperfections associated with surface treatments applied to machined parts.

5.6. Contamination

This section details the components which require special visual inspection. Material rejected for contamination shall be de-burred and/or cleaned and re-inspected to assure that all contamination is removed.

5.6.1. F.O.D. visible at 1x (refereed up to 10x) that cannot be easily removed, or any conditions or substance that would violate a design requirement or have detrimental effect on the component, would be considered nonconforming. Any F.O.D. that can be easily removed or blown away, or is inherent to typical handling practices, would be deemed acceptable.

5.7. Components Requiring Special Visual Inspection

5.7.1. Seats – in all cases, the valve seat edge must be sharp and free of nicks and burrs.

5.7.2. Bodies, Spacers, and Poppet Guides – These parts often consist of drilled holes. These drilled holes will be exposed to fluid flow when the valve is operational; therefore, it is imperative that all burrs, chips, and dirt are removed from these holes.

5.7.3. Solenoid Bores – The bore in the solenoid core must be free of burrs, nicks, dirt, and scratches.

5.7.4. Internal Threads – All internal threads must be inspected for contamination.

6. EQUIPMENT REQUIREMENTS

Below is a partial list of equipment used to aid in visual inspection of components or parts.

6.1. Lighting

Fixed white lighting in the inspection area shall be a white light intensity of 100 foot-candles minimum when measured at the inspection surface for the parts. The lighting shall be designed and arranged to provide shadow free and glare free illumination of the part surface to be inspected.

6.2. Supplemental Lighting

Special or supplemental lighting shall be used if necessary to properly inspect components. The need to use supplemental lighting is primarily determined by the size and configuration of the component.

6.3. Probe

A probe (stylus) with a spherical end (nose) radius ranging in size from 0.005 to 0.025 inch shall be available to assist in the detection of raised material or an imperfection.

6.4. Microscope (stereo-zoom, 5X – 30X)

This shall be available to assist visual inspection when in doubt of part imperfections.

6.5. Surface Roughness Gage (Profilometer)

This gage is to aid the operator in verification of the specified surface roughness callout on a part feature.

APPENDIX

IMPERFECTION TYPE	DEFINITION	MAGNIFICATION REQUIREMENT	DISPOSITION	COMMENTS
Blister	A localized lifting of a coating, plating or paint from the surface of the part base material. It appears as a protuberance that may break when probed.	1X Un-aided eye	If part fails copper sulfate test, Not Acceptable	
Burnish Mark	A local smoothing of a metal surface, often to a high luster from rubbing. It may show scratches of no apparent depth. Includes buffing and polishing marks.	1X Un-aided eye	Acceptable provided it cannot be felt by a probe and that the material thickness still meets the drawing requirement	
Burr	A rough ridge or edge left at the intersection of two surfaces. A fragment of metal which remains attached to the surface after a machining operation.	No burrs visible at 1-3X, (Referee Mag. 10X)	Not acceptable	See Table 2
Chatter Mark	Recurring undulations or irregularities on the surface that result from vibration or jumping of a machining cutting tool.	1X Un-aided eye	Acceptable provided it meets the drawing surface roughness requirement	
Corrosion	A deterioration of a metal surface resulting in a change of color and leaving a rough surface that may show pitting. Caused by chemical or electrochemical interaction.	1X Un-aided eye (Referee Mag. 10X)	Not acceptable	
Crack	A separation of metal on the surface visible to the un-aided eye.	1X Un-aided eye	Not acceptable	
Crazing	A network of fine cracks.	1X Un-aided eye	Acceptable provided it meets the drawing surface roughness requirement	
Deformation	Convex or concave change in the profile of a part.	1X Un-aided eye	If deformation causes any dimension to be out of spec, not acceptable	
Dent / Ding	A surface depression having rounded edges, corners and bottom caused by impact with an object.	1X Un-aided eye (Referee Mag.10X)	Acceptable provided depth of dent / ding is less than maximum allowable per drawing and no raised material	See table 2 for maximum allowable depth

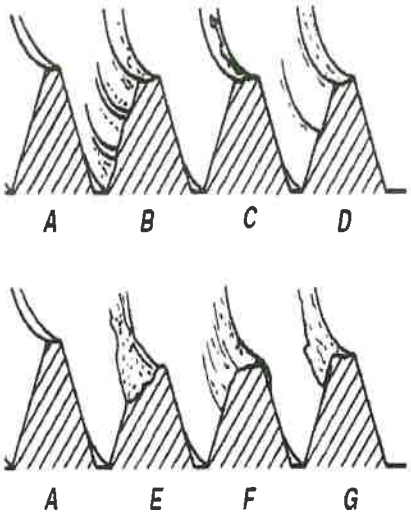
IMPERFECTION TYPE	DEFINITION	MAGNIFICATION REQUIREMENT	DISPOSITION	COMMENTS
F.O.D. / Contamination	Material or substance not integral to the part. The material or substance may or may not be adherent to the part surface. Chips from machining are considered foreign material.	No FOD visible at 1X. (Referee Mag. 10X)	Not acceptable	If the FOD is loose and can be blown away then it would be deemed acceptable
Gouge	A relatively wide trough-like depression caused by tearing away of the surface by another object.	1X Un-aided eye	Acceptable provided depth of the gouge is less than maximum allowable	See table 2 for maximum allowable depth
Heat Discoloration	Staining, ranging from straw color (low temperature effects) to purple in color (high temperature effect).	1X Un-aided eye	Acceptable provided it is light straw to light blue in color.	
Nick	A negative indication having raised sharp edges, corners or bottom.	1X Un-aided eye (Referee Mag. 10X)	Acceptable provided depth of nick is less than maximum allowable and no raised material	See table 2 for maximum allowable depth
Peeling	A section of a coating, plating or paint lifting away from the surface.	1X Un-aided eye	If part fails copper sulfate test, Not Acceptable	
Pits	Small irregular cavities in surfaces generally rough or dark bottomed resulting from corrosion.	1X Un-aided eye	Acceptable provided it meets the drawing surface roughness requirement	
Scoring	Multiple scratches caused by contact with a mating part or tooling.	1X Un-aided eye	Acceptable if scoring is smooth and does not violate surface roughness requirement	See table 2 for maximum allowable depth
Scratch	A linear depression with a sharp bottom.	1X Un-aided eye (Referee Mag. 10X)	Acceptable if scratches are smooth and do not violate surface roughness requirement	See table 2 for maximum allowable depth
Stain	Visual indication result from liquid drying on a part surface.	1X Un-aided eye	Acceptable if stain can be removed with alcohol / acetone or is inherent to the applicable process (i.e. thermal processing)	
Step	An abrupt change in the surface contour which looks like a step in cross section.	1X Un-aided eye (Referee Mag. 10X)	Acceptable provided it meets the drawing dimensional requirements	

IMPERFECTION TYPE	DEFINITION	MAGNIFICATION REQUIREMENT	DISPOSITION	COMMENTS
Tool Marks	A mark in the direction of the machining lay left by the machining tool or across the lay caused by improper tool withdrawal or metal chips. Mark can be straight, circular or spiral.	1X Un-aided eye	Acceptable provided it meets the drawing surface roughness requirement	
Non-Uniformity	The quality or state of not being uniform. Having different, non-continuous appearance.	1X Un-aided eye	Acceptable provided the plating / coating meets the requirements of the spec	

TABLE 2

IMPERFECTION TYPE	SEALING SURFACE	FUNCTIONAL SURFACE	NON-FUNCTIONAL SURFACE
Corrosion	Not Acceptable	Not Acceptable	Not Acceptable
Cosmetic (i.e.. dent / ding, gouge, nick, scoring, scratch)	0.0005"	0.002"	0.005"
Burrs	Not Acceptable	Dynamic (moving) – Not Acceptable Static – Acceptable	If solidly attached, Acceptable
Special Processes (Blister, flaking	Not Acceptable	Not Acceptable	Not Acceptable

Threaded bores/holes should be free of chips, burrs and major discontinuities. Chips and dislodged burrs may degrade or entirely disable systems, while major discontinuities may damage mating parts or complicate assembly.



A - As designed thread configuration

B - Tool marks or ribbed sidewall; ***ACCEPTABLE***

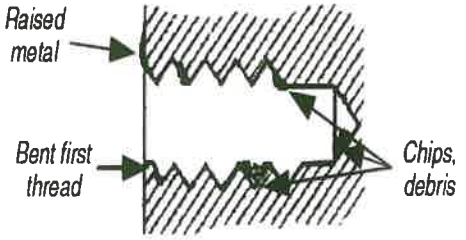
C –Burr rolled over material on crest; UNACCEPTABLE

D - Stepped sidewall and crest; ***ACCEPTABLE***

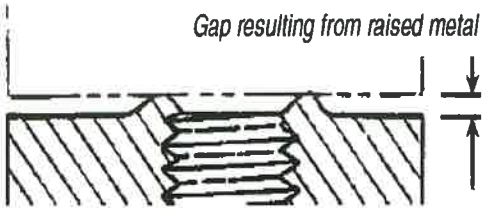
E - Torn sidewall & crest; ***UNACCEPTABLE*** *unless sharp edges are blended*

F - Loose burr turned partially concealed on sidewall; ***UNACCEPTABLE***

G - Same condition as in F shown in the exposed position; ***UNACCEPTABLE***

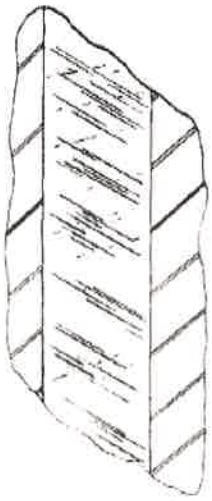


UNACCEPTABLE Conditions in Threaded Holes

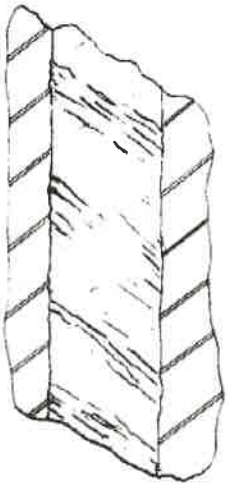


Extruded Material Surrounding Threaded Hole
UNACCEPTABLE

Surfaces of machined holes should be free of stripped and potentially loose metal particles.

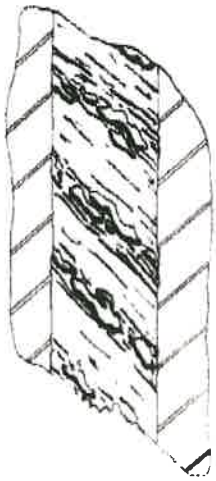


Uniform surface



Rough surface but no potentially loose particles

ACCEPTABLE



Potentially loose friction welded particles

UNACCEPTABLE

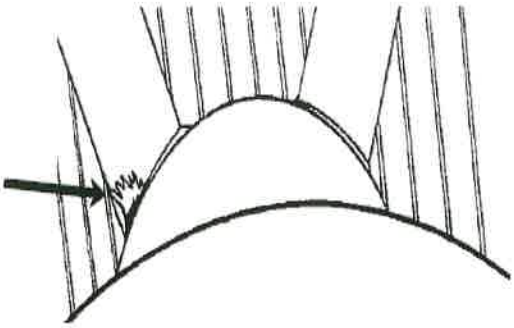
Part geometry may present challenges to detecting or removing burrs.

- Holes - Dependent upon the material, machining process, and dimensions, difficult to detect burrs and other imperfections may be created.

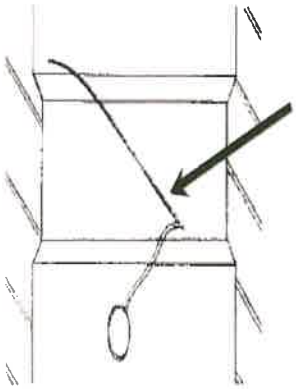
Feathered burr (UNACCEPTABLE) - Difficult to detect

- Scalloped recesses - Burrs and contaminants may be hidden from view.

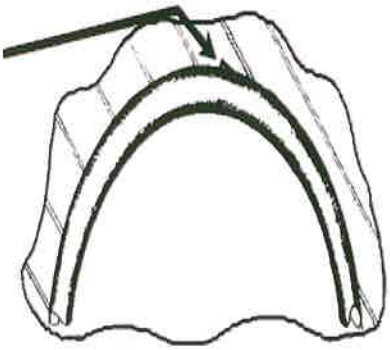
Burr in recess that may be hidden from view



- Seal surfaces - Typically machined to a ± .001 inch tolerance with 32 RHR surface finish, sealing surfaces are susceptible to scratches that may result in fluid leakage around O-ring and elastomeric seals.



UNACCEPTABLE Scratches completely across seal surfaces



Non-Conformance Part Examples

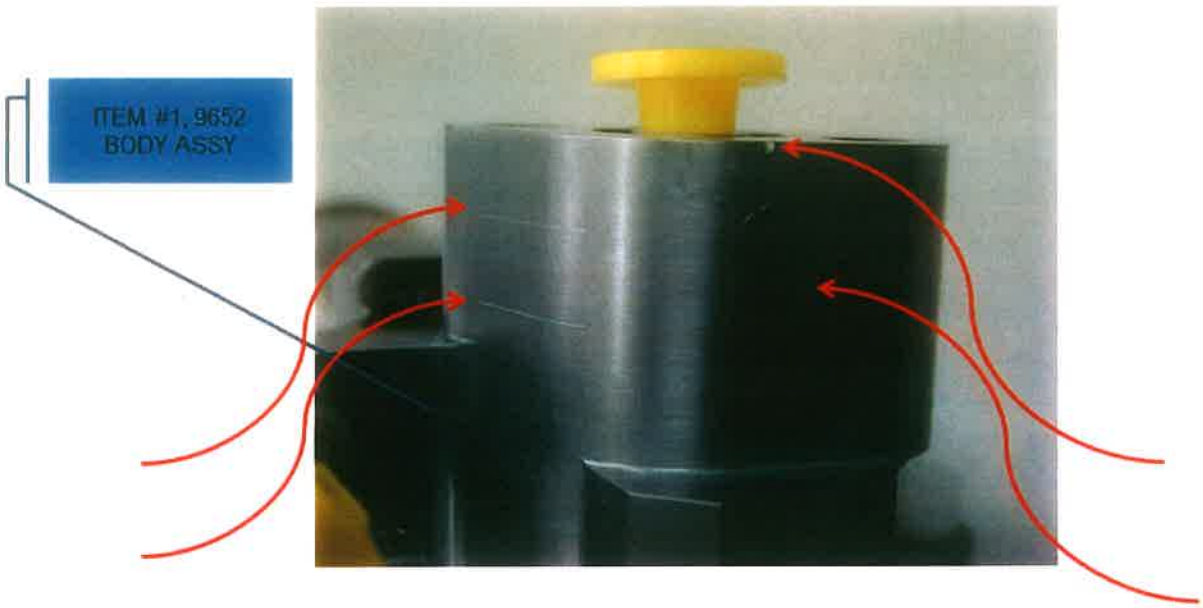


Figure 1 – Nicks & Scratches on Body Assembly

- Part is Non-Conforming if scratches violate the finish requirement.

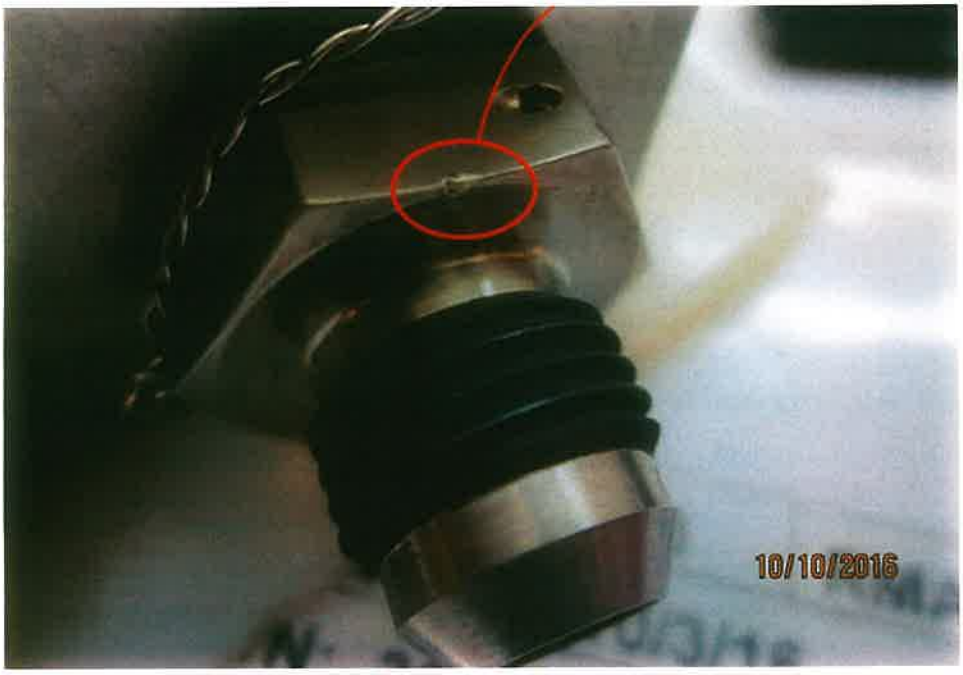


Figure 2 – Nick on Fitting Hex Edge

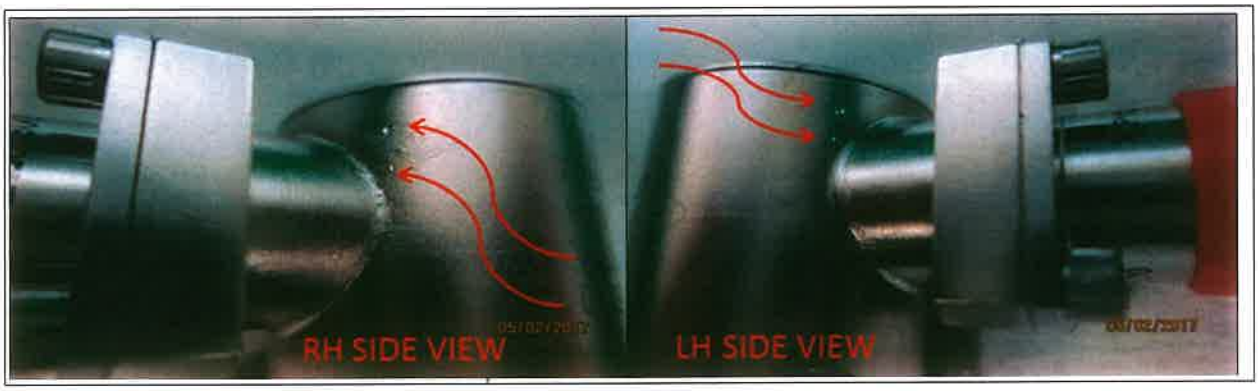


Figure 3 - Dents on Body

- Part is Non-Conforming if ding has raised material or is deeper than the max allowed.

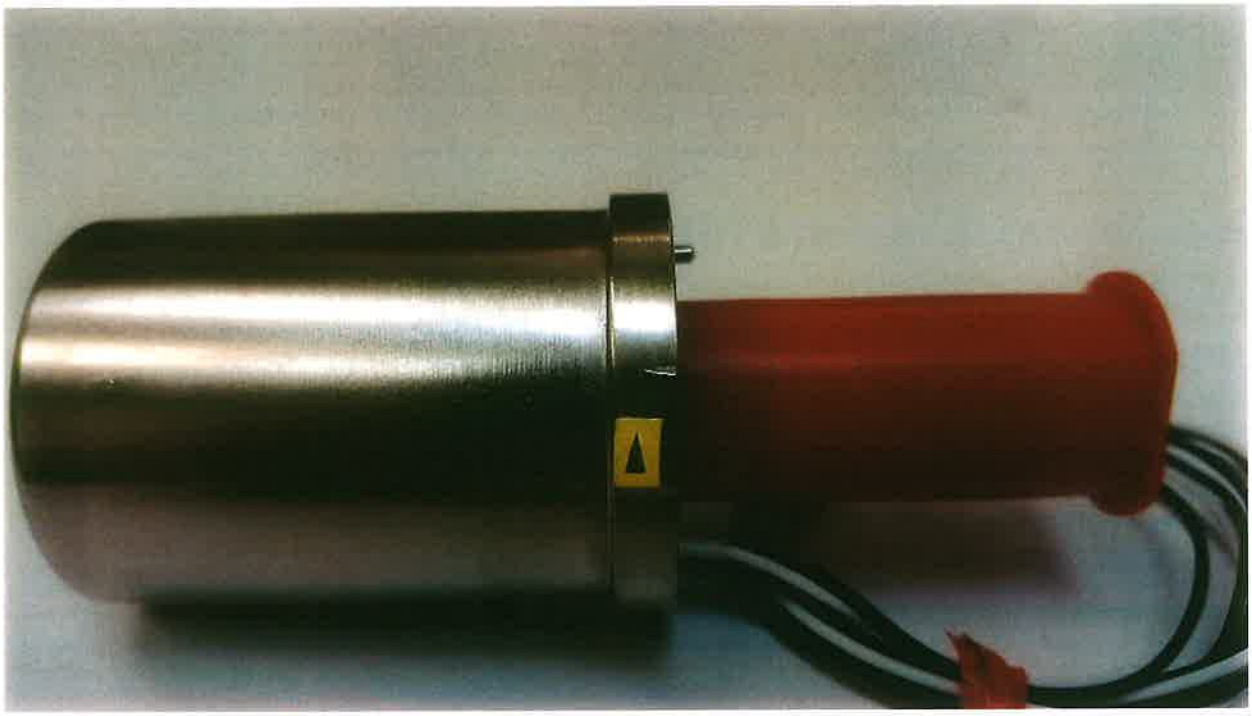


Figure 4 – Dent

- Part is Non-Conforming due to damage (Dent)

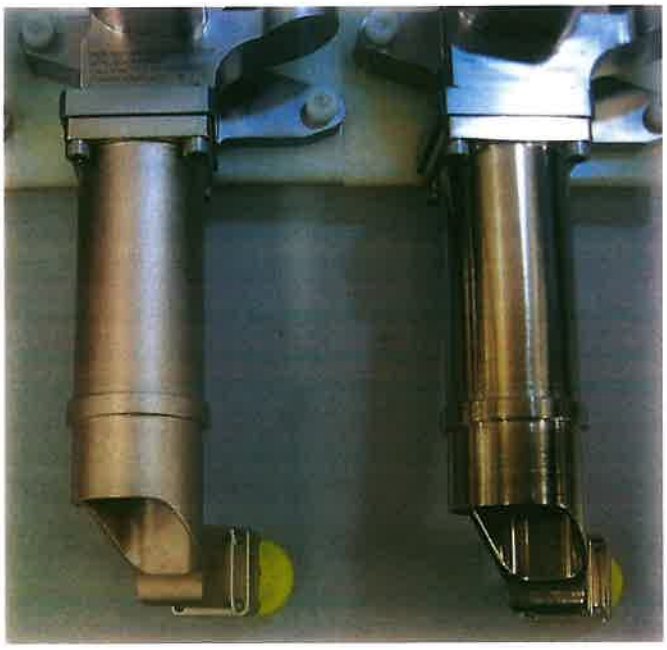


Figure 5 – "Inconsistent" Plating Appearance

- Parts are Acceptable although non-uniform condition, dull vs. shiny, parts meet plating spec.

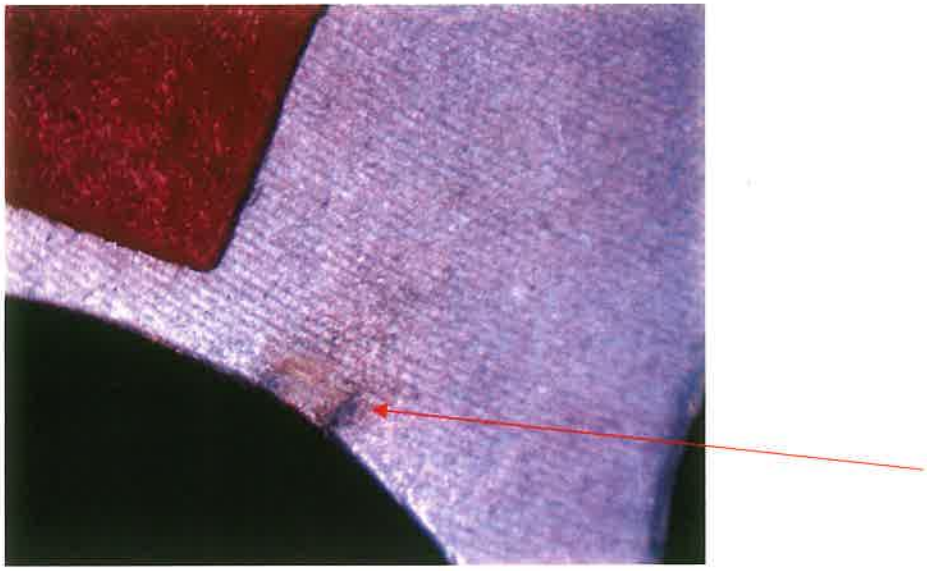


Figure 6 – Corrosion / Oxidation

- Part is Non-Conforming due to rust / corrosion / oxidation.

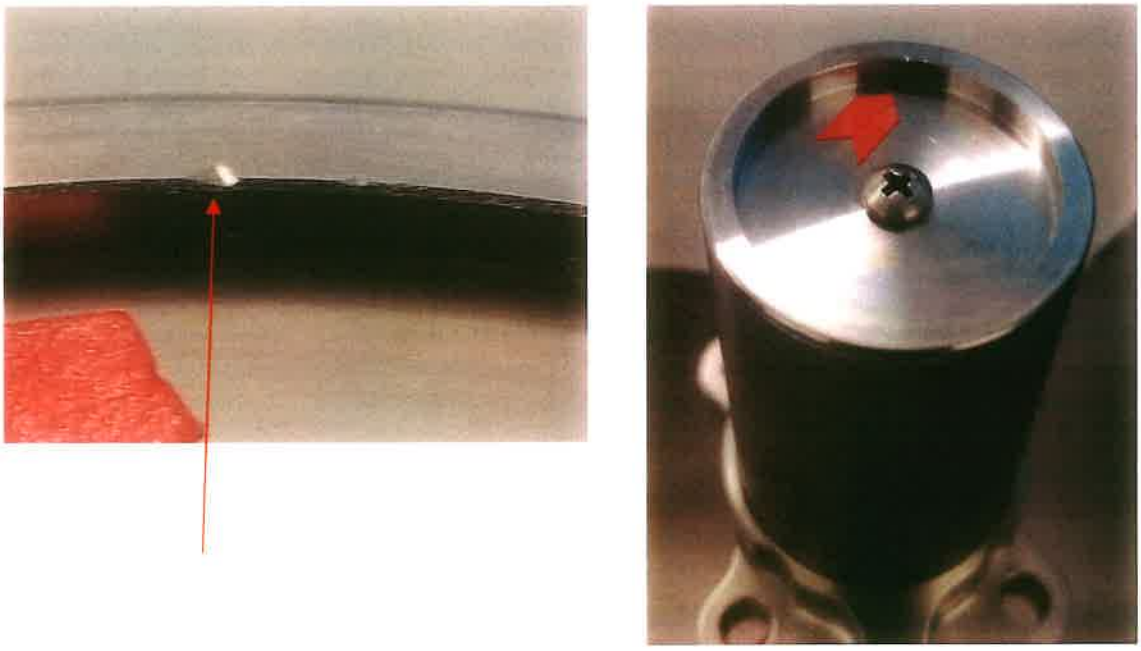


Figure 7 – Dings on Non-Functional Surface

- Part is Non-Conforming if ding has raised material or is deeper than the max allowed.

Figure 8 – "Inconsistent" Anodize Appearance

- Part is Acceptable although parts are not uniform, yellowish vs. silver, spec allows for it.

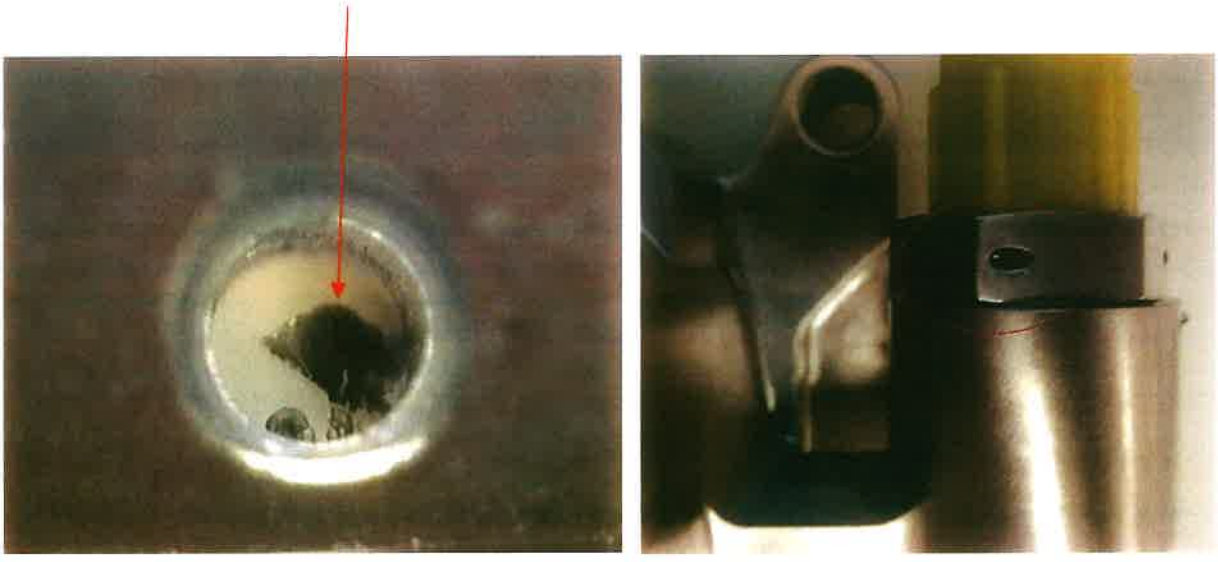


Figure 9 – Burrs

- Part is Non-Conforming due to loose burrs inside of the hole.

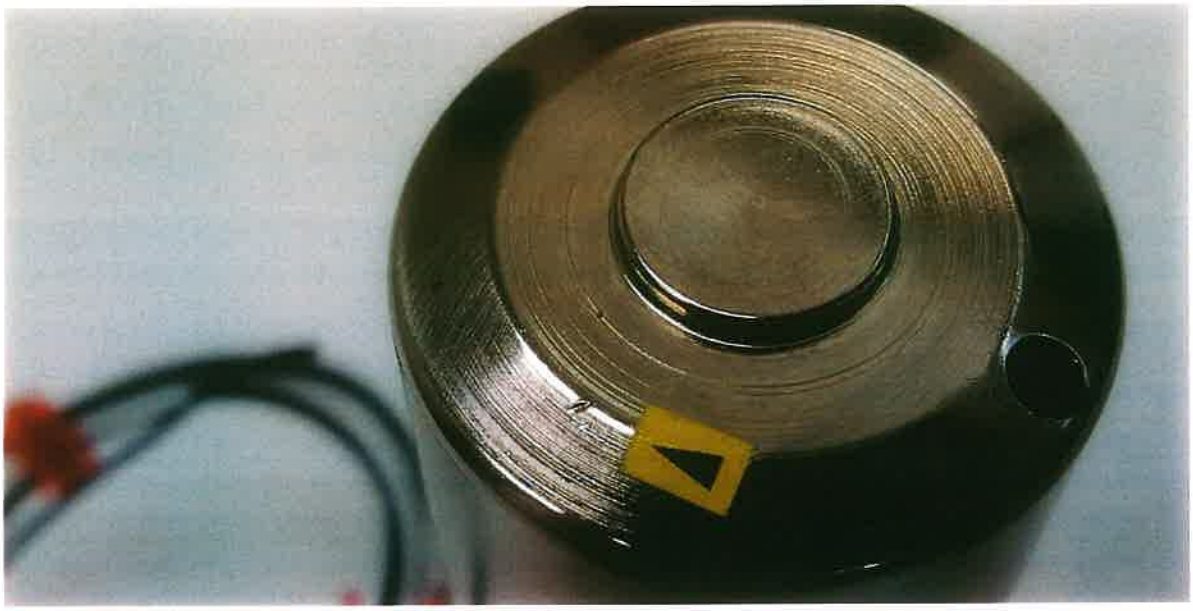


Figure 10 – Ding on Housing

- Part is Non-Conforming

Figure 11 – Plating Variation

- Part is Non-Conforming due to variation in the plating (uniformity).

Figure 12 – Ding on Port

- Part is Non-Conforming if ding has raised material or is deeper than the max allowed.

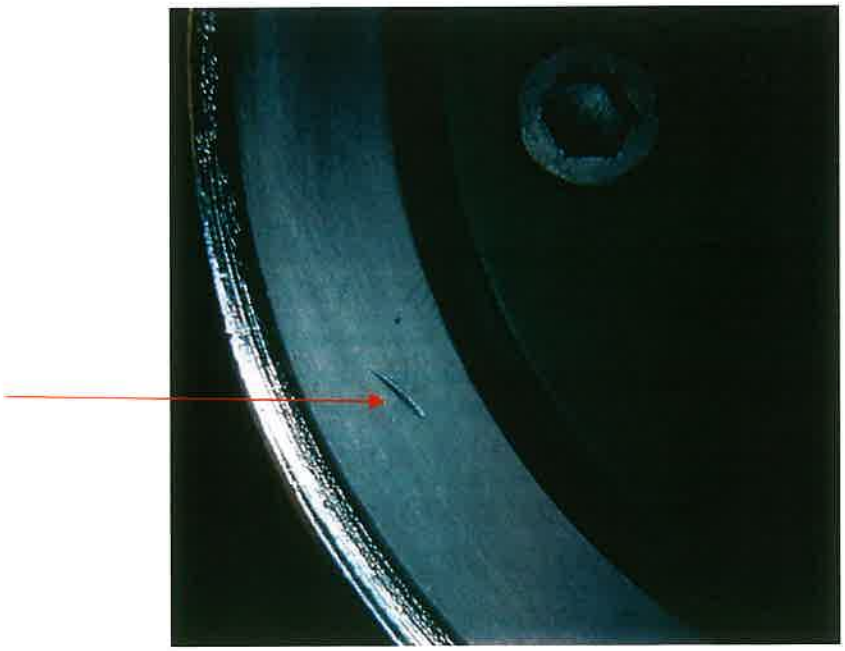


Figure 13 – Nick

- Part is Non-Conforming due to a nick that exceeds allowable depth.

Figure 14 – Contamination

- Part is Non-Conforming due to contamination / stains.

Figure 15 – "Inconsistent" Plating Appearance

- Part is Non-Conforming due to non-uniform condition, grainy vs. smooth.

Figure 16 – "Inconsistent" Plating Appearance

- Part is Non-Conforming due to non-uniform condition, shiny vs. stained.

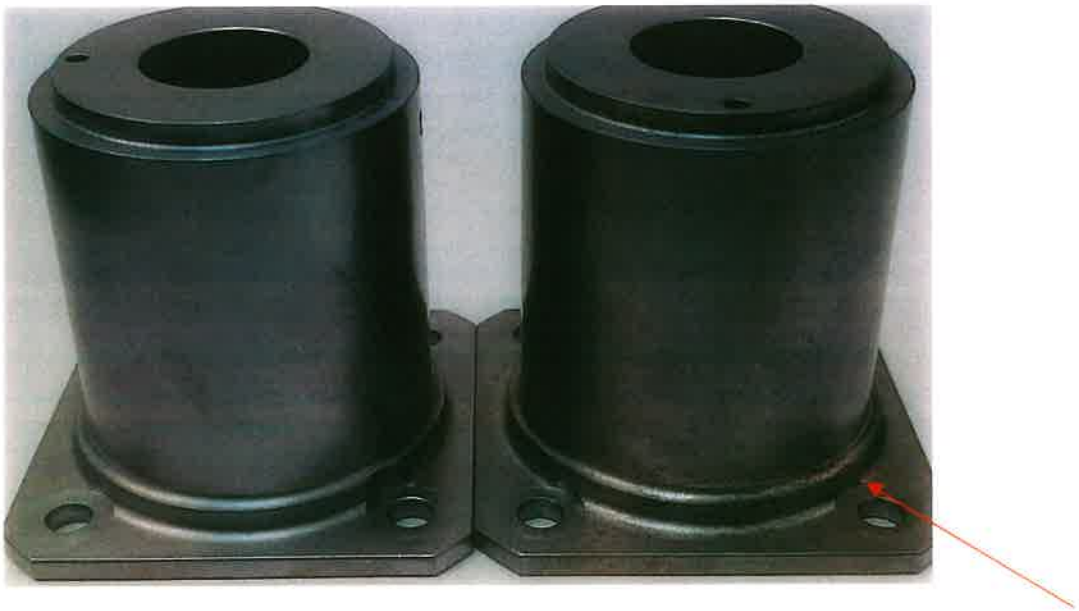


Figure 17 – "Stained" Appearance

- Part is Non-Conforming due to stains after the passivation process and parts are not uniform.

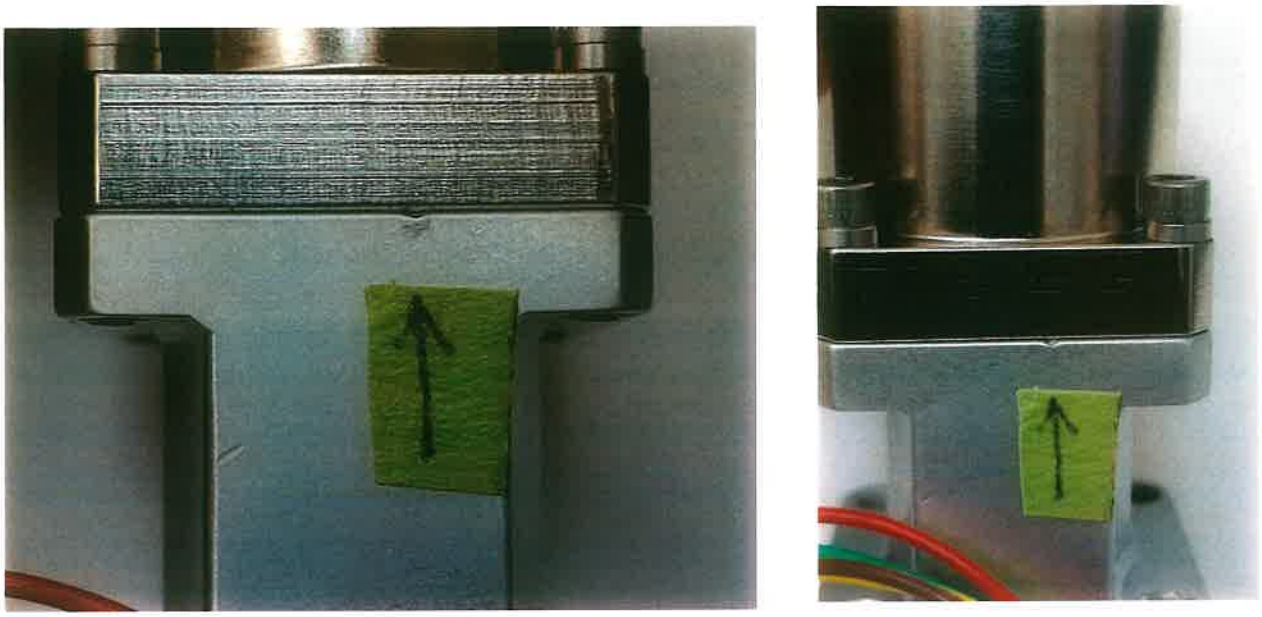


Figure 18 – Damaged Body

- Part is Non-Conforming

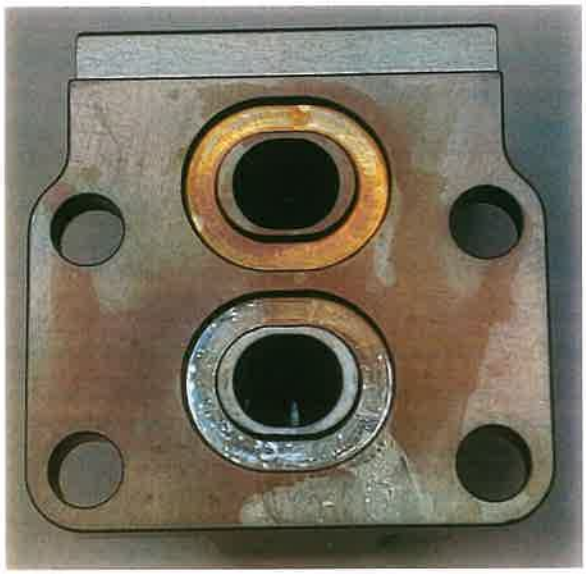


Figure 19 – Poor Coating

- Part is Non-Conforming due to non-uniform appearance of coating.

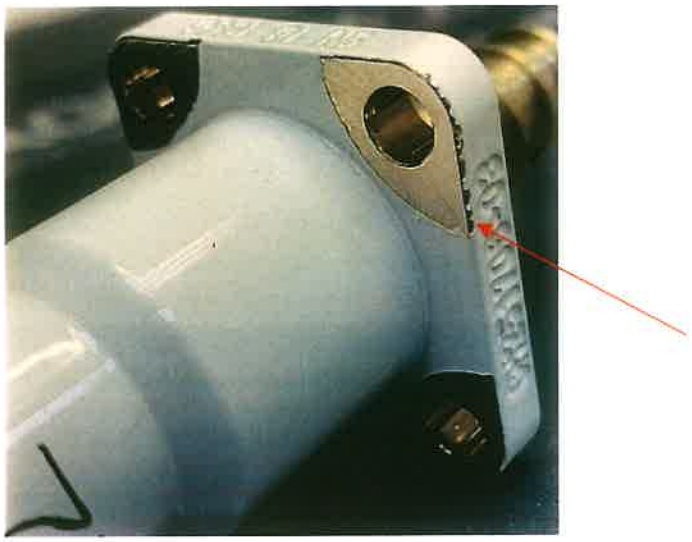


Figure 20 – Chipped Paint

- Part is Non-Conforming due to chipped paint.

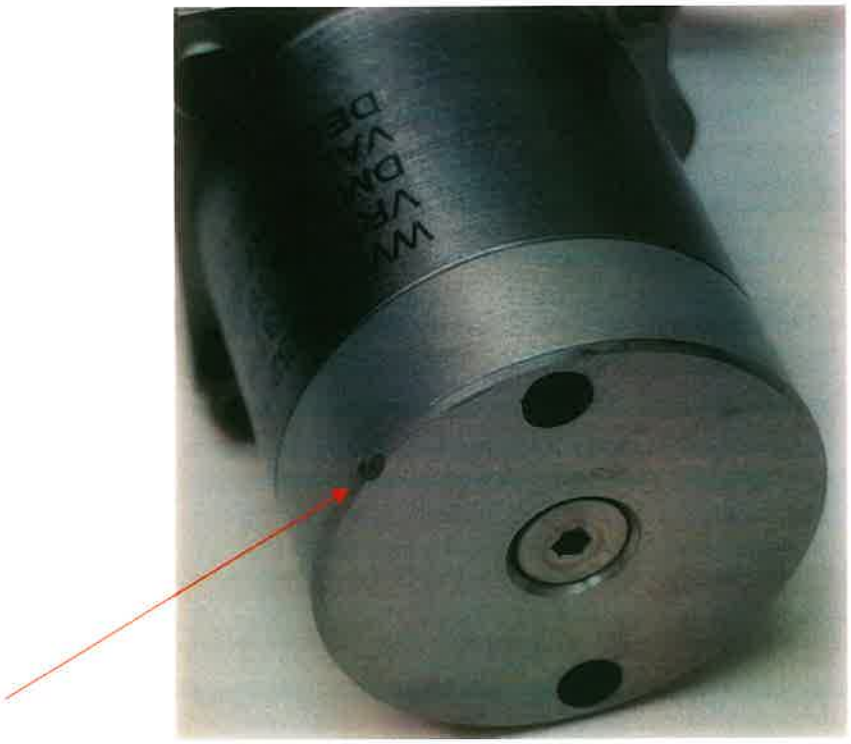


Figure 21 – Ding

- Part is Non-Conforming

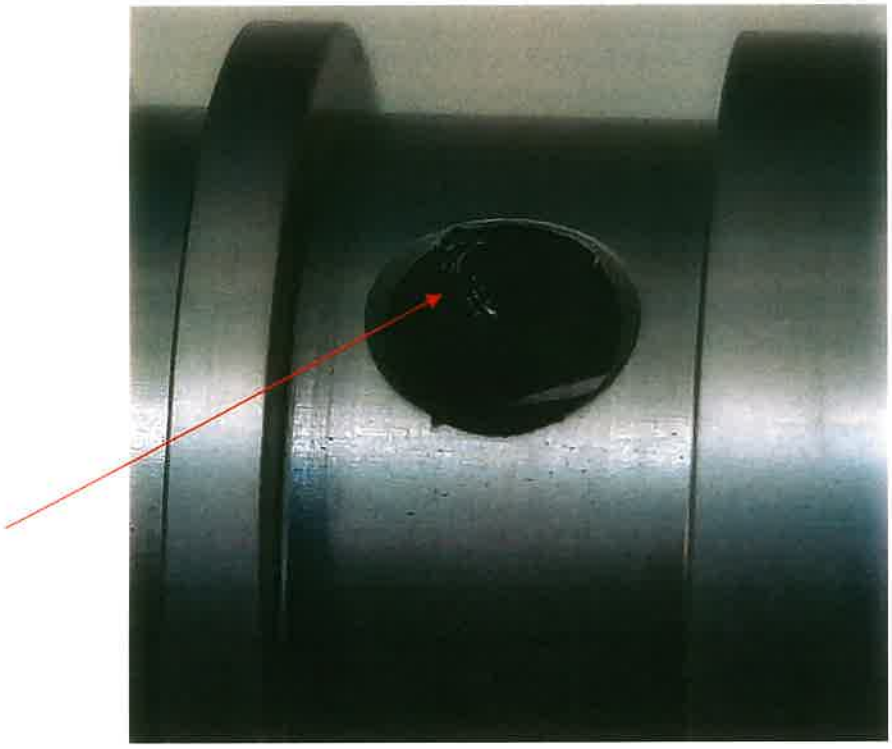


Figure 22 – Damage

- Part is nonconforming due to damage. Damage has raised material which is unacceptable.

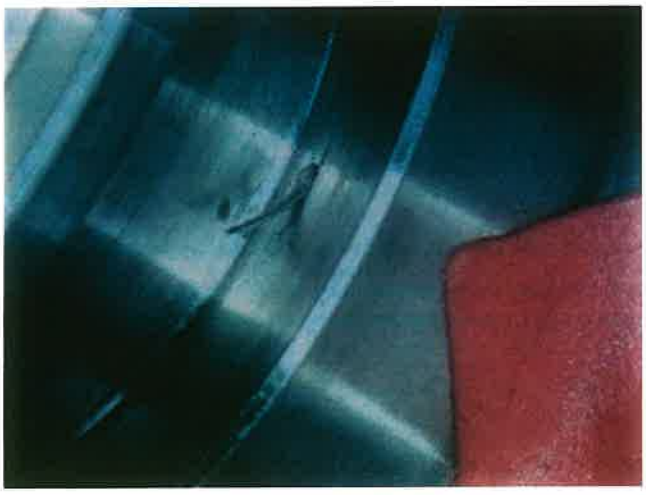


Figure 23 – Chip adhered to the part

- Part is nonconforming due to contamination which is attached to part.

Figure 24 – Chip adhered to the part

- Part is nonconforming due to contamination which is attached to part.

Figure 25 – Chip adhered to the part

- Part is nonconforming due to contamination which is attached to part.

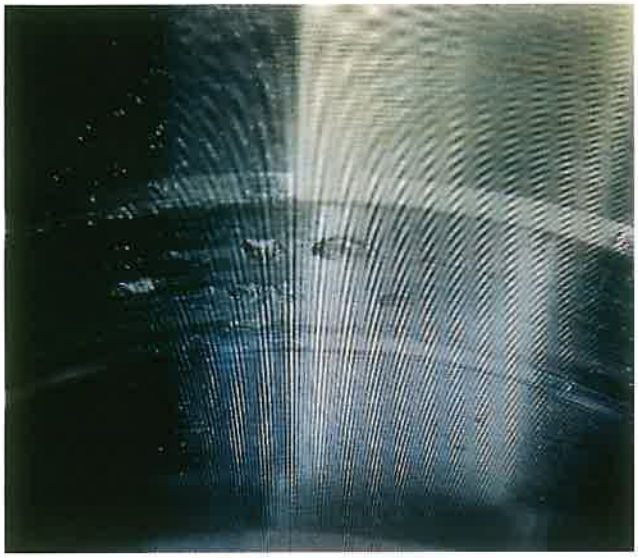


Figure 26 – Chip adhered to the part

- Part is nonconforming due to contamination which is attached to part.

Figure 27 – Burr

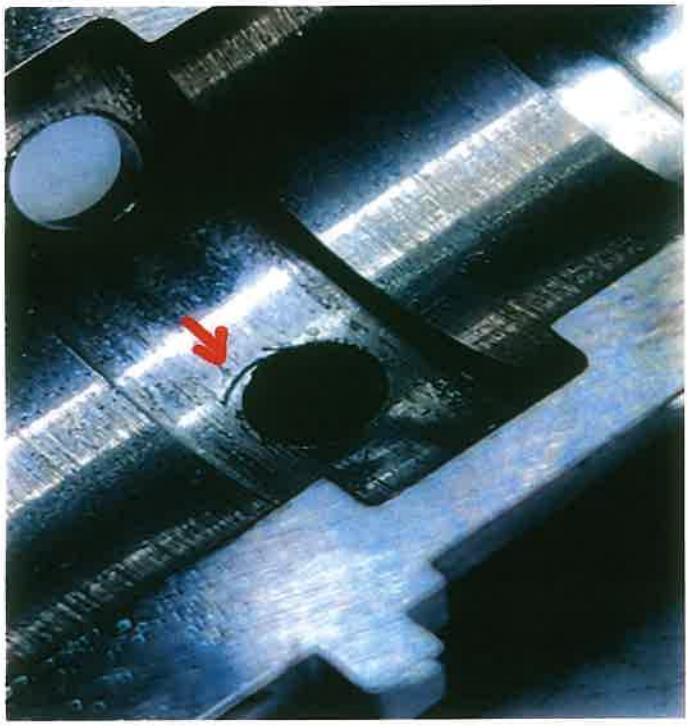


Figure 28 – Burr

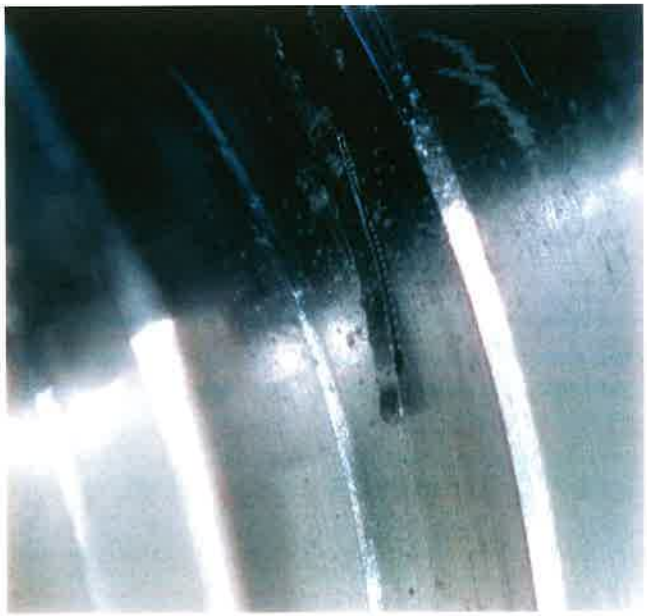


Figure 29 – Chip adhered to the part.

- Part is nonconforming due to contamination which is attached to part.

Figure 30 – Burr

Figure 31 – Damage.

Figure 32 – Damage

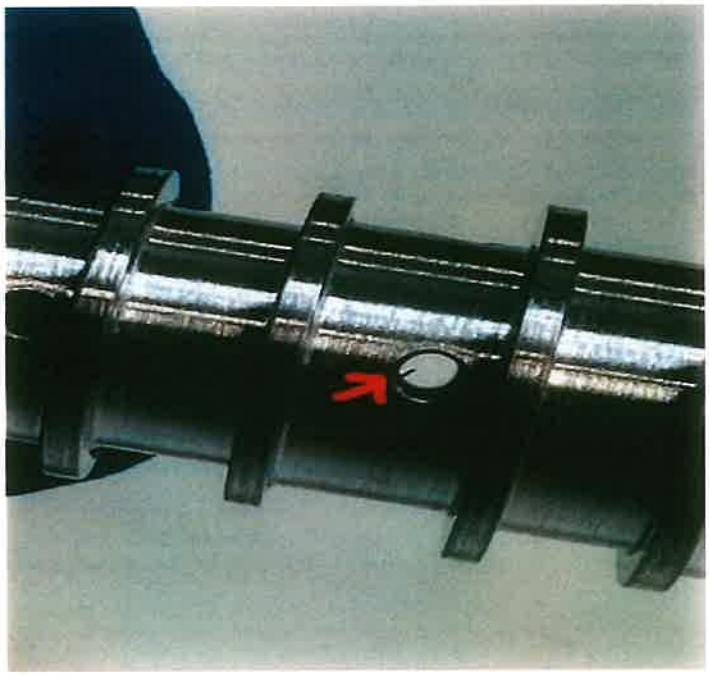


Figure 33 – Burr

Figure 34 – Corrosion

Figure 35 – Corrosion