# SARA SAE PRIVATE LIMITED

## Management System Document Control Cover Sheet

| Document Title | Ref. No. | Revision No. |
|---|---|---|
| **Procedure for Visual Examination of Steel Castings / Forgings and Welded Joints** | **SSE/QAD/VE-93** | **3** |

| | Name | Position | Signature | Date |
|---|---|---|---|---|
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Document Control Stamp (Valid only if in red)

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**Revision Status**

| Revision No. | Effective Date | Description / Summary of Revision |
|---|---|---|
| 1 | | Initial Issue |
| 2 | 10.11.2012 | Addition of Casting and Forgings |
| 3 | 28/12/2015 | Compliance with API 6A, 16A, 16C and MSS – SP - 55 |
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Contents



## 1. Scope

This procedure describes the requirements for visual examination of fusion welds in metallic materials and welded joints (for measurement of welding parameters and weld profiles in accordance with BS EN 970:1997 & ISO - 17637 - 2011 and evaluation of weld flaws in accordance with the specified acceptance standards).

The methods detailed herein shall be used by SARA SAE for visual examination of steel castings and forgings. Evaluation of flaws shall be done in accordance with the specified acceptance standards in this procedure.

## 2. Personnel Qualification

2.1 As a minimum, personnel assigned to perform visual inspection in accordance with this procedure shall:

i. Have an annual examination to assure natural or corrected near distance acquity such that they are capable of reading standard J1 letters on standard Jaeger test Type Chart for near vision or equivalent methods / have good vision in accordance with the requirements of EN 473.

ii. Color contrast will demonstrate the capability of distinguishing and differentiating contrast among colors or shades of gray used in the method. This should be conducted upon initial certification and five-year intervals thereafter.

iii. Vision examinations shall be administered by Ophthalmologists, Optometrists, other qualified medical professionals, ASNT/EN 9712 Level III personnel, or other nationally accredited Level-III.

iv. Be a certified Visual Welding Inspector (3.0, CSWIP), or a certified Associate Welding Inspector (CAWI-AWS) or ASNT RP SNT-TC-1A NDT Level 1 in Visual Testing or equivalent.

## 3 References

I. BS EN 970 : 1997/ISO – 17637 -2011 - Visual Examination of Fusion Welds
II. SNTC – TC – 1A – 2011
III. FMC Doc No: Q02500 Rev. Q: VISUAL EXAMINATION - RAW-COMPONENTS-ASSEMBLIES
IV. API – 6A "Specification for Well Head and Christmas Tree Equipment"
V. API - 16A "Specification for Drill Through Equipment"
VI. API 16C – Second Edition Specification for Choke and kill system"
VII. MSS – SP – 55 – 2006 Quality Standard for steel castings for valves, flanges, fittings, and other piping components – visual method for evaluation of surface irregularities.
VIII. API 7K – Specification for drilling Equipment
IX. ASME Sec. 5, Article 9 – Visual Testing

## 4 Measuring Equipment

4.1 For measurement of joint preparation and welding parameters :

i. Weld gauge
ii. 150-mm steel rule/straight edge
iii. protractor
iv. Internal/external caliper or vernier
v. Electrical clamp tester (ammeter)
vi. Temperature indicator

4.2 For measurement of weld profiles and imperfections :

i. Height or depth gauge
ii. Weld gauge
iii. Contour or profile gauge
iv. 150-mm steel rule

4.3 For welds where measuring devices are restricted, modelling clay or cold setting resins may be used to produce a replica of the weld profile that then can be measured.

4.4 For repetitive works, a special template may be made for checking weld profiles and dimensions.

## 5 Viewing Conditions

5.1 When accessibility permits, direct visual examination shall be made with the eye within 600 mm distance and at an angle of not less than 30° to the surface being examined.

5.2 If the access to the surface to be examined restricts the eye to a distance of not more than 250 mm, a hand lense with magnification of 2 diameters to 5 diameters may be used to enable the eye to view the area to be examined from a very short distance and carry out more accurate measurements.

5.3 For visual examination of surfaces / joints not directly visible or remote, appropriate visual aids shall be used to facilitate assessment and examination of welds. Such visual aid may be a dental mirror for welds within a viewing distance and for more remote welds, borescope/intrascope, fibre optics or portable camera may be used. These additional requirements shall be agreed with the client.

5.4 The surface to be examined shall have a minimum white light intensity of 1000 lux. Additional light source should be used if required to obtain a good contrast and relief effect between imperfections and background.

## 6 Methods

The extent of examination shall be defined in the project specification. The inspector shall be given access to the relevant inspection documents required. As a minimum Examinations shall include of 12 mm (0,5 in) of adjacent base metal on both sides of the weld.

6.1 Before Welding

6.1.1 Before welding commences the inspector shall obtain the following information :

i. Codes and standards to be used.

ii. Welding procedure specification.
iii. Working drawings.
iv. Welders' qualification.

6.1.2 Using an appropriate measuring device, check that the fit-up (gap and alignment) including backing materials and the edge preparation of the joint to be welded, is in accordance with the welding procedure specification or drawings.

6.1.3 Check that the fusion faces and adjacent areas are sufficiently clean as required.

6.1.4 Check that all consumables are in compliance with the welding procedure specification and that proper maintenance is being carried out.

6.1.5 If pre-heating is required check that the temperature through the joint to be welded and adjacent areas are within the range prescribed by the welding procedure specification, with the use of a temperature indicator.

6.2 Intermediate Inspection (during welding)

6.2.1 During the welding process, check that the current (amperes) being used and progression speed is within the requirement of the welding procedure specification. This check may only be carried out during the first production weld and when deemed necessary as part of the quality assurance system.

6.2.2 Check that the previous run of welds is properly cleaned before being covered by a further run. The existence of visible defects shall be reported so that remedial action can be taken before deposition of further weld metal.

6.2.3 Check that the inter-run temperature is within the range required by the welding procedure specification. The inter-run profile shall be such that satisfactory melting can be achieved when welding the next run.

6.2.4 When back gouging is required, check that it has been carried out in such a way that the back of the first run is gouged out to clean sound metal and with sufficient groove, prior to welding of the back gouged side.

6.3 After Welding

After the completion of welding or repair welding, if any, the following items shall be checked against the specification or standard being used:

6.3.1 *Cleaning and dressing.* The joint shall be free of slags , spatters, tool impression or blow marks and any debris that may obscure indication of flaws. When dressing is required, it shall be carried out in a manner that would not cause overheating of the joint, grinding marks or uneven finished surface. For fillet welds and butt welds that require to be dressed flush, the weld shall merge with the parent metal without under-flushing.

6.3.2 *Penetration and root inspection (for single-sided welds only).* With the use of appropriate measuring device, check that the root over the entire joint does not contain any flaw i.e. lack of penetration, concavity, burn-through or shrinkage, that are above the limit by the acceptance criteria.

6.3.3 *Weld contour and reinforcement.* With the use of contour gauge or weld gauge, check that the contour of the weld and the height of the cap reinforcement is within that required by the acceptance criteria and the surface of the weld is

such that the pitch of weave marks present an even, regular, satisfactory appearance

6.3.4 *Weld cap width and cold lap.* With the use of appropriate measuring device e.g. calliper, check that the weld cap is within the required width and reasonably consistent over the whole of the joint. Where there is excessive weld width, examine carefully the weld cap toes if the weld metal is fused to the parent metal. A slight build up of weld metal above the parent metal is indicative of cold lap.

In case of fillet welds where the weld width is not normally specified, the leg length shall be measured using the appropriate weld gauge. A convex fillet weld without building up of the weld metal over the parent metal will satisfy the required throat thickness, where a concave fillet weld is indicative of under fill or reduced throat thickness.

6.3.5 *Undercut.* Undercut shall be checked against the acceptance criteria. Depth of undercut may be measured with the use of modeling clay.

6.3.6 *Stray arcing and other weld flaws.* Using appropriate optical aids, if necessary, examine the weld and heat affected zone for weld flaws and check them against the acceptance criteria. All local hard spots or cracking caused by stray arcing shall be removed by mechanical means.

6.4 Repair works

Welds that do not comply with the acceptance criteria and require repair by removal of unacceptable flaws, shall be checked during repair operation.

6.4.1 Check to ensure that the required means of defect removal is carried out correctly and that pre-heating is applied, if specified, in case of thermal cutting or gouging.

6.4.2 With the use of a contour gauge and appropriate measuring ruler, check that the depth, width, length and tapering at the edges of the cut out portion is sufficient to ensure removal of defect and permit adequate access for re-welding. For completely removed weld, check that only faulty weld within the welded joint, has been cut through and that there has not been a serious loss of material. When a section of the material containing a faulty weld has been removed and a new section is to be inserted, check that all parameters including edge preparation and re-welding operation are in accordance with the welding procedure.

6.4.3 When a complete cut-out of the joint is required, check that the new edge preparation, gap and alignment are in accordance with the welding procedure specification.

6.4.4 Check that the re-welding operation is in accordance with the welding procedure specification or approved repair procedure, if any.

6.4.5 Repair welds shall be inspected base on the criteria of the original weld.

6.5 Post Weld Heat Treatment

Prior to any subsequent process e.g. post weld heat treatment, check to ensure that the completed fabrication is free from any scarred areas caused by removal of temporary

attachments.

When post weld heat treatment is required, check that all the conditions and parameters are applied properly to ensure that correct heat input, heating rate, soaking time and temperature control, and cooling rate are achieved. Re-inspection of the weld after post weld heat treatment shall be carried out.

7 Castings

7.1 Before carrying out the inspection it must be ensured that the surface is free from rust / scaled and other deposits . The following defects must be checked during visual examinations of casting: (Reference Photos in Annexure – A)

- Type– I Hot tears and Cracks
- Type- II Shrinkage
- Type-III Sand Inclusion
- Type-IV Gas porosity
- Type- V Rat Tails
- Type- VI Veining
- Type-VII wrinkles , Lapse , wears , Folds and cold shuts.
- Type- VIII Cutting Marks
- Type – IX Scabs
- Type – X Chaplets
- Type-XI Weld Repair Areas
- Type- XII Surface Roughness

8 Forgings & Wrought Surfaces:

Forged surfaces shall be free from visual cracks, scabs, seams, laps, pipe, excessive scale, laminations, and any other condition that affects the surface quality of the material.

9 Finished Products – Components and Assemblies:

Finished products are to be free from visual inclusions, burrs, sharp corners, cracks, slag, lack of fusion, forging or casting seams, torn threads, handling damage and any other condition that affects the surface quality of the material.

10 Markings

Any instruction or comment pertaining to the result of inspection carried out, should be written on the surface adjacent to the weld inspected, with an indelible marker. The markers to be used shall not cause damage to and shall not affect the fatigue life of the material.

11 Records

When required by the client, a written report shall be prepared for every visual inspection carried out in accordance with this procedure. The report (see report form WNT-06) shall contain, but not limited to the following information.

(a) Date of inspection

(b) Name of the fabricator or manufacturer

(c) Material specification

(d) Type of joint / Material thickness

(e) Welding process or procedure specification

(f) Acceptance criteria

(g) Material Identification, joint no. and repair status

(h) Unacceptable Imperfections, if any and their locations

(i) The extent of examination specified in the drawing or project specification, as appropriate

(j) Inspection devices used

(k) Comments and recommendations with reference to the acceptance criteria.

(l) Name and signature of inspector

When a permanent visual record of imperfection and welds examined are required, a photograph or on-scale accurate sketches shall be made indicating exact dimensions.

## 12 Acceptance Criteria

Acceptance criteria shall be in accordance with the client's specification and/or the production drawings. Some of standard acceptance criteria are listed in Annexure 1.

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# Annexure 1
# Acceptance Criteria

## API 6A:

1. Castings. In accordance with MSS-SP-55 **(Annexure A)**

Type 1: None acceptable.
Types 2 through 12: A and B.

2. Forgings. In accordance with manufacturer's written specifications. **(Annexure B)**

### Weld Examination:

The following acceptance criteria apply.

— All pressure-containing welds shall have complete joint penetration.

— Undercut shall not reduce the thickness in the area (considering both sides) to below the minimum thickness.

— Surface porosity and exposed slag are not permitted on or within 3 mm ($^1/_8$ in) of sealing surfaces.

## API 16C (Welds):

Pressure-containing welds shall have complete joint penetration. Undercut shall not reduce the thickness in the area (considering both sides) to below the minimum thickness. Surface porosity and exposed slag are not permitted on or within $^1/_2$ in. (12.7 mm) of sealing surfaces.

## API 16A:

As per manufactures specification (Annexure A & B)

## API 7K:

## Castings in accordance with MSS-SP-55 (Annexure A)

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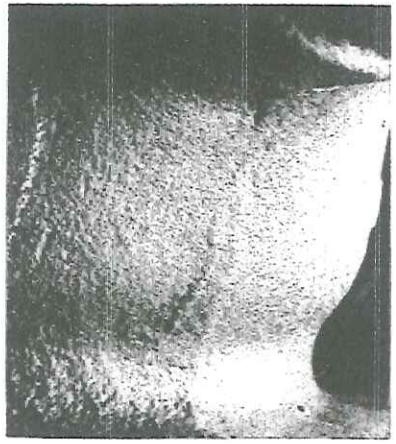
# Annexure A
# Acceptance Criteria as per MSS-SP-55

ACCEPTABLE

NON ACCEPTABLE

a



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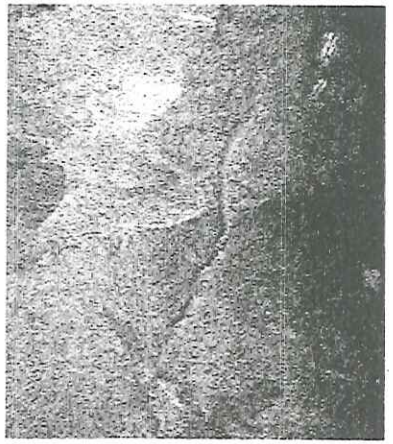

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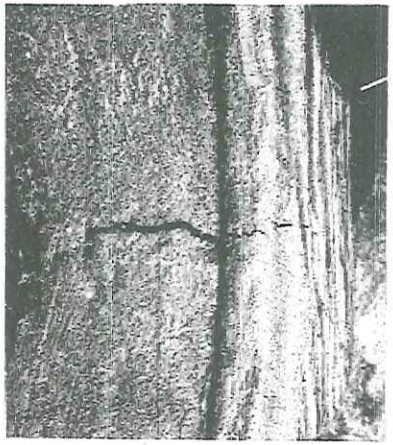
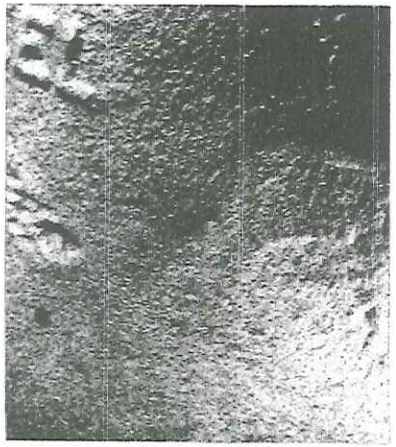


NOTE: The two acceptable examples of this type do not show hot tears or cracks. No irregularities of this Type are acceptable under this standard.

b



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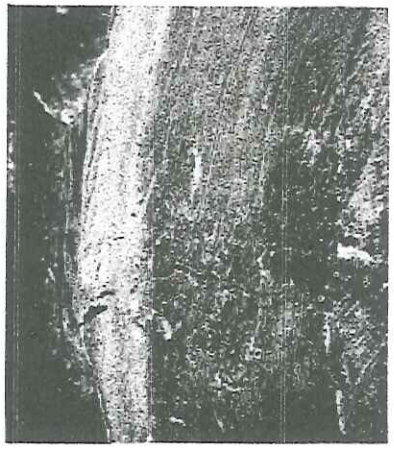

TYPE I
HOT TEARS AND CRACKS

ACCEPTABLE

NON ACCEPTABLE

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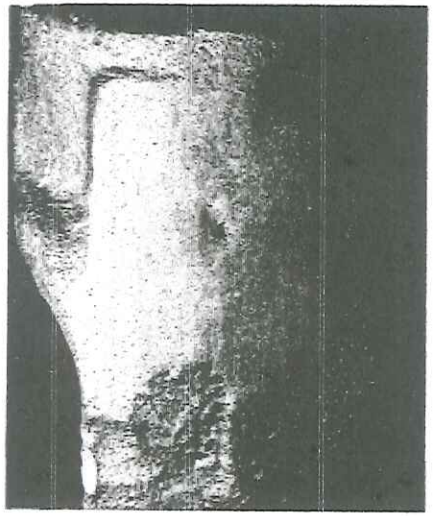

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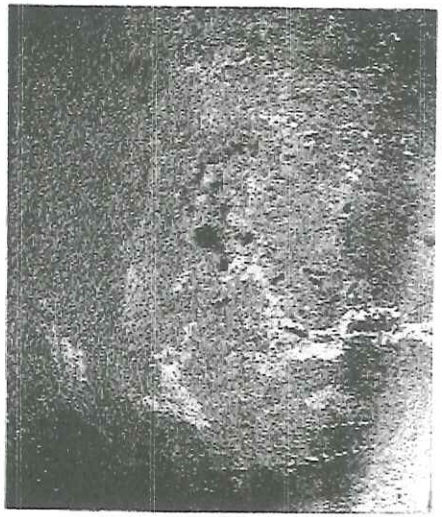

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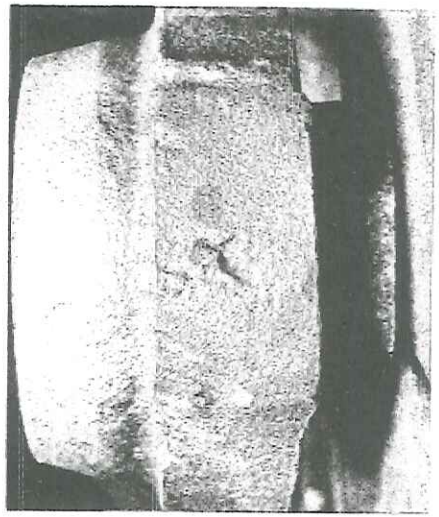

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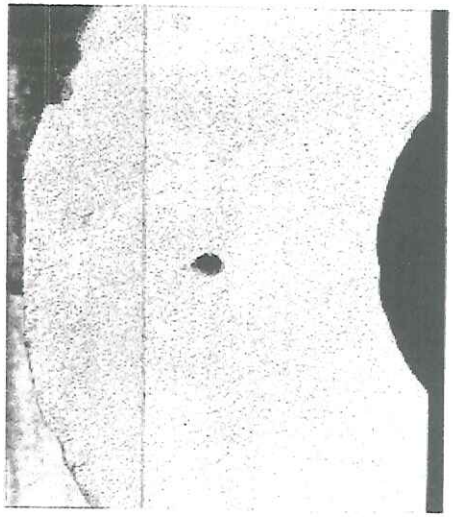

TYPE II
SHRINK

PRTD. IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

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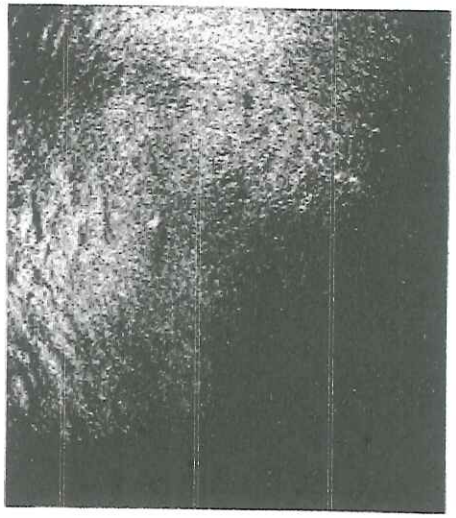

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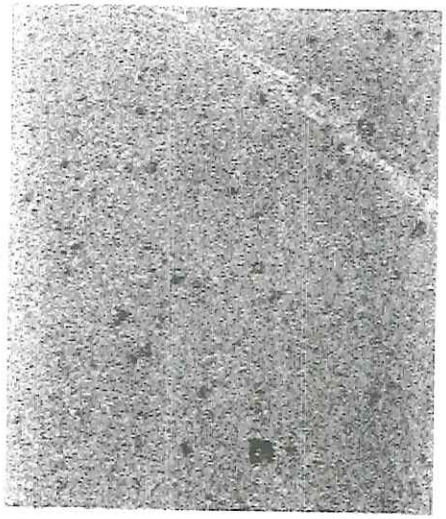

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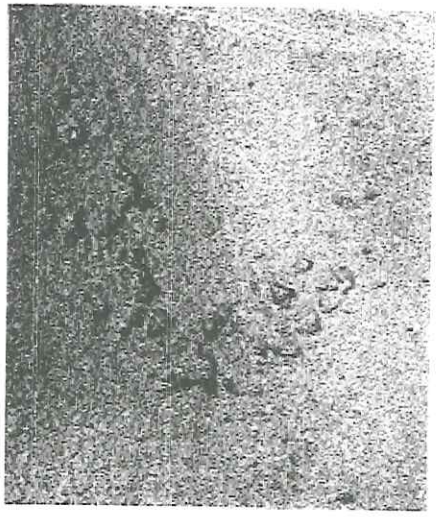

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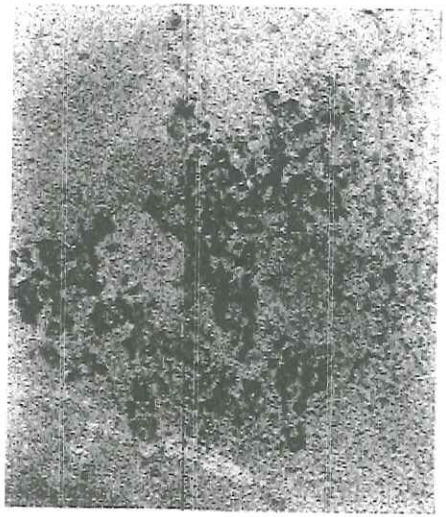

TYPE III
SAND INCLUSIONS

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ACCEPTABLE

NON ACCEPTABLE

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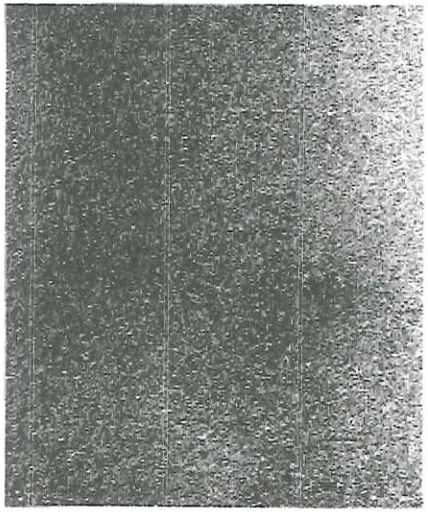

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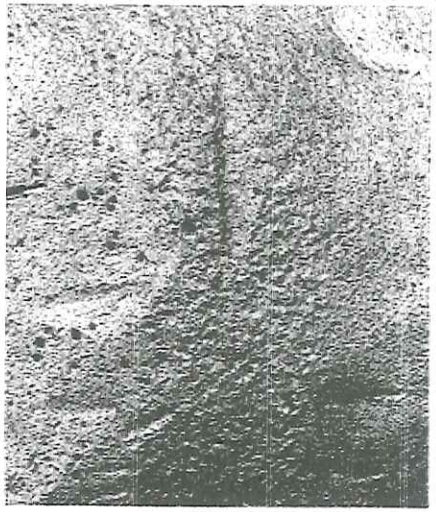

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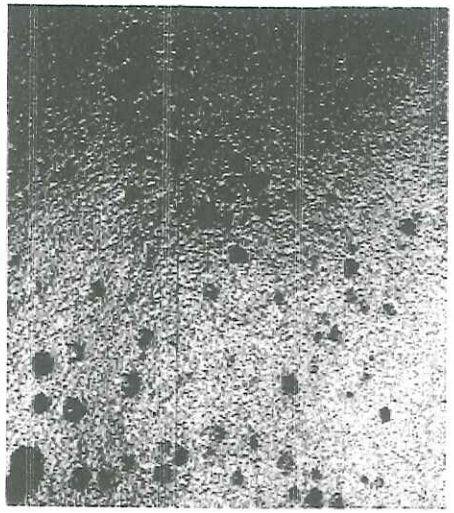

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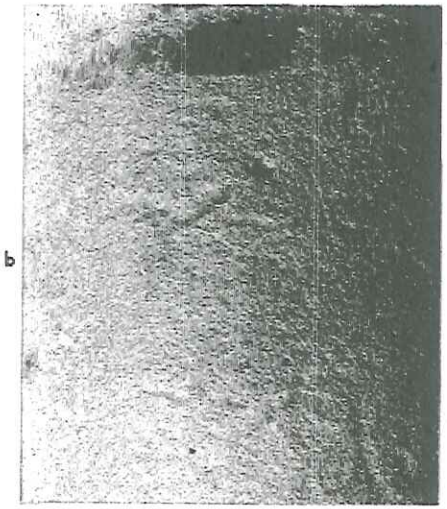

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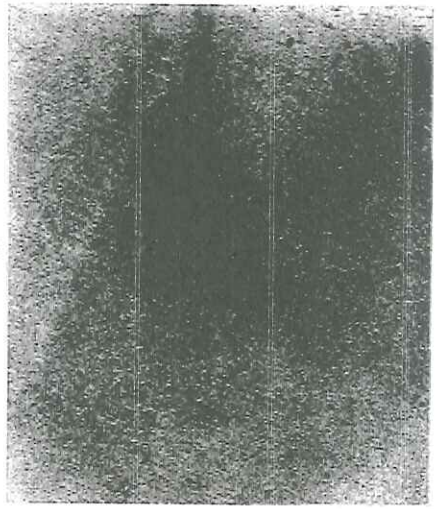

TYPE IV
GAS POROSITY

PRTD. IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

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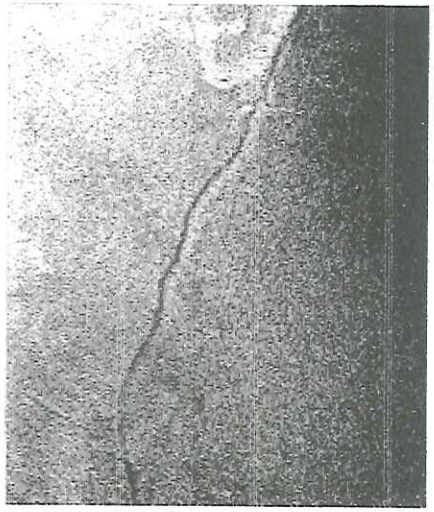

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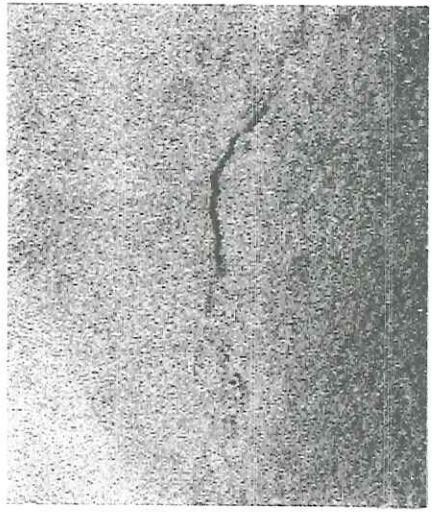

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TYPE V
VEINING

PRTD. IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

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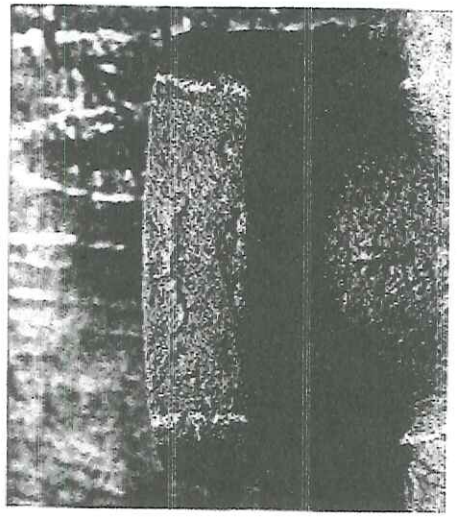

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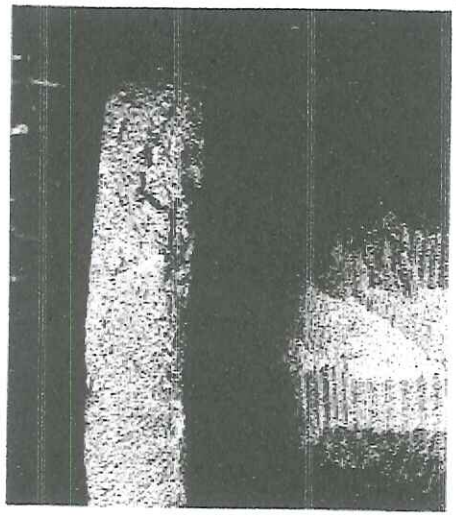

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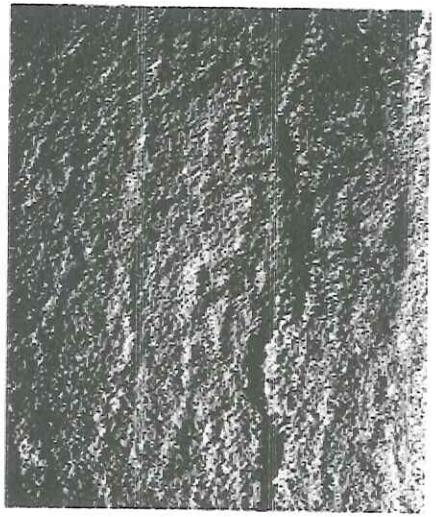

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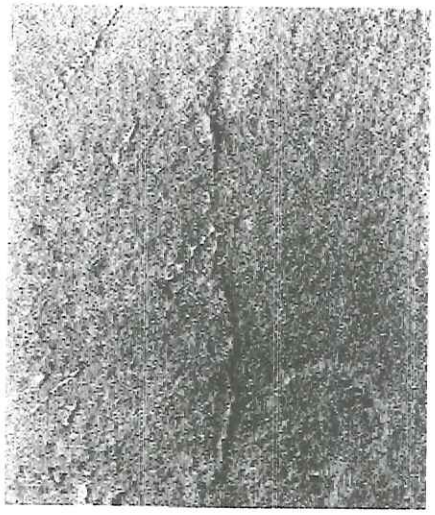

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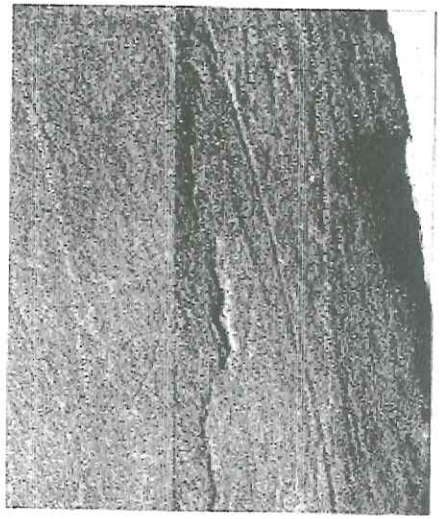

TYPE VI
RAT TAILS

PRTD. IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

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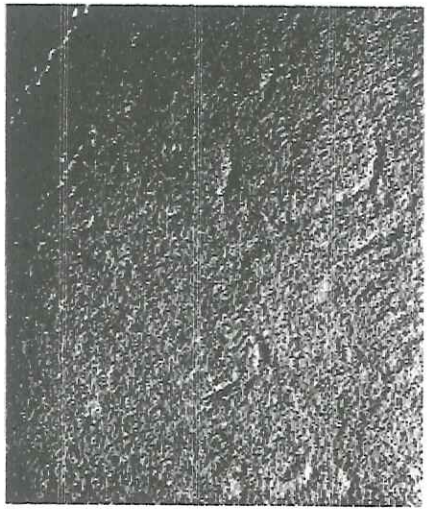

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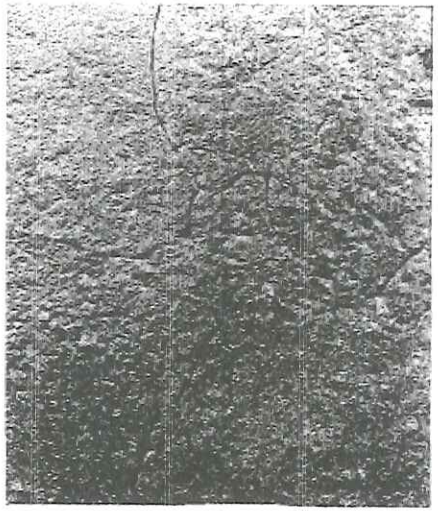

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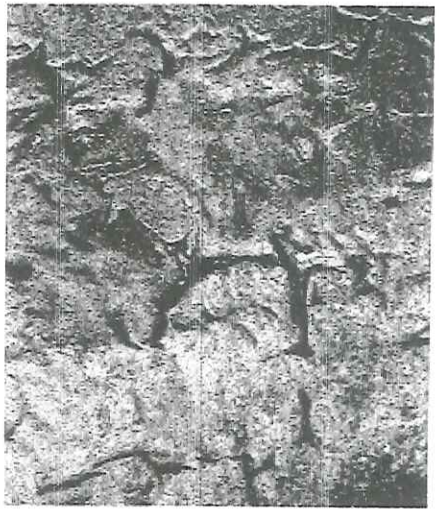

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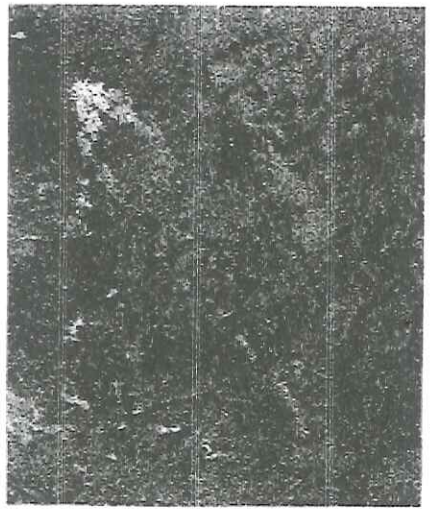

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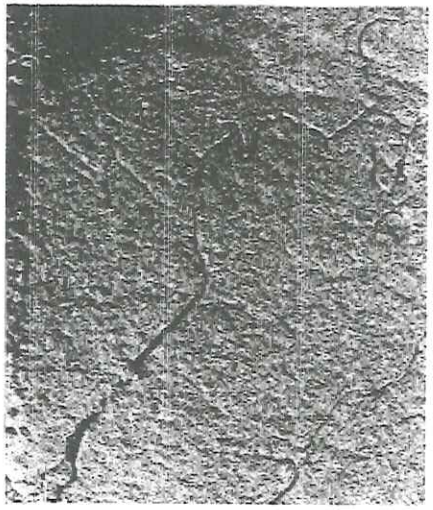

TYPE VII

WRINKLES, LAPS, FOLDS

AND COLDSHUTS

PHTD. IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

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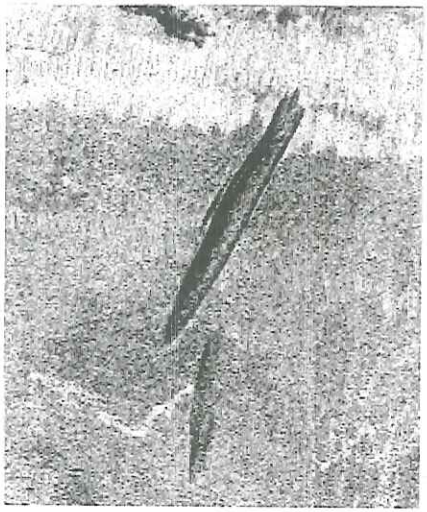

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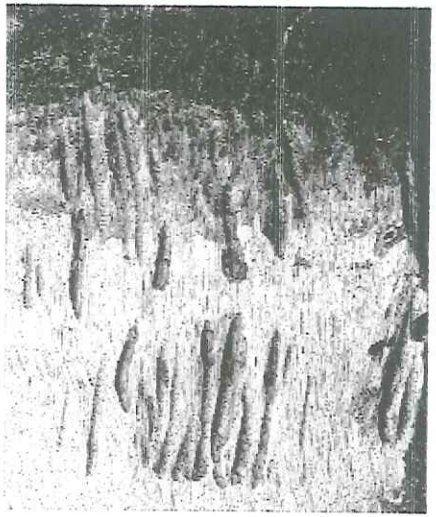
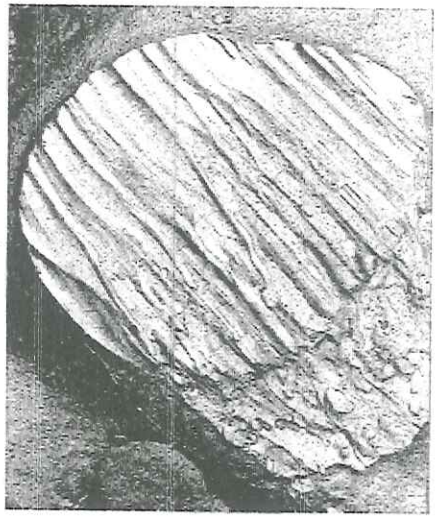


d

e



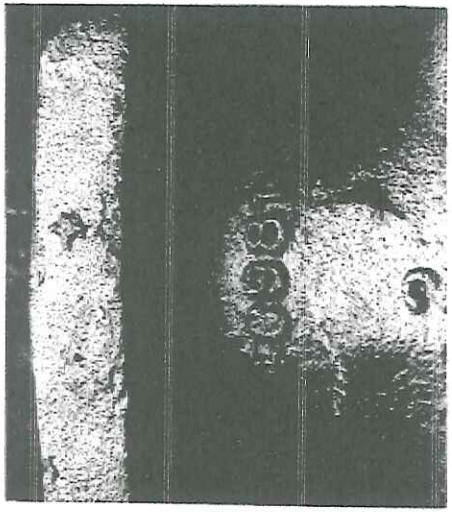
TYPE VIII
CUTTING MARKS

PATD. IN U.S.A.

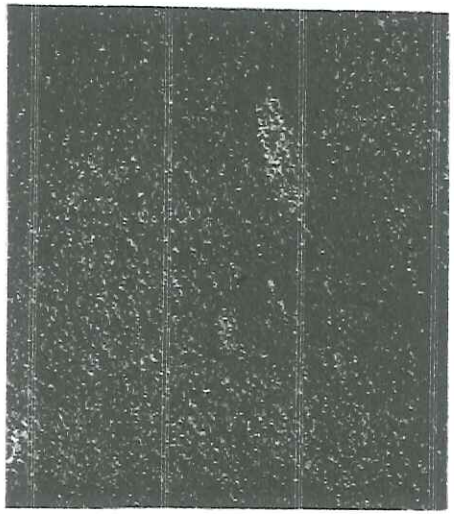
ACCEPTABLE

NON ACCEPTABLE

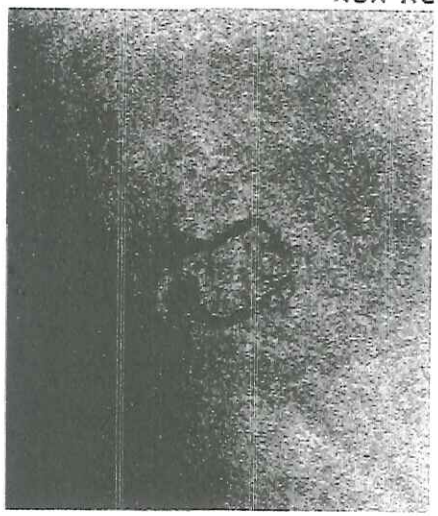
a



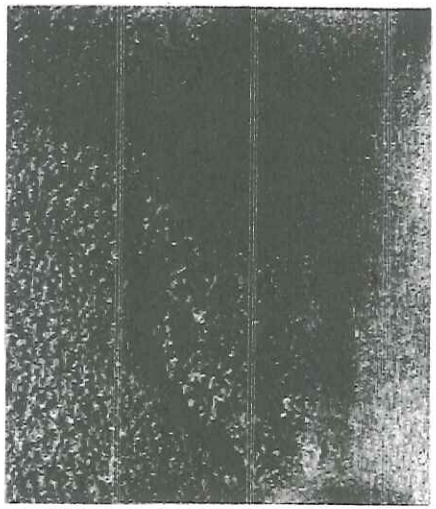
b



c



d



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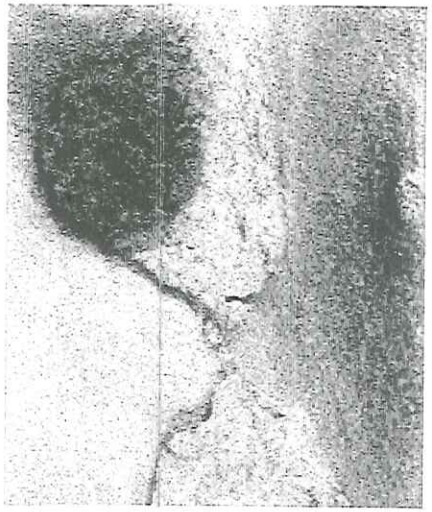


TYPE IX
SCABS

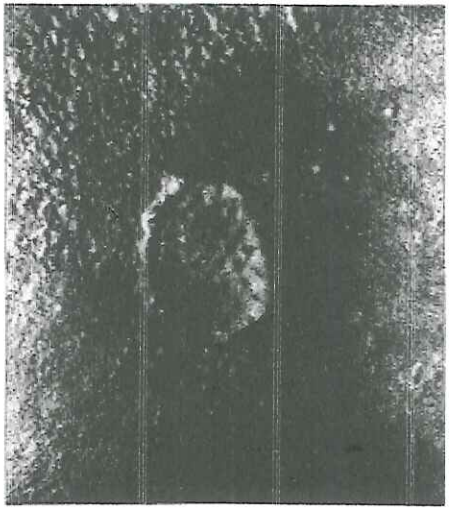
PRTD. IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

a

c



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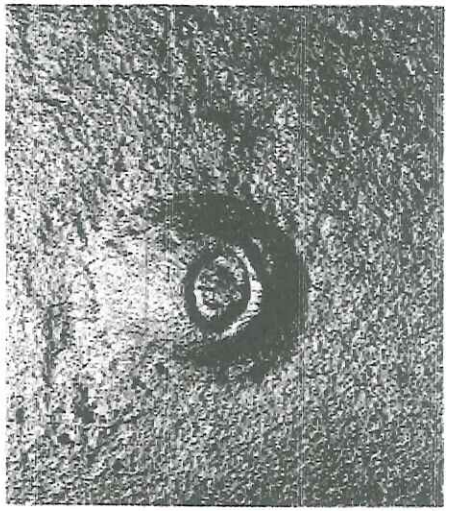

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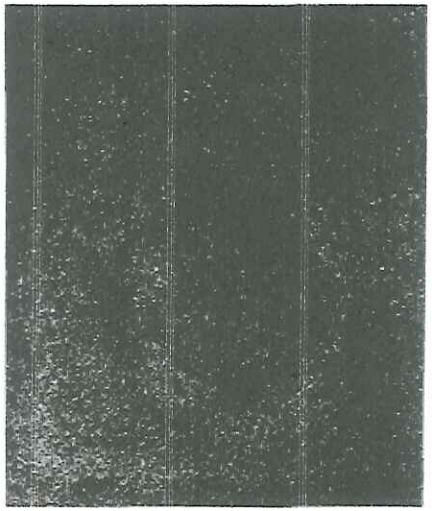


d

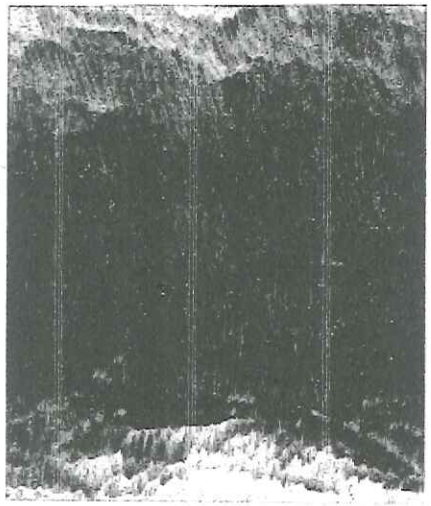
TYPE X
CHAPLETS

PRTD IN U.S.A.

ACCEPTABLE

NON ACCEPTABLE

a



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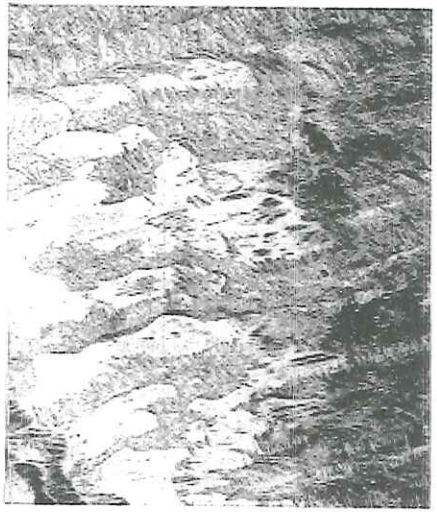

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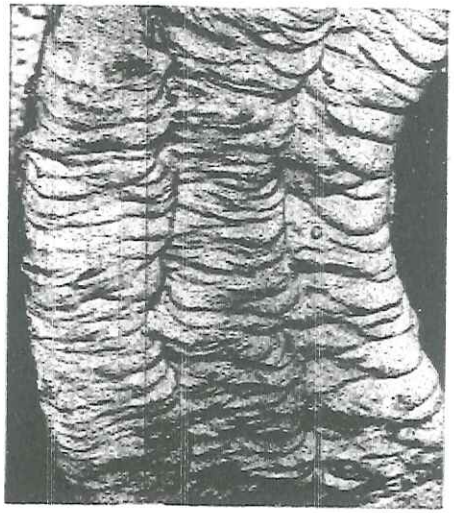

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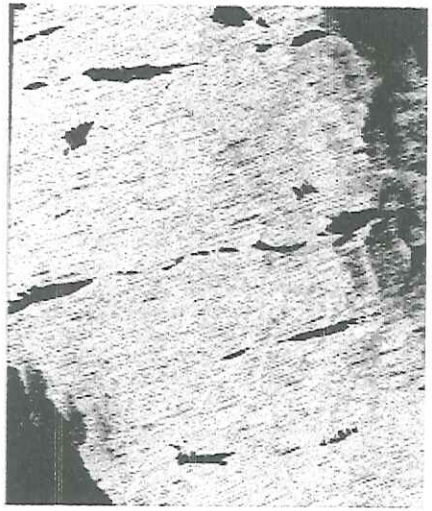

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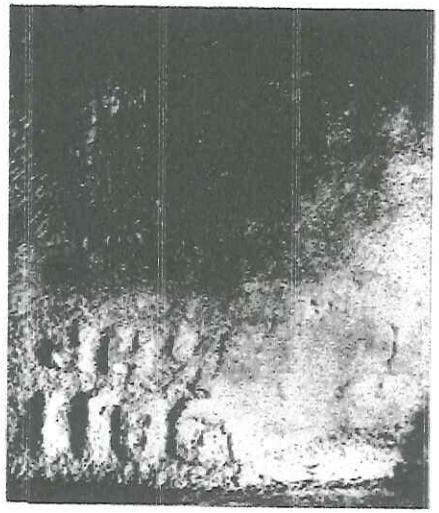
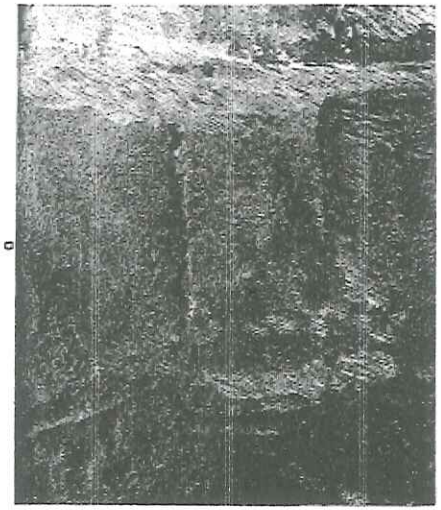


TYPE XI
WELD REPAIR AREAS

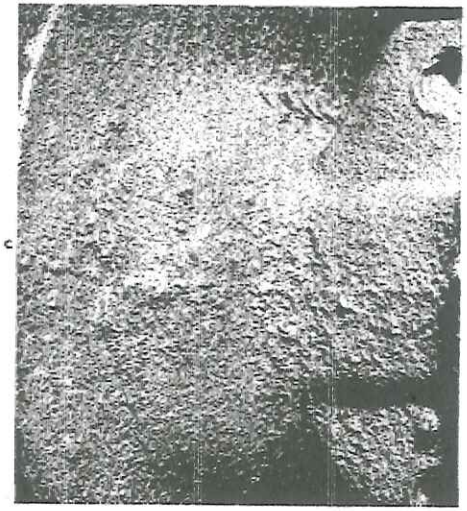
PRTD. IN U.S.A.

ACCEPTABLE

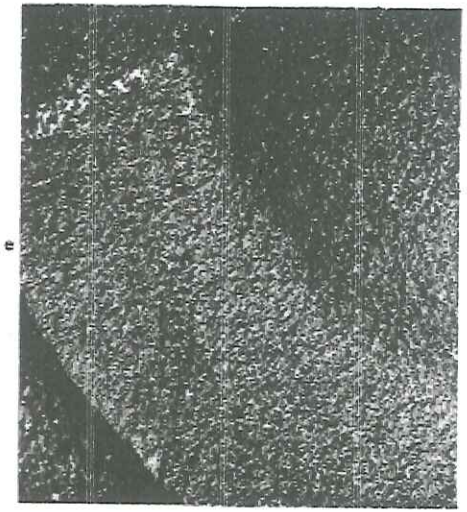
NON ACCEPTABLE



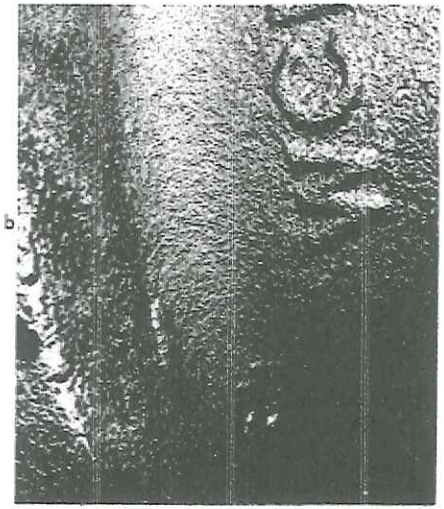
a



c



e



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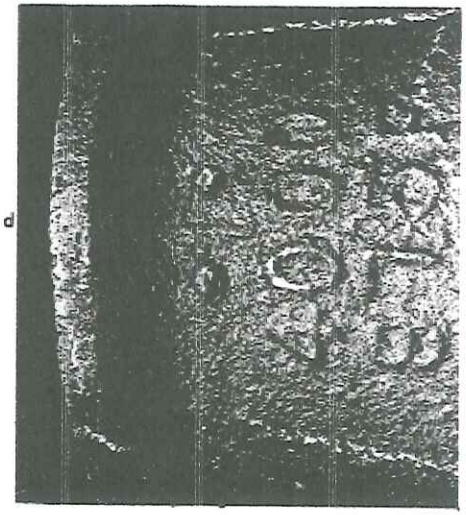
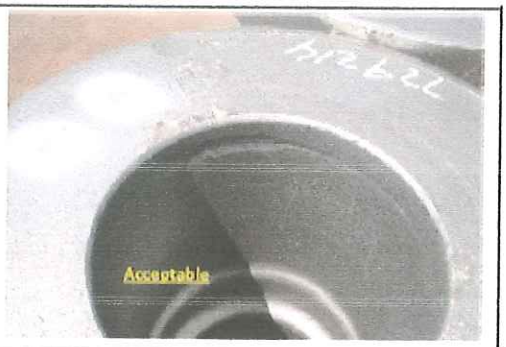


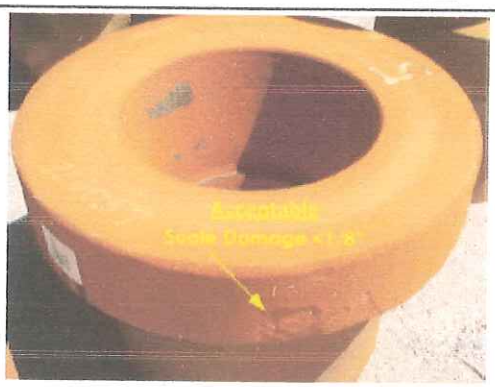
d

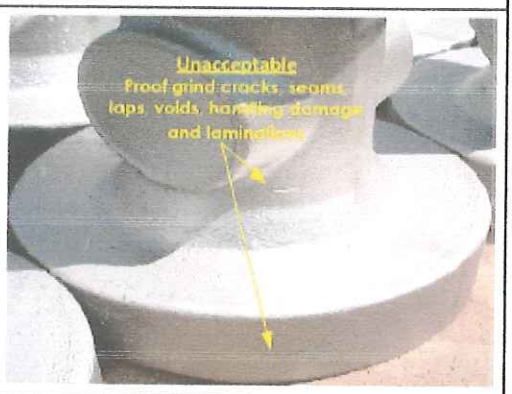
TYPE XII
SURFACE ROUGHNESS

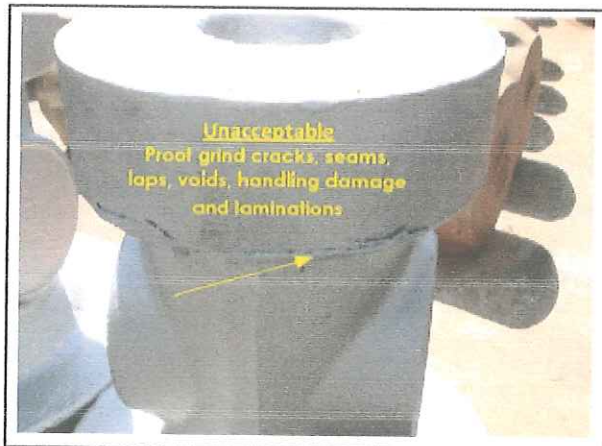
# Annexure B
# Acceptance Criteria for Forgings (FMC)

3.1 Proof ground discontinuities, seams, laps, voids, handling damage and laminations shall not exceed ~ 1/8" (3.5 mm) depth or least material condition of the forging drawing whichever is greater.

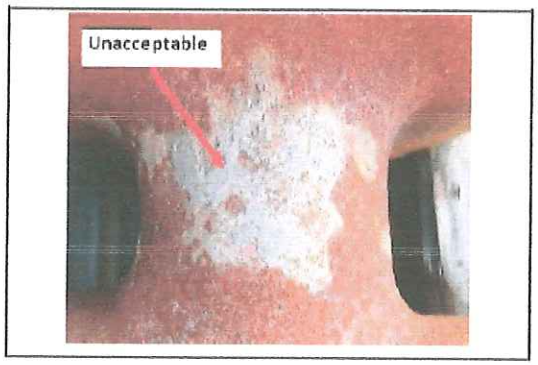


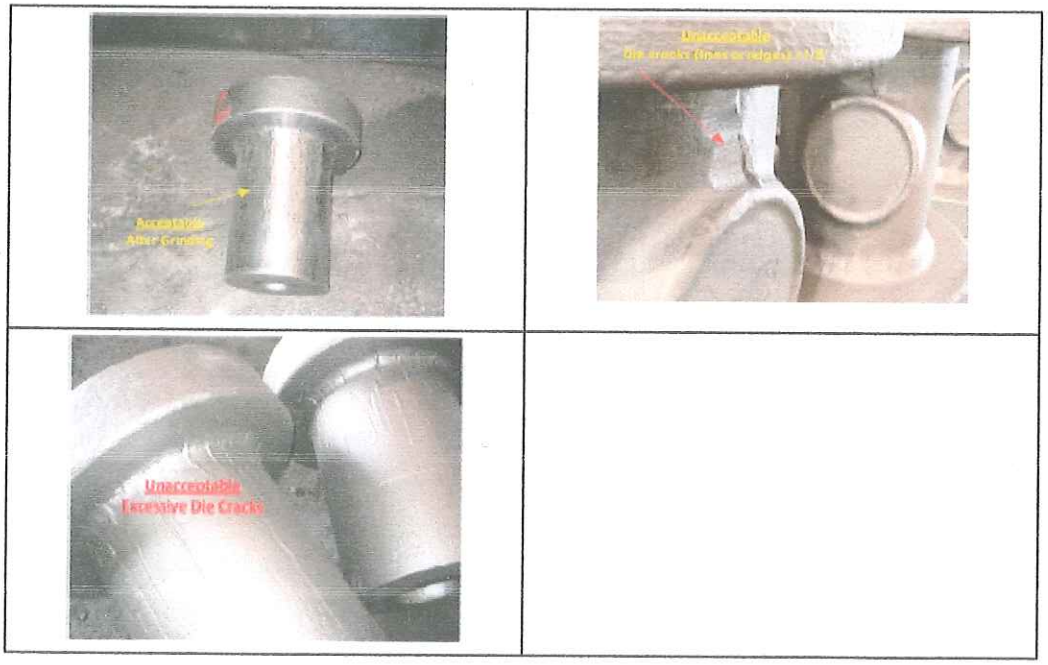
3.2 Excessive scale is determined by the percent of scale remaining on the non-machined surfaces (body) of the forging after shotblast or sandblast. Embedded scale that cannot be removed with shotblast or sandblast shall be ground and blended to remove the scale.

3.2.1 For PSL-3 and higher forging, 100% of scale shall be cleaned off the body of the forging. To enable volumetric NDE, the surface roughness of the as forged or as cast material must allow proper coupling of the search units, typically a maximum of between 250-350 RMS. The NDE technician shall ascertain the surface roughness suitability and direct the need for surface grinding in spots where required. The surface shall be comparable to the reference block used for calibration.

3.2.2 For PSL-2 Forgings, 80% of scale as needed to conduct inspection per 3.1 shall be cleaned off the body of the forging

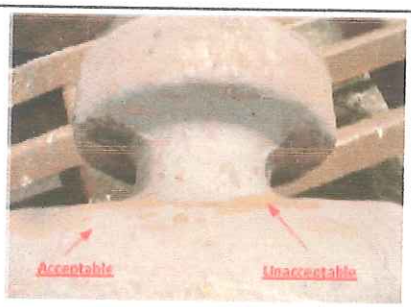


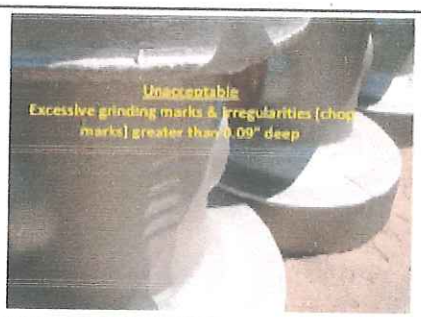

3.3 Die discontinuities (parting lines or ridges often called die cracks) should not leave excess stock on the body of the forging greater than approximately 1/8" (3.5 mm) above the normal forge surface. An excess number of these (see photos) may also be detrimental in subsequent machining thereby, requiring removal by grinding. When grinding is performed, dimensional requirements of the part shall be verified after grinding. Removal of discontinuities shall be verified by surface NDE.



3.4 Parting line grinding shall be flush and uniform for PSL 3 forgings to enable volumetric NDE. Excessive grinding marks and irregularities (chop marks) greater than (>) 0.09" (2.28 mm) deep are not acceptable. When grinding is performed, dimensional requirements of the part shall be verified after grinding. Removal of discontinuities shall be verified by surface NDE.






3.5 Rust is not a basis for rejection. Rust is a bi-product of alloy raw material and the shot used to clean the forgings.