SARA SAE PRIVATE LIMITED

Management System Document Control Cover Sheet

Document Title	Ref. No.	Revision No.
Procedure for Visual Examination of Steel casting /Forging /Wrought material and Welded Joints	SSE/QAD/VE-93	6

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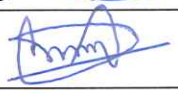
Prepared By:	SAURAV KUMAR	ENGINEER QA/QC		18/07/2021

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1. Scope

This procedure describes the requirement for visual examination of fusion welds in metallic materials and welded joints (for measurement of welding parameter and weld profiles evaluation of weld flaws in accordance with the specified acceptance standards).

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

2. Personnel Qualification

2.1 As 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 JI letters on standard jaeger test Type Chart for near vision or equivalent methods/ have good vision in accordance with the requirements of SNT-TC-1A.

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

iii. Vision examination shall be administrated 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 certified Associate Welding Inspector (CAWI-AWS) or ASNT RP SNT-TC-1A NDT Level-II in Visual Testing or equivalent as per SARA SAE Witten Practice.

3. References

The latest edition of the standards and References cited were utilized in the current release of this inspection method. Changes to these Standards and References determined to affect the quality of the products and services of the project shall be cause for revision to this document.

I. BS EN 970: 1997/ISO-17637-2011, Visual Examination of Fusion Welds
II. SNTC-TC-1A-2020
III. FMC Doc No.: Q02500 Rev Q, Visual Examination-Raw-Components-Assemblies
IV. API-6A 21ST Edition Err. 2 "Specification for Well Head and Christmas Tree Equipment"
V. API 16A 4TH Edition "Specification for Drill Through Equipment"
VI. API 16C 3RD Edition "Specification for Choke and Kill System"
VII. MSS-SP-SS-2011 Quality Standard for steel castings for valves, flanges, fittings, and other piping components – visual method for evaluation of surface irregularities.
VIII. API 7K: 2015 – "Specification for Drilling Equipment.
IX. ASME Sec. 5 Article 9,2021- Visual Testing
X. API 20A: 2020 Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Castings for use in the Petroleum and Natural Gas Industry

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 When visual aids are used, they must provide resolution at least equal to that obtainable by direct visual examination

4.4 For weld 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.

4.5 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 600mm distance and at the angle of not less than 30 deg 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 250mm, a hand lenses 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 surface / 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/ Introscope, 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 minimum white light intensity of 1076 lux. Additional light source should be used if required to obtain a good contrast and relief effect between imperfections and background. Light meters shall be calibrated at least once a year or whenever they have been repaired. If meters have not been in use for 1 year more, they shall be calibrated before they are used.

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 examination shall be include of 50 mm (2.00 in) of adjacent base base metal on both sides of the weld. All areas of temporary attachment removal shall be examined regardless of their distance from 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 When required by drawing, surface finish shall be checked with appropriate gauges to verify compliance with the required roughness.

6.1.6 If pre-heating id 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 gauging 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 inspection shall be carried out not less than 24 hours after weld completion. 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 weld only)*.with the use of appropriate measuring device , check 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 the 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. The weld cap beads shall not have significant peaks and valleys between passes or beads such that they interfere with the subsequent volumetric and surface NDE interpretation.

6.3.4 *Weld cap width and cold lap.* With the use of appropriate measuring device e.g. caliper, 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 (0.8 mm or 0.1% T whichever is lesser)

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.

6.3.7 Surface porosity that cannot be seen when viewed from a distance of 600mm is accepted as not affecting the integrity on paint application, and is therefore accepted although seen from closer distance.

6.3.8 Pressure containing welds shall be 100% inspected with VT. The inner diameter of every closer weld shall be inspected using a borescope or high definition camera system if direct visual examination is not possible.

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 Weld overlay

Pre-Overlay:

Prior to weld overlay of base material all components to welded shall be subjected to VT to ensure freedom from scale, laps, oxide, non-metallic, grease or other contaminants that may affect the welding process. Where necessary this examination shall be conducted with the aid of a high definition camera system.

Post-Overlay:

Overlaid surfaces shall be 100% VT. Where necessary this examination shall be conducted with the aid of a high definition camera system.

Where weld overlay takes place internally,>1meter in total length or, in locations such that viewing is restricted, examination shall be conducted with aid of camera system.

The camera system shall be capable of remote operation such that all relevant indications can be viewed on a monitor, recorded and the locations documented relative to circumferential and longitudinal datum points.

Weld overlaid areas, inspected by camera techniques, may be inspected in the as welded or machined conditions.

Weld overlays that are subsequently machined may be inspected visually at the same time as liquid penetrant inspection.

6.6 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 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 and Wrought Surfaces**

Forging 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 – Component 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. **Marking**

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 from 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, 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 Appendix 1.

Appendix 1

Acceptance Criteria

API 6A:

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

   Type 1: None acceptable.

   Type 2 through 12: A and B

   Weld Examination:

   The acceptance criteria shall be as follows.

   - 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 surface

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 ½ in. (12.7mm) of sealing surfaces.

API 16A:

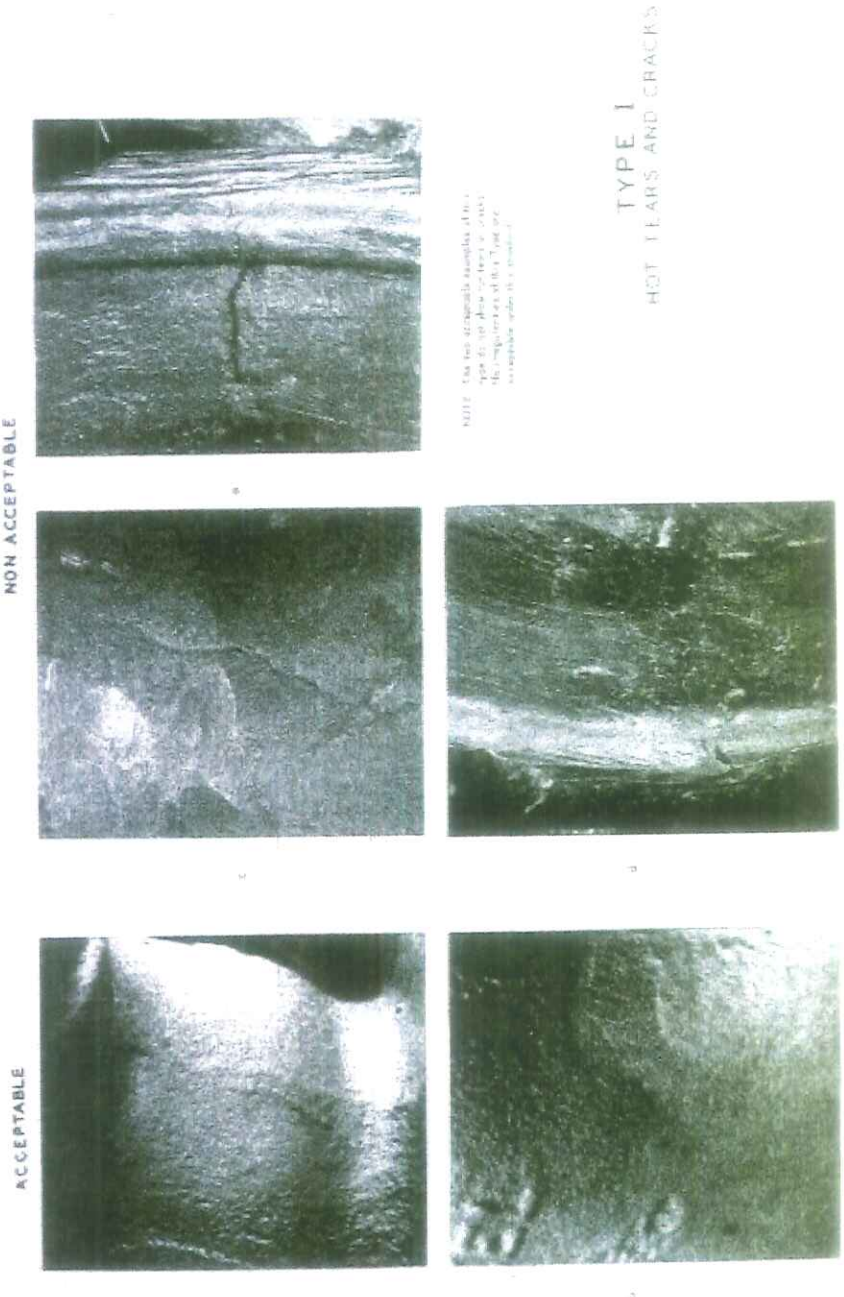
As per manufactures specification (Annexure A & C)

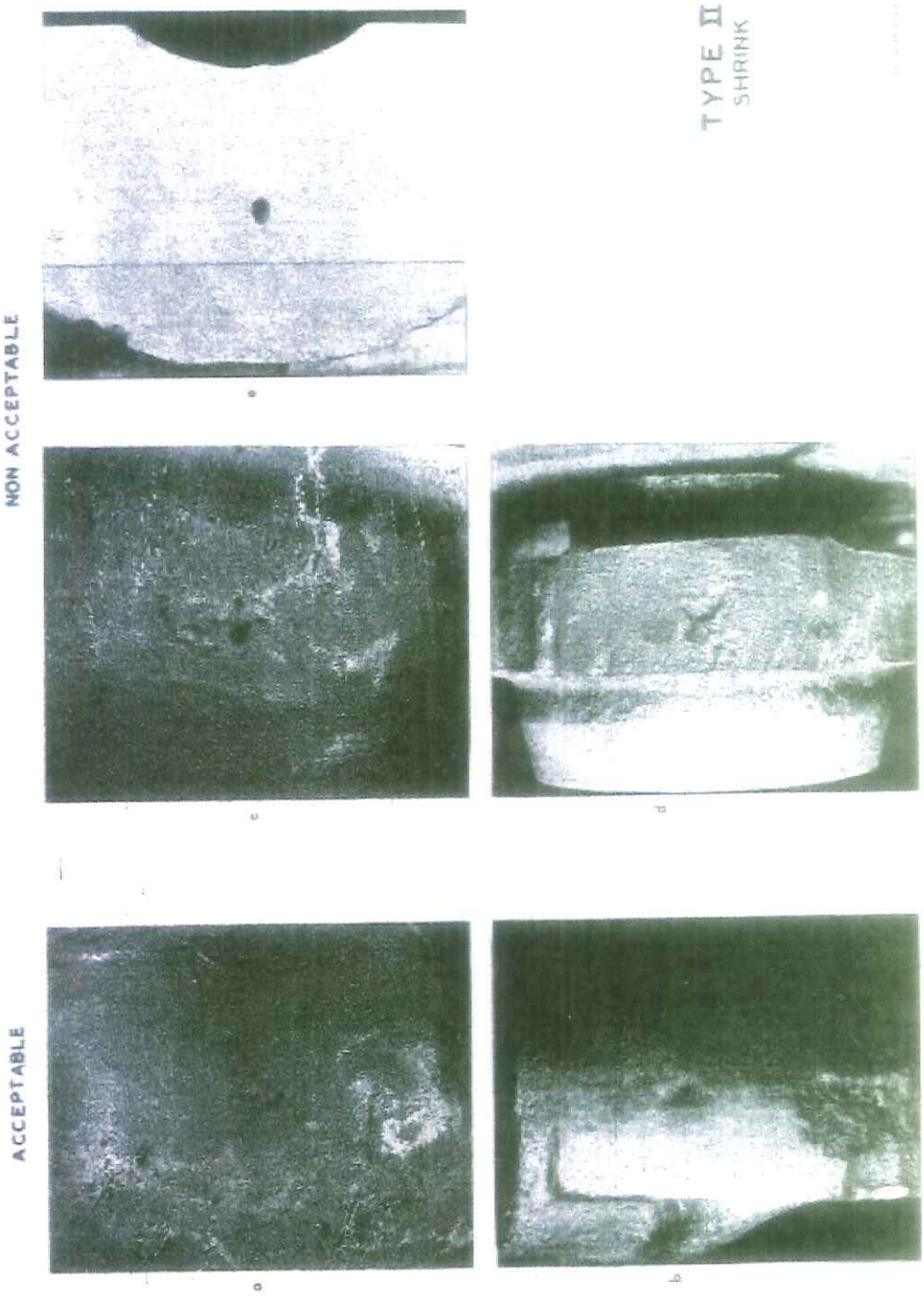
API 7K/API20A:

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

Visual defects of Pressure Retaining Weld Roots Using Borescope Camera (Annexure C)

Annexure A
Acceptance Criteria as per MSS-SP-55

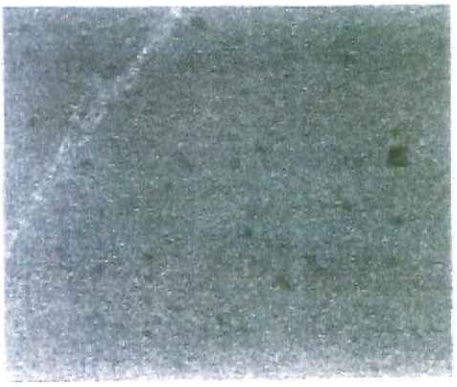



TYPE II
SHRINK
NON ACCEPTABLE
ACCEPTABLE

TYPE III
SAND INCLUSIONS

NON ACCEPTABLE

a



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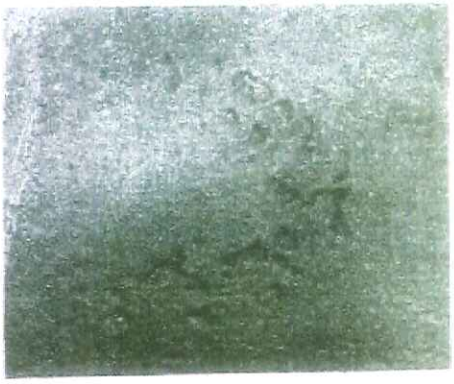
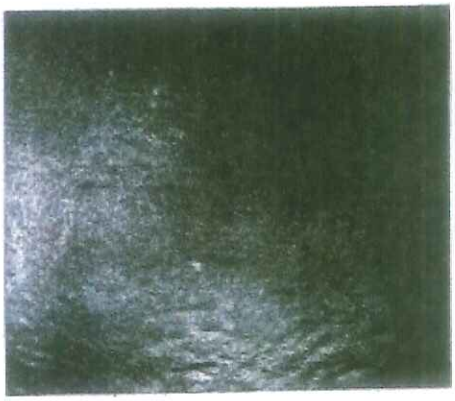


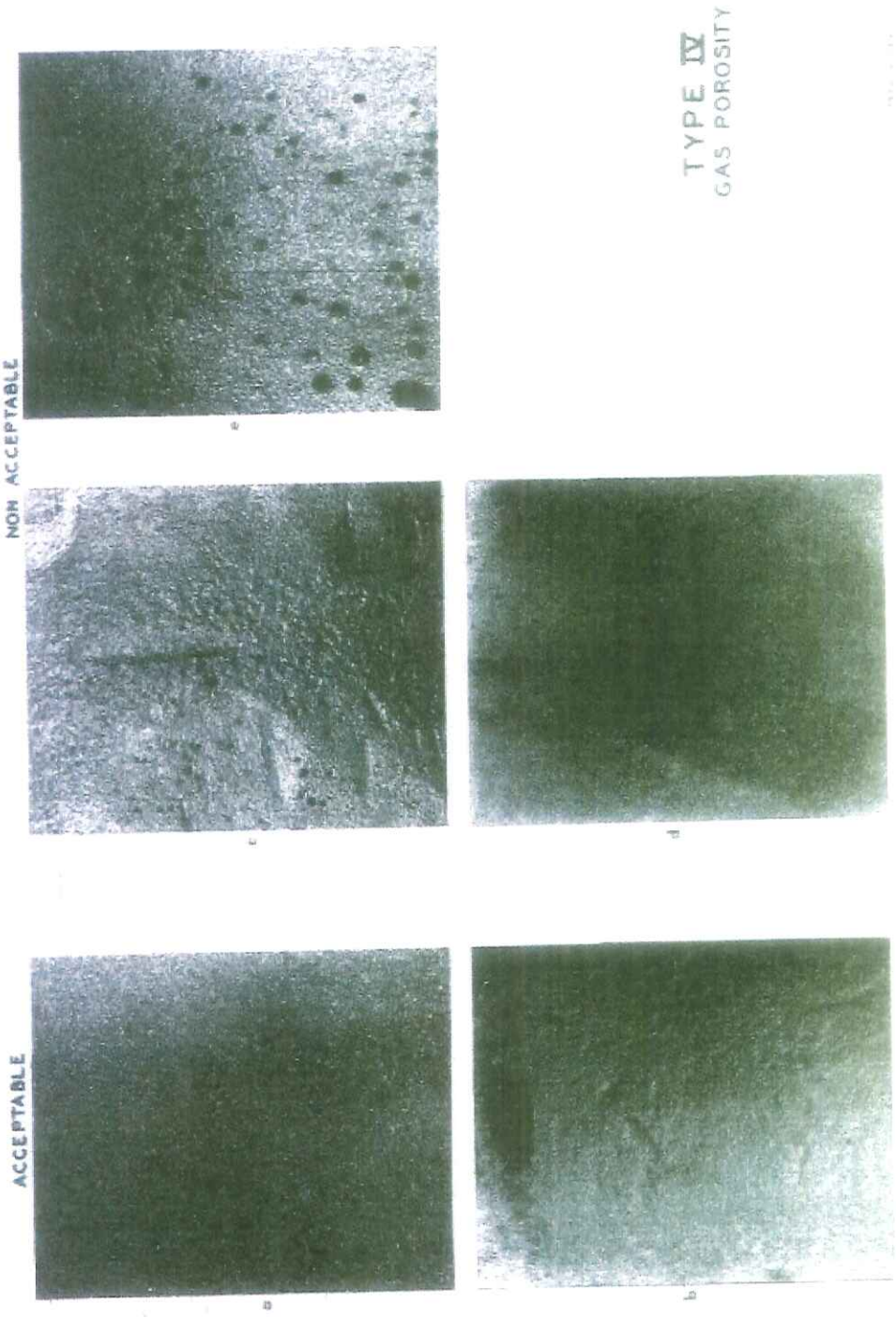
d

ACCEPTABLE



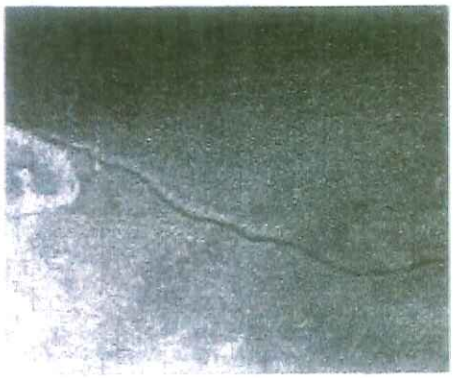
a

b


TYPE IV
GAS POROSITY
NON ACCEPTABLE
ACCEPTABLE

TYPE V
VEINING

NON ACCEPTABLE



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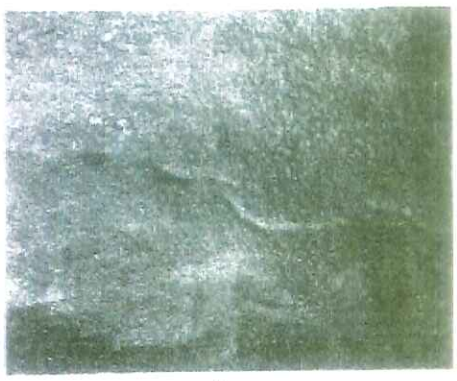
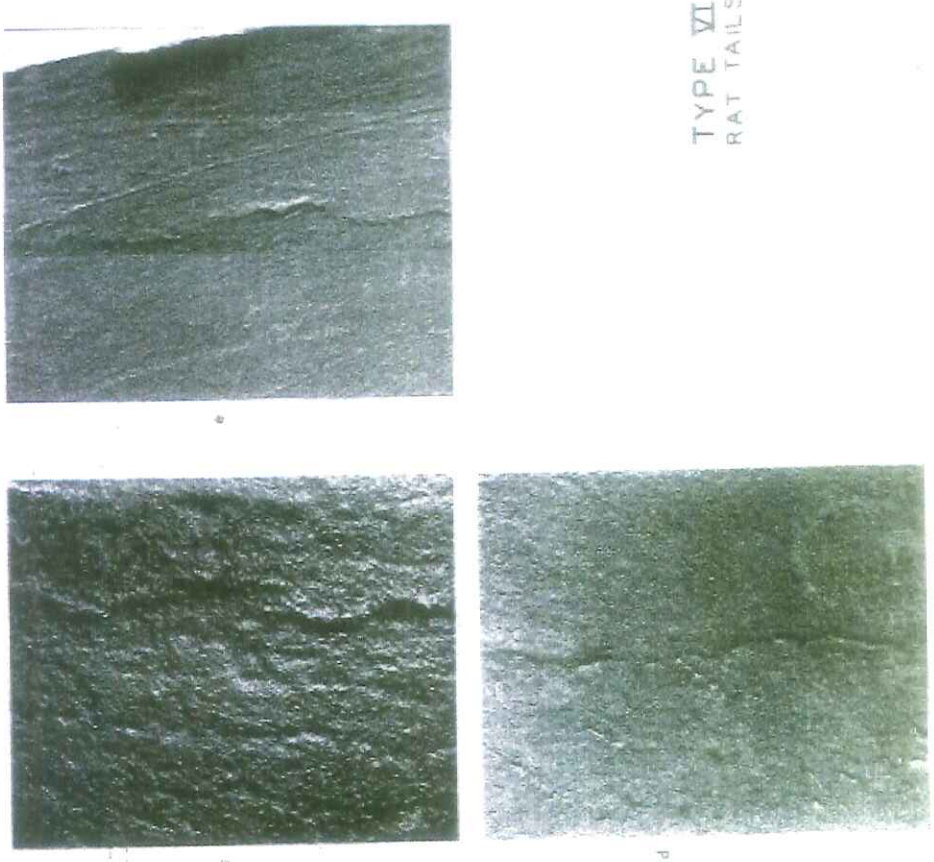


TYPE VI
RAT TAILS

NON ACCEPTABLE



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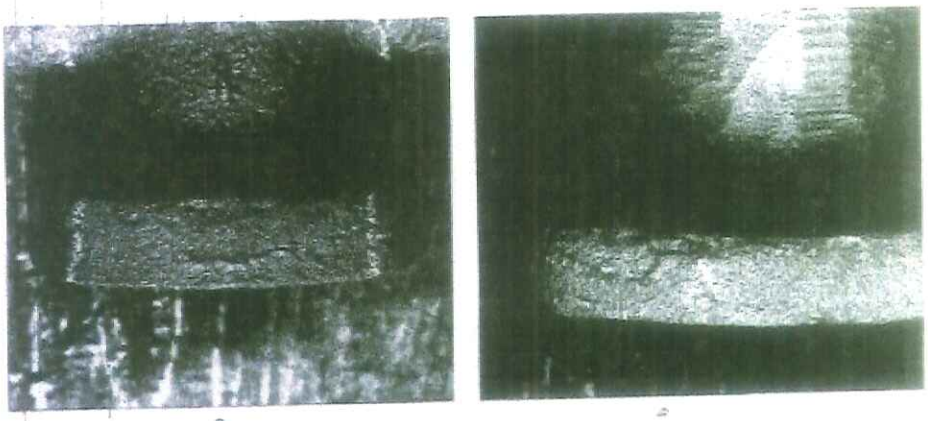


TYPE VII

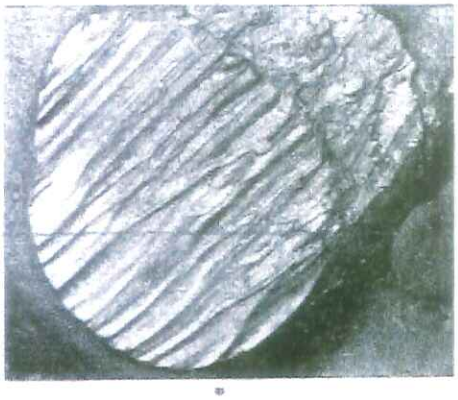
WRINKLES, LAPS, FOLDS AND COLDSHUTS

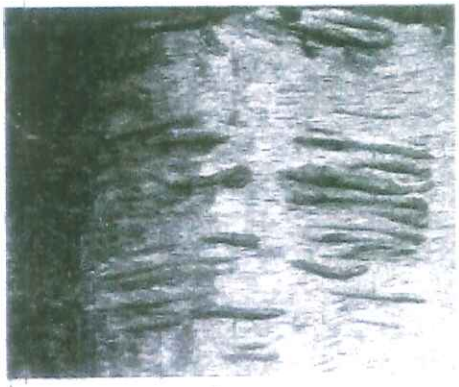
NON ACCEPTABLE

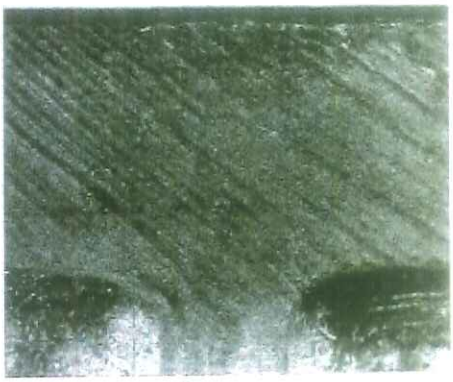
ACCEPTABLE

TYPE VIII
CUTTING MARKS

NON ACCEPTABLE







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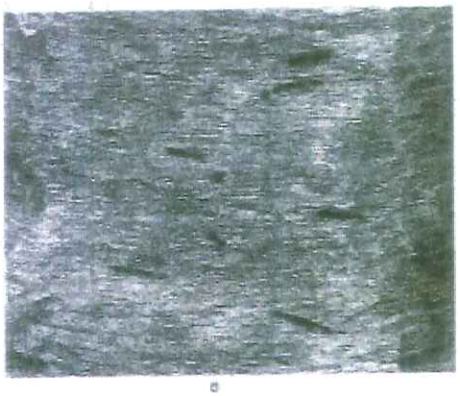
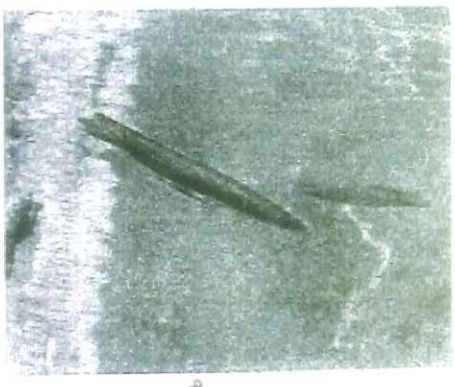
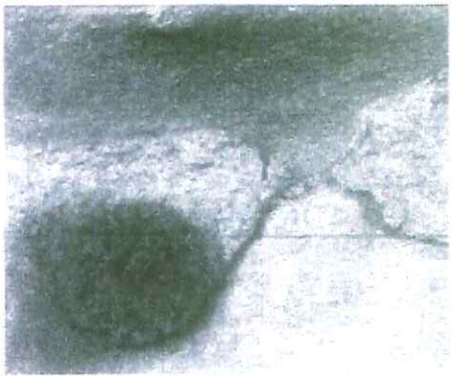
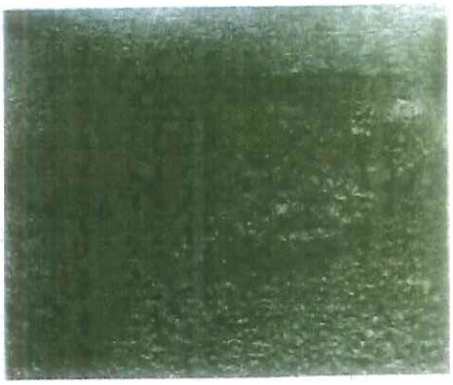




TYPE IX
SCABS

NON ACCEPTABLE





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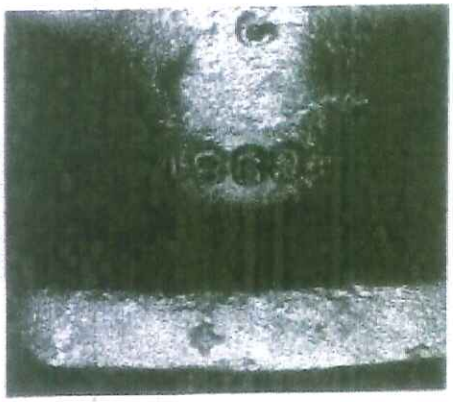

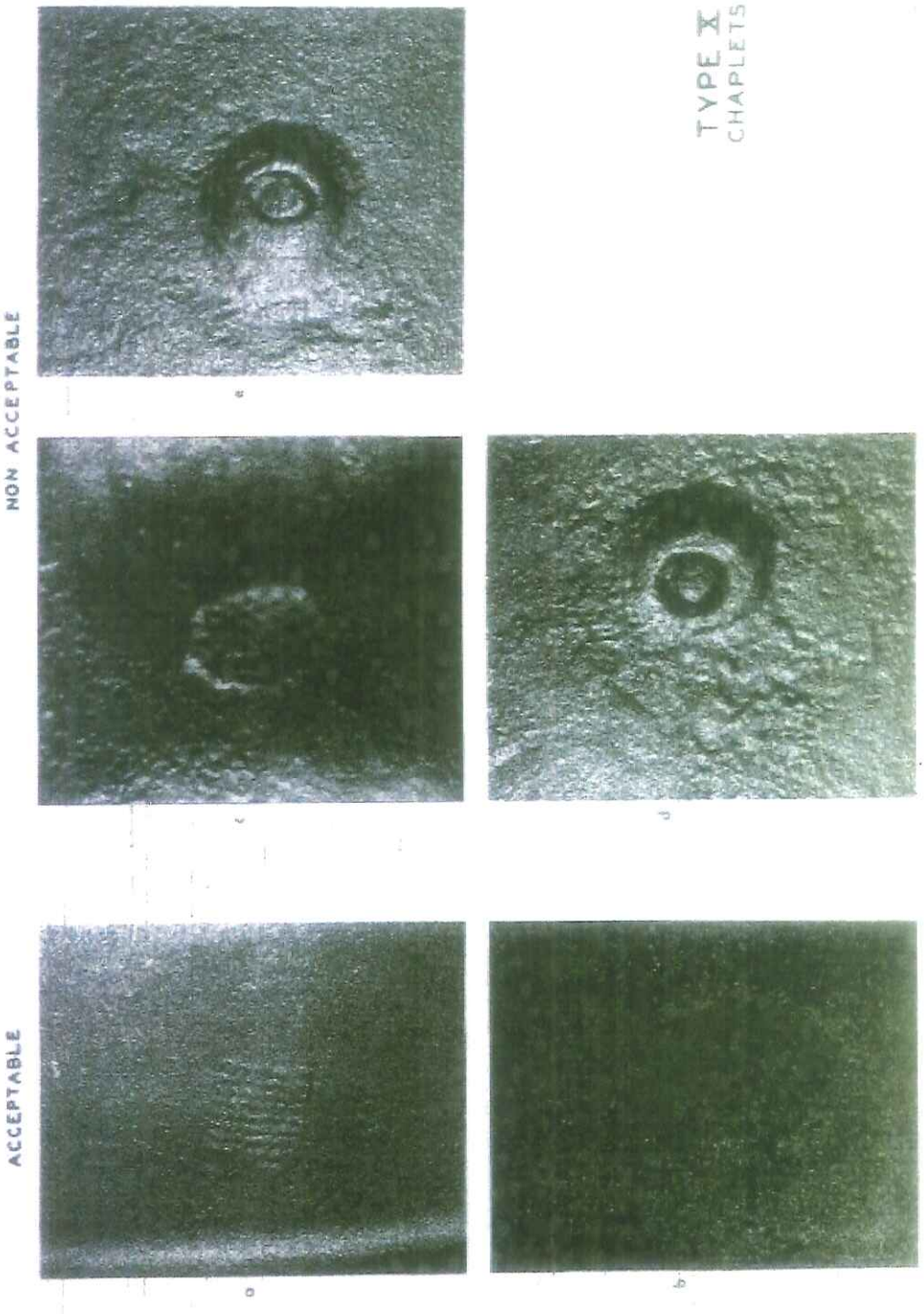
TYPE X
CHAPLETS
NON ACCEPTABLE
ACCEPTABLE

TYPE XI
WELD REPAIR AREAS

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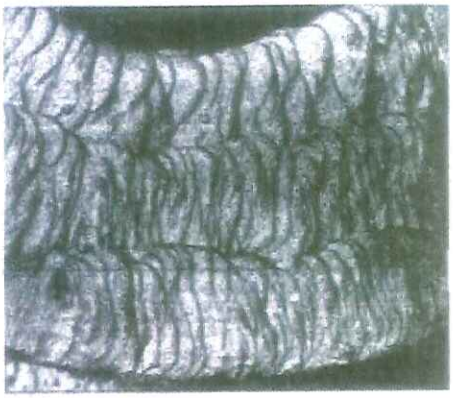

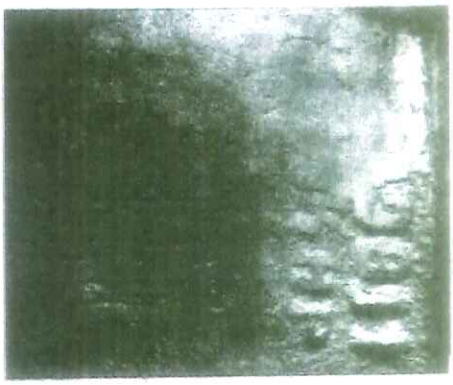

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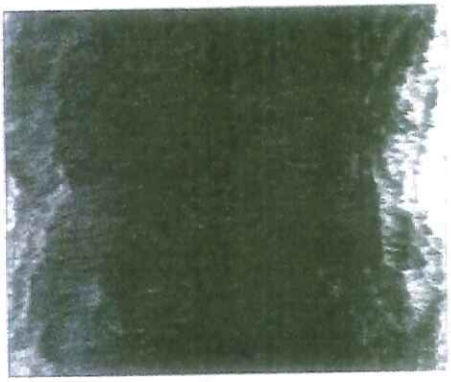

TYPE XII
SURFACE ROUGHNESS

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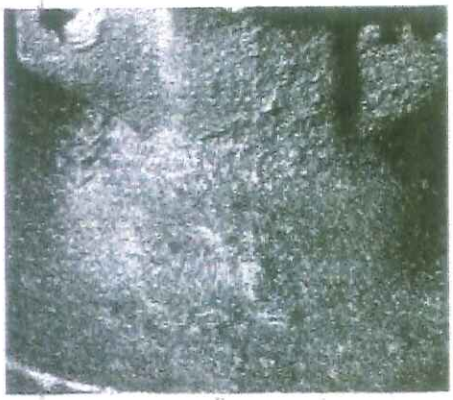

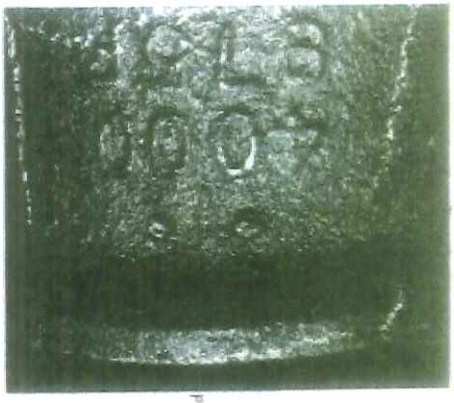

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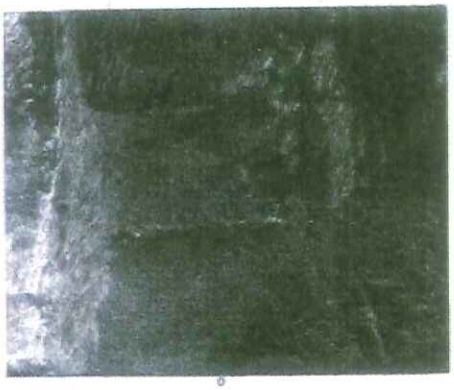


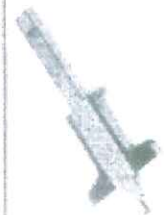
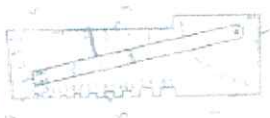
Annexure - E

Measuring instruments and weld gauges with measuring range and accuracy

Weld gauge	Description	Type of weld				Measuring range mm	Reading accuracy mm	Included or fillet angle degree	Permissible deviation of included or fillet angle
		Fillet weld			Butt weld				
		Flat weld	Concave weld	Convex weld					
	Simple weld gauge a) Measures fillet weld from 3 to 15 mm thickness. The gauge will be placed by the curved part in the fusion faces so as to have three points of contact with the work piece and the fillet weld. b) Measures butt welds reinforcement with the straight part. Because the gauges consists of relative soft aluminium they wear out rapidly.	x	x	-	x	3 to 15	≈ 0,5	90	small
	Set of welding gauges Measures fillet welds from 3 to 12 mm thickness : from 3 to 7 mm : graduations of 0,5 mm ; above 8 mm, 10 mm and 12 mm. The gauge measures by using the principle of three point contact	x	x			3 to 12	according to fan part	90	none

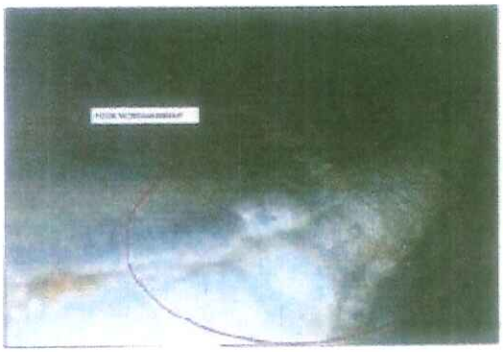
Weld gauge	Description	Type of weld				Measuring range	Reading accuracy	Included or fillet angle	Permissible deviation of included or fillet angle
		Fillet weld			Butt weld				
		Flat weld	Concave weld	Convex weld					
	Weld gauge with vernier Measures fillet welds ; also reinforcement of butt welds can be determined. The legs of the gauge are so formed that included angles of 60 °, 70 °, 80 ° and 90 ° of V- and single-V butt weld with broad face can be measured. But slight deviations from these lead to significant errors.	x	x	-	x	0 to 20 mm	0,1 mm	90 degree	none
	Self made weld gauge Measures 7 throat thickness of fillet welds with an included angle of 90 °	x	-	-	-	0 to 20 mm	0,2 mm	90 degree	none
	Three-scale weld gauge Measures throat thickness and leg length. Can also measure weld reinforcement of butt welds. Easy to use. Also appropriate for asymetric fillet welds	x	x	x	x	0 to 15 mm	0,1 mm	90 degree	small

Weld gauge	Description	Type of weld				Measuring range mm	Reading accuracy mm	Included or fillet angle degree	Permissible deviation of included or fillet angle
		Fillet weld			Butt weld				
		Flat weld	Concave weld	Convex weld					
	Gauge for checking profile of fillet welds Checking the profile of one shape for one size of fillet welds. This type of gauge needs one model for each size of fillet weld.								
	Multi purpose gauge Measures angle of bevel, leg length of fillet weld, undercut, misalignement, throat thickness and weld reinforcement.	x	x	x	x	0 to 50	0.3	0 to 45 (angle of bevel)	none
	Universal weld gauge Measures tasks : - fillet welds shape and dimensions - butt welds misalignement of plates, joint preparation (angle width) weld reinforcement, weld width, undercuts.	x	x	x	x	0 to 30	0.1		± 25 %

Weld gauge	Description	Type of weld				Measuring range mm	Reading accuracy mm	Included or fillet angle degree	Permissible deviation of included or fillet angle
		Fillet weld			Butt weld				
		Flat weld	Concave weld	Convex weld					
	**Gap gauge** Measures the width of gaps	-	-	-	x	0 to 6	0,1	-	-
	**Hook gauge for misalignement** Measures the misalignement of the preparation for butt welds on plates and pipes	-	-	-	x	0 to 100	0,05	-	-
	**Universal butt weld gauge** Measures the preparation and the finished butt weld : (1) angle of bevel, (2) width of root gap, (3) weld reinforcement, (4) width of weld surface (5) depth of undercut (6) diameter of consummables	x	x	x	x	0 to 30	0,1	-	± 25 %

Visual Defects of Pressure Retaining Weld Roots Using Boroscope Camera (Annexure C)

Note: Reject or inspect further by alternate NDE methods

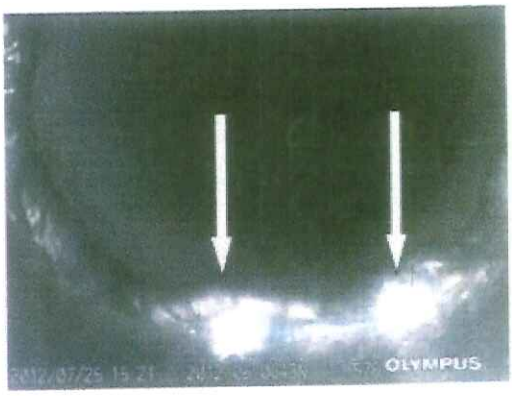


Poor Workmanship

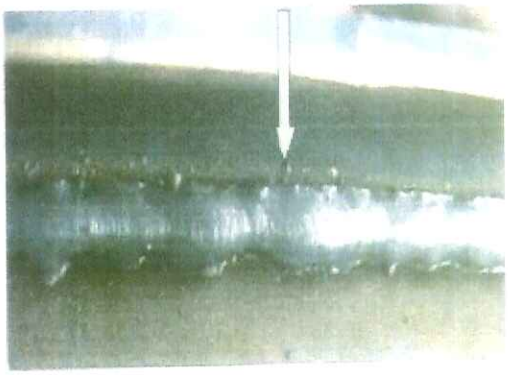
Poor Start/ Stop and Crater

Oxidation

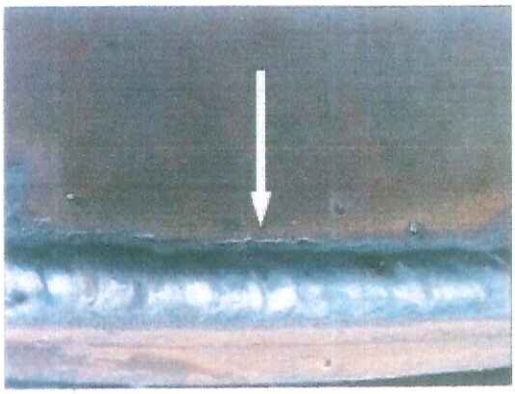
Suck Back



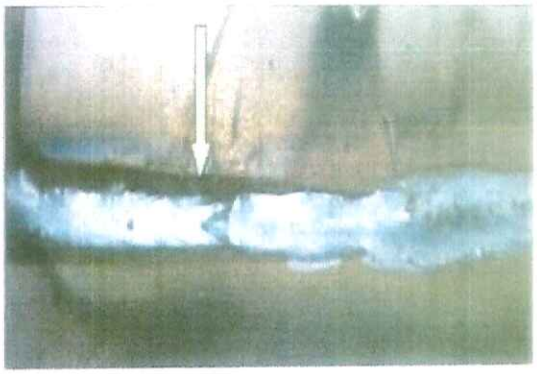
Excess Root Penetration



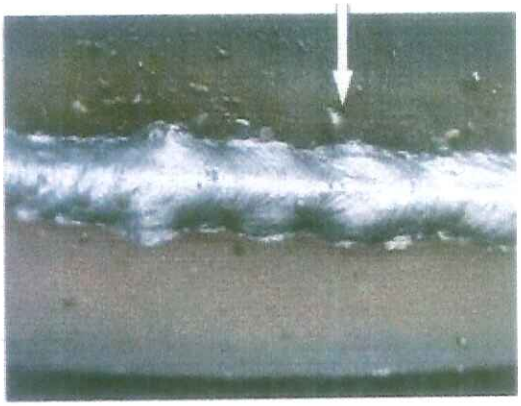
Incomplete Fusion



Undercut



Under Fill



Spatter