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RECORD OF REVISION

Rev. No	Revision Date	Revision of Details
07	01-07-1991	1.2 Re designated as 2.0 and modified 4.4 Re designated as 5.4 and revised 5.1.3 Re designated as 6.1.3 and revised 5.3.2 Re designated as 6.3.2 and revised
08	28-03-1994	Clause 3 numbered as 1.2 and rest of the clauses renumbered. ASME Section VIII added as reference. 6.4 Added 7.0 Modified. 'Qualification of procedure for Non-Standard Temperatures'- deleted and rest of the clauses renumbered.
09	01-08-1996	Revised in entirety
10	01-06-1997	1.0 Scope of application enhanced 8.2 Maximum Dwell time included 10.3 Evaluation to meet AWS code added 10.4 Title changed to meet ASME Code 12.2 & 12.3 Acceptance Standards added for structural applications
11	04-01-1999	Clauses 2.0, 7.1.1, 8.2.1, 8.4.3.1, 9.1, 9.3, 10.3, 10.4 and 11.1.1 modified 11.2.4 Added and rest of the clauses renumbered. Editorial Corrections made. Annexure A added
12	28-12-2002	5.4 Modified 6.1 Revised Annexure A incorporated in main text, revised and renumbered.
13	22-01-2004	4.0, 6.1, 8.4.1, 8.4.3.1 Modified 7.2 combined with 5.4 5.4, 9.3 Revised
14	27-12-2007	Clause 2.0, 7.0, 8.2, 11.2.2, 11.2.3 and 19.1-Revised
15	02-05-2009	Clause 2.0, 5.4, 9.2 and 18.1 revised
16	30-12-2010	Clause 1.1, 2.0, 5.4, 8.2.1 and 8.4.2.1 Revised. Table 3 added
17	30-01-2015	Clause 15.2 modified
18	01-01-2016	Clause 2, 9.1 revised. Sr.11, Column-3, of Table-3 revised. Clause 5.5 Added. Clauses 6.1, 8.1, 8.2.1, 8.2.2, 8.3.2.1, 8.4.2.1 Clause 9.1, 9.2, 10.1 modified. Table-1, Table-2 modified.
19	03-10-2017	Clause 8.2.1, 10.1 and 16.1 modified.
20	30-05-2018	Clause 1.3 added. Clause 2.1, 2.2, 4.4, 4.5, 8.1, 8.2.1, 8.4.2.1, 8.4.2.2, 10.1, 18.1, Table 1 & 3 revised.
21	07.01.2019	Clause 2.3, 8.4 & Clause 15.1.



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1.0 SCOPE

- 1.1. This procedure defines the method, techniques and acceptance standards for Liquid Penetrant Examination by Solvent removable color contrast technique, for all shapes of weldment and materials used for Boilers, Pressure Vessels, Heat Exchangers, Piping and Structural components.
- 1.2. In pressure vessels the examination shall include all welds around openings, attachment welds with a throat thickness over 6 mm and on finished surfaces of welds as required by referencing code. The examination includes base material 13 mm on each side of the weld.
- 1.3. This procedure shall also be applicable for Ferrous and Non-Ferrous materials and Welded components used for AUSC Projects

2.0 REFERENCE

- 2.1. ASME Section V, I and VIII (Division 1&2) / 2017
- 2.2. ASME B 31.1 / 2016
- 2.3. AWS D 1.1 / D1.1M:2015

3.0 EQUIPMENT

- 3.1. The term 'penetrant materials' as used in this procedure is intended to include all Liquid penetrants, Solvents (penetrant removers) or cleaning agents, developers etc. used for 'Liquid Penetrant Examination'.

4.0 CHEMICALS FOR EXAMINATION

- 4.1 The cleaner used for the surface cleaning will be an organic chemical such as Acetone or Trichloro-ethylene.
- 4.2 Penetrant- Solvent removable type with good colour contrast like Red or Pink.
- 4.3 Developer- Non-aqueous suspendable type.
- 4.4 Sulphur content in Penetrant materials for Nickel base alloys testing shall be less than 0.1 % of the residue by weight.
- 4.5 Chlorine plus Fluorine content shall not exceed 0.1% of the residue by weight in Penetrant materials when used for testing of Stainless steel or Titanium.
- 4.6 The certification of contaminant shall be obtained from the supplier with Batch number details.

5.0 SURFACE PREPARATION

- 5.1 In general as welded, as rolled, as forged or as cast condition is accepted. When the surface irregularities might mask the indications of unacceptable discontinuities, the surface shall be prepared by grinding or Machining or any other suitable method.
- 5.2 The surface to be examined and all adjacent areas within at least 25 mm shall be dry and free of any dirt, grease, lint, scale, welding flux, weld spatter, rust, paint, oil or any other extraneous matter that could prevent the penetration.
- 5.3 Shot / sand blasting of the surface is not acceptable for conducting penetrant examination. If the component is shot blasted, the surface is to be etched before conducting penetrant examination.
- 5.4 The following Brands of Penetrant chemicals will be used.

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5.5. <i>Cleaning of the surface shall be done with lint free white cotton cloth moistened in solvent cleaner (given in Table-1).</i>			
Table – 1 LIST OF PENETRANT MATERIALS			
Manufacturer	MATERIAL (DESIGNATION)		
Pradeep Metal Treatment Chemicals Pvt. Ltd	CLEANER	PENETRANT	DEVELOPER
	Flaw guide Cleaner	Flaw guide Penetrant	Flaw guide Developer
Other brands may be used with the approval of Level III / NDT. Intermixing of penetrant materials from different families or different manufacturers is not permitted			
6.0 DRYING AFTER PREPARATION			
6.1. After cleaning, drying of the surfaces shall be by normal evaporation. The minimum time required for the cleaner to dry from the surface shall be 60 Seconds <i>and maximum time shall be 10 minutes.</i>			
7.0 TEMPERATURE			
7.1. The temperature of the penetrant and the surface of the part shall not be below 5° C and not above 52° C throughout the examination period.			
8.0 EXAMINATION			
8.1. <i>Penetrant Application</i> The penetrant shall be applied by brushing or spraying. For spraying, an aerosol spray can is recommended			
8.2. Penetration Time:			
8.2.1 <i>The penetration time (dwell time) shall be minimum 10 minutes and maximum 20 minutes for the standard testing temperature which is within 16 to 50 Deg. Celsius.</i> For Nickel and Titanium based material and Welds, the penetration time (dwell time) shall be 20 minutes <i>Any change from this duration shall be qualified by demonstration.</i> The penetrant shall be allowed to remain wet on the part for a minimum and <i>maximum period</i> (dwell time) as qualified by demonstration for specific application.			
8.2.2 Regardless of the length of the dwell time, the penetrant shall not be allowed to dry. If for any reason the penetrant does dry, the examination procedure shall be repeated, beginning with a cleaning of the examination surface.			
8.3. Removal of Excess Penetrant:			
8.3.1 After the required dwell time has elapsed, the excess penetrant remaining on the surface shall be removed by wiping with a lint free cloth, repeating the operation until most traces of penetrant have been removed. Final left out penetrant shall be removed by wiping with a clean cloth moistened with the solvent. Excessive application of the cleaner shall be avoided to prevent the possibility of removing the penetrant from discontinuities causing a decrease in the sensitivity of the test. Flushing the material surface with the solvent following the application of penetrant and prior to developing is prohibited.			
8.3.2 Drying after excess penetrant removal:			



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8.3.2.1 After the removal of excess penetrant the surface shall be dried by normal evaporation. The minimum time required for the surface to get dried by normal evaporation shall be 60 seconds and maximum shall be 10 minutes

8.4. Developer Application

8.4.1 Prior to application, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles. The developer shall be applied as soon as possible by spraying using aerosol spray can for complete coverage of the part with a thin, uniform film of developer. The maximum time interval between excess penetrant removal and application of developer shall be 10 minutes. Drying of developer shall be by normal evaporation.

8.4.2 Development Time

8.4.2.1 *Developing time for final interpretation begins immediately after the drying of wet developer coating.*

8.4.2.2 Final inspection shall be made after a minimum period of developing time as detailed below.

Developing Time for conventional steels and Welds: Min.10 minutes to Max 60 Minutes

Developing time for Nickel and Titanium based material and Welds: 60 minutes

9.0 LIGHTING

9.1. A minimum light intensity of 100 foot candle (1000 lux) is required to ensure adequate sensitivity during the examination and evaluation of indications. "A Hand lamp with 240 Volts, 09 Watt LED *Electric* bulb *white light* is held at 300 mm distance normal to the test surface within a circle of 280 mm diameter" is considered adequate to provide above level of illumination. The *supplemental white* light source, technique used, and light level verification shall be demonstrated one time, documented, and maintained on file.

9.2. Light meters shall be calibrated at least once a year or whenever a meter has been repaired. *If meter has not been used for one year it shall be calibrated before use.*

10.0 EVALUATION

10.1. Flaws at the surface will be indicated by bleed out of the penetrant. However localized surface irregularities such as machining marks or other surface conditions may produce false indications. *In case of excessive diffusion of penetrant in to the developer, close observation of the formation of indications during application of the developer may assist in characterizing and determining the extent of the indications.*

10.2. The surface shall be examined in increments if the surface to be examined is large enough to complete the inspection within the prescribed time.

10.3. An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation.

10.4. Relevant indications are those which result from mechanical discontinuities (imperfection).

10.5. Only indications with major dimension greater than 1.5 mm shall be considered relevant.

10.6. Any indication which is believed to be non-relevant shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is evaluated by other non-destructive testing methods and proved to be non-relevant.

10.7. Linear indication - length is more than three times the width.

10.8. Rounded indication -circular or elliptical with the length equal to or less than three times the width.

10.9. Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.



11.0 ACCEPTANCE STANDARD

11.1. Welds and Materials (as per ASME Sec I and VIII / Div. 1 and 2)

11.1.1 All surfaces to be examined shall be free of

11.1.2 a) Relevant linear indications.

b) Relevant rounded indications greater than 5.0 mm.

c) All relevant indications shall be investigated to assure that no leak-path exists in welds joining nipples to drums, dished-ends and headers.

11.1.3 Four or more relevant rounded indications in a line separated by 1.5 mm or less edge to edge.

11.1.4 In attachment welds of non-load carrying class, indications from cracks or due to material separation are unacceptable.

11.2. For Power Piping (as per ASME B31.1 Power Piping)

11.2.1 11.2.1 Indications whose major dimensions are greater than 2.0 mm shall be considered relevant.

11.2.2 11.2.2 The following relevant indications are unacceptable:

a) Any cracks or linear indications

b) Rounded indications with dimensions greater than 5.0 mm

c) Four or more rounded indications in a line separated by 2.0 mm or less edge to edge

d) Ten or more rounded indications in any 3870 mm² of surface with the major dimension of this area not to exceed 150 mm with the area taken in the most unfavorable location relative to the indications being evaluated

12.0 WELDS MADE TO STRUCTURAL WELDING CODE -AWS D 1.1

12.1. For Statically and cyclically loaded non-tubular connections made to AWS code the acceptance of any discontinuity shall be based upon a visual examination of the discontinuity after the removal of developer medium and evaluated for its nature and size. Where the discontinuity cannot be seen after removal of the developer medium either directly or using magnifying glass evaluation shall be based on the size and nature of liquid penetrant indication.

13.0 ACCEPTANCE STANDARD

13.1. Statically loaded non-tubular connections

13.1.1 Indications from Cracks, Lack of penetration and lack of fusion are not acceptable.

13.2. Porosity

13.2.1 Complete joint penetration groove welds in butt joints transverse to the computed tensile stress shall have no visible piping porosity.



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13.2.2 For all other groove welds and for fillet welds, the sum of the visible piping porosity 1.0 mm or greater in diameter shall not exceed 10 mm in any linear 25 mm of weld and shall not exceed 20 mm in any 300 mm length of weld.

13.3. Undercut

13.3.1 For material less than 25 mm thick, undercut shall not exceed 1.0 mm except that a maximum 2.0 mm is permitted for an accumulated length of 50 mm in any 300 mm.

13.3.2 For material equal to or greater than 25 mm thick, undercut shall not exceed 2.0 mm for any length of weld.

14.0 Cyclically loaded non-tubular connections

14.1. Indications from Cracks, Lack of penetration and lack of fusion are not acceptable in any welds.

14.2. Porosity

14.2.1 Complete joint penetration groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the frequency of piping porosity shall not exceed one in 100 mm of length and the maximum diameter shall not exceed 2.5 mm.

14.2.2 The frequency of piping porosity in fillet welds shall not exceed one in each 100 mm of weld length and the maximum diameter shall not exceed 2.5 mm. EXCEPTION: for fillet welds connecting stiffeners to web, the sum of the diameters of piping porosity shall not exceed 10mm in any linear 25mm of weld and shall not exceed 20mm in any 300 mm length of weld.

14.3. Undercut

14.3.1 In primary members, undercut shall not be more than 0.25 mm deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall not be more than 1 mm deep for all other cases.

15.0 REPAIR AND RE-EXAMINATION

15.1. Whenever an imperfection is repaired by chipping or grinding the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners. **The extent of the crack shall be ascertained by use of acid etching, MT, PT, or other equally positive means; the crack and sound metal 50mm beyond each end of the crack shall be removed.**

15.2. After a defect is thought to have been removed and where welding is required after repair, the area shall be examined for removal of defects, area cleaned and repair carried out. The repaired area shall be blended into the surrounding surface as in 13.1 and re-examined by the liquid penetrant or any other NDT methods originally required for the affected area.

16.0 PERSONNEL QUALIFICATION

16.1. All personnel carrying out the examination and evaluation shall be qualified to as per BHE: NDT: G: CRT. The testing shall be done by minimum Level-I *working under the NDT Level II* and Evaluation by Level II / III Personnel.

17.0 POST CLEANING

17.1. After the examination and evaluation is completed all penetrant testing materials shall be removed from the surface by using white cloth soaked with cleaner, so that it will not interfere with the subsequent processing or service requirements.

18.0 REPORTING AND RETENTION PERIOD

18.1. Report shall be given in the format, signed by Level II / III after the completion of the examination. All the reports for ASME Coded works shall be retained for a period of 5 years.

Table - 3
Requirements of a Liquid Penetrant Examination procedure

Sl No	Requirement (As per TABLE T-621.1, Article 6 of ASME Section –V)	Type of variable	Applicable clause in the procedure
01	Identification of and any change in type or family group of penetrant materials including developers, emulsifiers, etc.	Essential	Clause 5.4: As per Table-1
02	Surface preparation (finishing and cleaning, including type of cleaning solvent)	Essential	Clause 5.1 & 5.5: As welded / as ground / as machined condition and cleaning with lint free cotton cloth moistened in solvent cleaner (table-1).
03	Method of applying penetrant	Essential	Clause 8.1: By brushing
04	Method of removing excess penetrant	Essential	Clause 8.3.1: Manual Wiping with lint free cloth till the traces of excess penetrant on the surface disappear. Then, remove by gentle wiping with lint free cloth moistened with solvent.
05	Hydrophilic/ lipophilic emulsifier concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers	Essential	Not Used & Not applicable
06	Hydrophilic emulsifier concentration in spray application	Essential	Not Used & Not applicable
07	Method of applying developer	Essential	Clause 8.4.1: By spraying with aerosol spray can
08	Minimum and maximum time between steps and drying aids	Essential	Drying time after preparation- Clause 6.1: Natural Evaporation, Minimum 60 seconds & max 10 minutes. Drying after excess penetrant removal time- Clause 8.3.2.1: Minimum 60 seconds & max 10 minutes.
09	Decrease in penetrant dwell time	Essential	Dwell time-Clause 8.2.1: minimum 10 minutes & maximum 20 minutes for steels. 20 minutes for nickel and titanium based alloys
10	Increase in developer dwell time(Interpretation time)	Essential	Development time- Clause 8.4.2.2: Minimum 10 minutes and maximum 60 minutes for steels. 60 minutes for for nickel and titanium based alloys
11	Minimum light intensity	Essential	Clause 9.1:Minimum 100fc, Source: A hand lamp with 240 V/ 09 W LED electric bulb white light at a maximum distance of 300 mm.
12	Surface temp. outside 5 to 52 deg. C or as previously qualified	Essential	Clause 7.1: The temperature of the penetrant and the surface of the part shall not be below 16° C and not above 50° C throughout the examination period.
13	Performance demonstration , if required	Essential	A change in values of variables 1 to 12 in this table beyond their range specified range will call for demonstration and re-qualification of this procedure.

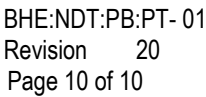


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14	Personnel qualification requirement	Non-Essential	Clause 13.0: BHEL's Written Practice
15	Material shape / size to be examined and extent of examination	Non-Essential	Clause 1.1: For all shapes of weldment and materials used for Boilers, Pressure Vessels, Heat Exchangers, Piping and Structural components.
16	Post- examination cleaning technique	Non-Essential	Clause 17.1:Dry white cotton cloth & finally cleaning with dry white cotton cloth soaked with solvent cleaner



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Report No:	Date:	Notification Ref:
Work Order:	Material:	Stage of test:
Form:	Part:	Drawing No:
Thickness:	Surface Condition:	
Temperature of part:	Pre-cleaning: Solvent cleaning	Drying Time: Secs
Penetrant: Visible –Solvent Removable		Dye Application: By Brush
Brand & Identification:	Penetrant: Cleaner Developer	
Dwell Time : Mts		Excess Penetrant cleaning: Using Cloth
Drying time after removal of excess penetrant: Seconds		
Time interval for Developer Application: Minutes		
Developer Application: Aerosol can-Spraying	Development Time: Mts	
Post Cleaning: Using Cloth	Lighting Equipment: Hand Lamp 230V 100W	
Light Intensity: lux	Date of Examination:	
(A hand lamp is held at 200 mm distance normal to the test surface within a circle of 280 mm diameter.)		
Procedure & Acceptance: BHE:NDT:PB:PT- Rev)		

[illegible]

Operator's Name	Evaluated By	Reviewed by
(Level I / II)	(Level II / III)	AI