NDT Procedure for Liquid Penetrant Testing as per ASME, API, AWS codes

NDT Procedure No: TNWSPL-DOC-PT-11 Rev '0'

A Nondestructive testing (NDT) Procedure suitable for Liquid Penetrant Testing. Includes acceptance criteria as per ASME Section IX, AWS D1.1 and ASME B31.1, ASME B31.3 and API 650 & API 653 standards. This is a sample PT procedure and may be required to be modified as per specific requirements. For more specific NDT procedure preparation as per customer need, contact Trinity NDT, ASNT/ISO9712/NAS410 Level III Expert Consulting services.

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PROCEDURE FOR LIQUID PENETRANT EXAMINATION AS PER ASME, AWS, API CODES

Procedure No. TNWSPL-DOC-PT-11 Rev '0'

REVISION RECORD

No.	Date	Description of Revision	Revised by	Approved by

CONTENTS

1. Scope

In general, this Article is in conformance with ASTM E-165, Standard Test Method for Liquid Penetrant Examination. The liquid penetrant examination method is an effective means for detecting discontinuities which are open to the surface of nonporous metals and other materials. Typical discontinuities detectable by this method are cracks, seams, laps, cold shuts, laminations, and porosity.

2. Reference Documents

2.1. ASME Boiler and Pressure Vessel Code Section I : Rules for Construction of Power Boilers
2.2. ASME BPVC Sec. II : Materials
2.3. ASME, Boiler and Pressure Vessel Code Section V : Non Destructive Examination
2.4. ASME, Boiler and Pressure Vessel Code Section VIII : Rules for Construction of Pressure Vessels
2.5. ASME, Boiler and Pressure Vessel Code Section IX : Welding and Brazing Qualification
2.6. ASME, B 31.1 : Power Piping
2.7. ASME, B 31.3 : Process Piping
2.8. AWS D1.1: Structural Welding Code – Steel
2.9. ASTM E1417 / E1417MAS Standard Practice for Liquid Penetrant Testing
2.10. ASTM E165: Standard Method for Liquid Penetrant Examination
2.11. API 6 A / ISO 10423 , Specification for wellhead and Christmas tree equipment
2.12. API 650 Welded Steel Tanks for Oil Storage
2.13. API 653 Tank Inspection, Repair, Alteration, and Reconstruction
2.14. SNT-TC-1A : Personnel Qualification and Certification in Nondestructive
2.15. ANSI/ASNT CP-189 ASNT : Standard for Qualification and Certification of Nondestructive Testing
2.16. EN ISO 9712: Qualification and Certification of NDT Personnel

2.17. NAS 410: NAS Certification & Qualification of Nondestructive Test Personnel
2.18. RCI Qualification and Certification of NDT procedure
2.19. Applicable referencing code section or project specification

3. Abbreviation

3.1. NDT : Non-Destructive Testing
3.2. PT: Liquid Penetrant Testing
3.3. ASNT: American Society for Non-destructive Testing
3.4. ASME: American Society of Mechanical Engineers
3.5. AWS: American Welding Society
3.6. API: American Petroleum Institute
3.7. ANSI: American National Standards Institute
3.8. ASTM: American Society for Testing Metals
3.9. ISO: International Standards Organization
3.10. NAS: National Aerospace Standard
3.11. SNT-TC: Society for Non-destructive Testing- Testing Council

4. Personnel Qualification

Personnel performing the test shall be qualified and certified in accordance with one of the following.
4.1 SNT-TC-1A : Personnel Qualification and Certification in Nondestructive
4.2 ANSI/ASNT CP-189 ASNT : Standard for Qualification and Certification of Nondestructive Testing
4.3 EN ISO 9712 : Qualification and Certification of NDT Personnel
4.4 NAS 410 : NAS Certification & Qualification of Nondestructive Test Personnel

5. Equipment's and Material

Liquid Penetrant Testing Materials consist of fluorescent or visible penetrants, emulsifiers (oil-base and water base), removers (water and

solvent), and developers (dry powder, aqueous and non-aqueous). A family of liquid penetrant examination materials consists of the applicable penetrant and emulsifier, as recommended by the manufacturer. Any liquid penetrant, remover and developer listed in QPL-25135/QPLAMS2644 can be used, regardless of the manufacturer. Intermixing of penetrants and emulsifiers from different manufacturers is prohibited.

6. Surface preparation

6.1. In general, satisfactory results may be obtained when the surface of the part is in the as-welded, as-rolled, as-cast, or as-forged condition. Surface preparation by grinding, machining, or other methods may be necessary where surface irregularities could mask indications.

6.2. Prior to each liquid penetrant examination, the surface to be examined and all adjacent areas within at least1 in. (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux, weld spatter, paint, oil, and other extraneous matter that could obscure surface openings or otherwise interfere with the examination.

6.3. Typical cleaning agents which may be used are detergents, organic solvents, descaling solutions, and paint removers. Degreasing and ultrasonic cleaning methods may also be used.

7. Extent of Examination

The extent of liquid penetrant examination shall be as specified by the referencing Code section and project specification

8. Calibration

Light meters, both visible and fluorescent (black) light meters, shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

9. Examination

9.1. Drying after preparation after cleaning, drying of the surfaces to be examined shall be accomplished by normal evaporation or with forced hot or cold air. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to application of the penetrant.

9.2. Techniques, either a color contrast (visible) penetrant or a fluorescent penetrant shall be used with one of the following two penetrant processes:

9.2.1. Water washable

9.2.2. Solvent removable

9.3. Techniques for standard temperatures, as a standard technique, the temperature of the penetrant and the surface of the part to be processed shall not be below 40°F (5°C) nor above 125°F (52°C) throughout the examination period. Local heating or cooling is permitted provided the part temperature remains in the range of 40°F to 125°F (5°C to 52°C) during the examination. Where it is not practical to comply with these temperature
limitations, other temperatures and times may be used, provided the procedures are qualified as specified in T-653.

9.4. Technique Restrictions, Fluorescent penetrant examination shall not follow a color contrast penetrant examination. Intermixing of penetrant materials from different families or different manufacturers is not permitted. A retest with water washable penetrants may cause loss of marginal indications due to contamination.

9.5. Penetrant application the penetrant may be applied by any suitable means, such as dipping, brushing, or spraying. If the penetrant is applied by spraying using compressed-air-type apparatus, filters shall be placed on the upstream side near the air inlet to preclude contamination of the penetrant by oil, water, dirt, or sediment that may have collected in the lines.

9.6. The minimum penetration time shall be as required in Table 1 or as qualified by demonstration for specific applications. The maximum dwell time shall not exceed 2 hrs or as qualified by demonstration for specific applications. 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.

9.7. Excess penetrant removal, after the specified penetration (dwell) time has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from discontinuities.

9.7.1. Water-Washable Penetrants. Excess water washable penetrant shall be removed with a water spray. The water pressure shall not exceed 50 psi (350 kPa), and the water temperature shall not exceed 110°F (43°C).

9.7.2. Solvent Removable Penetrants. Excess solvent removable penetrants shall be removed by wiping with a cloth or absorbent paper, repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by lightly wiping the surface with cloth or absorbent paper moistened with solvent. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess solvent. **Flushing the surface with solvent, following the application of the penetrant and prior to developing, is prohibited.**

9.8Drying after excess penetrant removal

9.8.1For the water washable technique, the surfaces may be dried by blotting with clean materials or by using circulating air, provided the temperature of the surface is not raised above 125°F (52°C).

9.8.2For the solvent removable technique, the surfaces may be dried by normal evaporation, blotting, wiping, or forced air.

9.8.3Developing, the developer shall be applied as soon as possible after penetrant removal; Insufficient coating thickness may not draw the penetrant out of discontinuities; conversely, excessive coating thickness may mask indications.

With color contrast penetrants, only a wet developer shall be used. With fluorescent penetrants, a wet or dry developer may be used.

9.8.4Dry Developer Application. Dry developer shall be applied only to a dry surface by a soft brush, hand powder bulb, powder gun, or other means, provided the powder is dusted evenly over the entire surface being examined.

9.8.5Wet Developer Application. Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

9.8.6Aqueous Developer Application. Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, brushing, spraying, or other means, provided a thin coating is obtained over the entire surface being examined. Drying time may be decreased by using warm air, provided the surface temperature of the part is not raised above 125°F (52°C). Blotting is not permitted.

9.8.7Nonaqueous Developer Application, Nonaqueous developers shall be applied by spraying, except where safety or restricted access preclude it. Under such conditions, developer may be applied by brushing. For water washable penetrants, the developer shall be applied to a dry surface. For solvent removable penetrants, the developer may be applied as soon as practical after excess penetrant removal. Drying shall be by normal evaporation.

9.8.8Developing time, developing time for final interpretation begins immediately after the application of a dry developer or as soon as wet developer coating is dry.

Table 1
Minimum Dwell Times

Material	Form	Type of Discontinuity	Dwell Times [Note (1)], (minutes) Penetrant
Aluminum, magnesium, steel, brass and bronze, titanium and high- temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks (all forms)	5
	Wrought materials — extrusions, forgings, plate	Laps, cracks	10
Carbide-tipped tools	Brazed or welded	Lack of fusion, porosity, cracks	5
Plastic	All forms	Cracks	5
Glass	All forms	Cracks	5
Ceramic	All forms	Cracks	5

NOTE:
(1) For temperature range from 50°F to 125°F (10°C to 52°C). For temperatures from 40°F (5°C) up to 50°F (10°C), minimum penetrant dwell time shall be 2 times the value listed.

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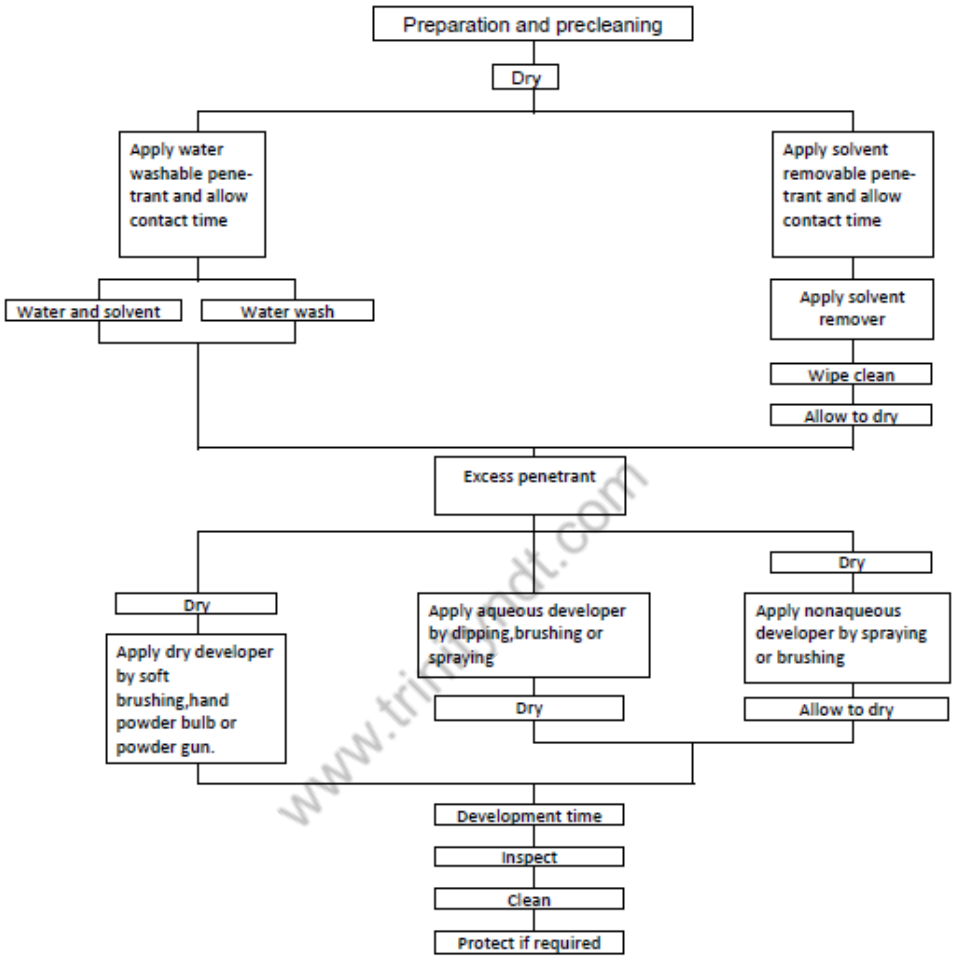

10. Evaluation and Acceptance Criteria

10.1. Final Interpretation, final interpretation shall be made not less than 10 min nor are more than 60 min after the requirements of 9.7.4 satisfied. If bleed-out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed or established time, the examination shall be performed in increments.

10.2. Characterizing Indication(s), the type of discontinuities are difficult to evaluate if the penetrant diffuses excessively into the developer. If this condition occurs, close observation of the formation of indication (s) during application of the developer may assist in characterizing and determining the extent of the indication(s).

10.3. Color Contrast Penetrants. With a color contrast penetrant, the developer forms a reasonably uniform white coating. Surface discontinuities are indicated by bleed-out of the penetrant which is normally a deep red color that stains the developer. Indications with a light pink color may indicate excessive cleaning. Inadequate.

10.4. Cleaning may leave an excessive background making interpretation difficult. Illumination (natural or supplemental white light) of the examination surface is required for the evaluation of indications. The minimum light intensity shall be 100 fc (1000 lx). The light intensity, natural or supplemental white light source, shall be measured with a white light meter prior to the evaluation of indications or a verified light source shall be used. Verification of light sources is required to be demonstrated only one time, documented, and maintained on file.

10.5. Fluorescent Penetrants, with fluorescent penetrants, the process is essentially the same as in 10.3, with the exception that the examination is performed using an ultraviolet light, called black light. The examination shall be performed as follows:

10.5.1. It shall be performed in a darkened area.

10.5.2. Examiners shall be in a darkened area for at least 5 min prior to performing examinations to enable their eyes to adapt to

dark viewing. Glasses or lenses worn by examiners shall not be photosensitive.

10.5.3. Black lights shall achieve a minimum of 1000 µW/cm2 on the surface of the part being examined throughout the examination.

10.5.4. Reflectors and filters should be checked and, if necessary, cleaned prior to use. Cracked or broken filters shall be replaced immediately.

10.5.5. The black light intensity shall be measured with a black light meter prior to use, whenever the light's power source is interrupted or changed, and at the completion of the examination or series of examinations.

10.6. Post-Examination cleaning, when post-examination cleaning is required by the procedure it should be conducted as soon as practical after Evaluation and Documentation using a process that does not adversely affect the part.

10.7. Evaluation

10.7.1. All indications shall be evaluated in terms of the acceptance standards of the referencing Code Section.

10.7.2. Discontinuities at the surface will be indicated by bleed-out of penetrant; however, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

10.7.3. Broad areas of fluorescence or pigmentation which could mask indications of discontinuities are unacceptable, and such areas shall be cleaned and reexamined.

10.7.4. The Manufacturer shall be responsible for the review, interpretation, evaluation, and acceptance of the completed examination to assure compliance with the applicable standard as shown in appendix I-VI.

11. Documentations

11.1. Record of indications

11.1.1. Non-rejectable Indications, non-rejectable indications shall be recorded as specified by the referencing Code Section.

11.1.2. Rejectable Indications, rejectable indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

11.2. Examination records, For each examination, the following information shall be recorded:

11.2.1. Date of the examination

11.2.2. Name and/or identity and certification level (if applicable) for personnel performing the examination the dimensional map (if used) of marker placement

11.2.3. Identification of the weld, part, or component examined including weld number, serial number, or other identifier

11.2.4. Examination method, technique, procedure Identification, and revision

11.2.5. Results of the examination

11.2.6. Liquid penetrant type (visible or fluorescent);

11.2.7. Type (number or letter designation) of each penetrant, penetrant remover, emulsifier, and developer used;

11.2.8. Map or record of indications per 11.1;

11.2.9. Material and thickness, and;

11.2.10. Lighting equipment.

12. Safety and Environment

As penetrant inspection techniques often require the use of harmful, flammable and/or volatile materials, certain precautions shall be taken. Prolonged or repeated contact of these materials with the skin or any mucous membrane should be avoided. Working areas shall be adequately ventilated and sited away from sources of heat, sparks and naked flames in accordance with local regulations. The penetrant testing products and equipment shall be used with care and always in compliance with the instructions supplied by the manufacturer. When using UV-A sources, care shall be taken to ensure that unfiltered radiation from the UV-A source does not directly reach the eyes of

the operators. Whether it forms an integral part of the lamp or is a separate component, the UV-A filter shall always be maintained in good condition. There is legislation and regulations regarding health, safety, pollution and storage, etc

Appendix I Acceptance Criteria for ASME BPVC Section I

Evaluation of Indications

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. Only indications that have any dimension greater than 1⁄16 in. (1.5 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.

(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

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

Acceptance

All surfaces to be examined shall be free of

(a) Relevant linear indications

(b) Relevant rounded indications greater than 3⁄16 in. (5 mm)

(c) Four or more relevant rounded indications in a line separated by 1⁄16 in. (1.5 mm) or less, edge to edge

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Appendix II Acceptance Criteria for ASME BPVC Section VIII Div.1, API 650 and API 653

Evaluation of Indications

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. Only indications with major dimensions greater than 1/16 in. (1.5 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.
(b) A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width.
(c) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant

Acceptance

These acceptance standards shall apply unless other more restrictive standards are specified for specific materials or applications within this Division. All surfaces to be examined shall be free of:
(a) relevant linear indications;
(b) relevant rounded indications greater than 3/16 in.(5 mm);
(c) four or more relevant rounded indications in a line separated by 1/16 in. (1.5 mm) or less (edge to edge).

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Appendix III Acceptance Criteria for ASME B31.1

Evaluation of Indications

1.) Mechanical discontinuities at the surface will be indicated by bleeding out of the penetrant; however, localized surface imperfections, such as may occur from machining marks or surface conditions, may produce similar indications which are non-relevant to the detection of unacceptable discontinuities.
2.) Any indication that is believed to be non-relevant shall be regarded as a defect and shall be reexamined to verify whether or not actual defects are present. Surface conditioning may precede the reexamination. Non-relevant indications and broad areas of pigmentation which would mask indications of defects are unacceptable.
3.) Relevant indications are those which result from mechanical discontinuities. Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.
4.) An indication of a discontinuity may be larger than the discontinuity that causes it; however, the size of the indication and not the size of the discontinuity is the basis of acceptance or rejection.

Acceptance Criteria

Indications whose major dimensions are greater than 1⁄16 in. (2.0 mm) shall be considered relevant. The following relevant indications are unacceptable:
1.) Any cracks or linear indications
2.) rounded indications with dimensions greater than 3⁄16 in. (5.0 mm)
3.) Four or more rounded indications in a line separated by 1⁄16 in. (2.0 mm) or less edge to edge
4.) ten or more rounded indications in any 6 in.2(3 870 mm2) of surface with the major dimension of this area not to exceed 6 in. (150 mm) with the area taken in the most unfavorable location relative to the indications being evaluated

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Appendix IV Acceptance Criteria for ASME B31.3

Evaluation of Indications

Liquid penetrant indications are caused by the bleed-out of a visible or fluorescent dye from a surface discontinuity in the area under test. However, all such indications are not necessarily imperfections, since excessive roughness, poor surface
preparation, etc., may produce non-relevant indications. In advertent evidence of penetrant not related to actual bleed-out is classified as a false indication. Indications shall be verified as being relevant, non-relevant, or false. Additional surface preparation and/or other test methods may be used as needed to verify the relevance of an indication. 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. Only indications that have any dimension greater than 1.5mm (1⁄16 in.) shall be considered relevant.

Acceptance Criteria

(a) Indications

(1) A linear indication is one having a length greater than three times its width.

(2) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

(b) Examination. All surfaces to be examined shall be free of

(1) Relevant linear indications.

(2) Relevant rounded indications >5.0 mm (3⁄16 in.)

(3) Four or more relevant rounded indications in a line separated by 1.5 mm (1⁄16 in.) or less, edge to edge.

Appendix V Acceptance Criteria for AWS D1.1

Table 6.1
Visual Inspection Acceptance Criteria (see 6.9)

Discontinuity Category and Inspection Criteria	Statically Loaded Nontubular Connections	Cyclically Loaded Nontubular Connections
(1) Crack Prohibition Any crack shall be unacceptable, regardless of size or location.	X	X
(2) Weld/Base Metal Fusion Complete fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.	X	X
(3) Crater Cross Section All craters shall be filled to provide the specified weld size, except for the ends of intermittent fillet welds outside of their effective length.	X	X
(4) Weld Profiles Weld profiles shall be in conformance with 5.23.	X	X
(5) Time of Inspection Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature. Acceptance criteria for ASTM A514, A517, and A709 Grade HPS 100W [HPS 690W] steels shall be based on visual inspection performed not less than 48 hours after completion of the weld.	X	X
(6) Undersized Welds The size of a fillet weld in any continuous weld may be less than the specified nominal size (L) without correction by the following amounts (U): L, specified nominal weld size, in [mm] — U, allowable decrease from L, in [mm] ≤ 3/16 [5] — ≤ 1/16 [2] 1/4 [6] — ≤ 3/32 [2.5] ≥ 5/16 [8] — ≤ 1/8 [3] In all cases, the undersize portion of the weld shall not exceed 10% of the weld length. On web-to-flange welds on girders, underrun shall be prohibited at the ends for a length equal to twice the width of the flange.	X	X
(7) Undercut (A) For material less than 1 in [25 mm] thick, undercut shall not exceed 1/32 in [1 mm], with the following exception: undercut shall not exceed 1/16 in [2 mm] for any accumulated length up to 2 in [50 mm] in any 12 in [300 mm]. For material equal to or greater than 1 in [25 mm] thick, undercut shall not exceed 1/16 in [2 mm] for any length of weld.	X	
(B) In primary members, undercut shall be no more than 0.01 in [0.25 mm] deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall be no more than 1/32 in [1 mm] deep for all other cases.		X
(8) Porosity (A) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no visible piping porosity. For all other groove welds and for fillet welds, the sum of the visible piping porosity 1/32 in [1 mm] or greater in diameter shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld.	X	
(B) The frequency of piping porosity in fillet welds shall not exceed one in each 4 in [100 mm] of weld length and the maximum diameter shall not exceed 3/32 in [2.5 mm]. Exception: for fillet welds connecting stiffeners to web, the sum of the diameters of piping porosity shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld.		X
(C) CJP 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 4 in [100 mm] of length and the maximum diameter shall not exceed 3/32 in [2.5 mm].		X

Note: An "X" indicates applicability for the connection type; a shaded area indicates non-applicability.

Appendix VI Liquid Penetrant Testing PT Report Form

RCI TESTING INSPECTION & CONSULTING CO.,LTD.

RCI

INSPECTION REPORT

LIQUID PENETRANT TESTING

Report No.: Rev.

Page No.: of

Client: Location:

Project Name: Project No.:

Procedure No.(Rev): Date of Test:

Reference Code: Request No.:

Examination Applications

Penetrants: ☐ Visible ☐ Fluorescent ☐ Dual Mode

Manufacture: Model:

Removal Methods: ☐ Water Washable ☐ Solvent Removable ☐ Post Emulsifying

Manufacture: Model:

Developers: ☐ Dry Developer ☐ Wet Developer

Manufacture: Model:

Penetrant Dwell Time: Minute Developer Dwell Time: Minute

DWG No: Material Type:

Weld Process:

State of Examination: ☐ After Welding ☐ After Repair ☐ After PWHT ☐ After Machining ☐ After Leak Testing

Surface Preparation: ☐ Grit Blasting ☐ Grinding ☐ Blasting ☐ Solvent Clean ☐ Other

Evaluation

Acceptance Criteria: ASME SEC.8

Weld Identification					Evaluation				
Joint No.	Weld Type	Welder No.	SIZE (dl)	Thickness (mm)	Accept	Reject	Repair	Defect Type	Remark

Note:

We, the undersigned, certify that the statements in this record are correct and that the welds and/or pieces were examined in accordance with the requirement of the above specified project specification and acceptance standard.

Judgement : ☐ Acceptable ☐ Unacceptable

Authorization	Examined/Evaluated By	Witnessed/Approved By	Witnessed/Approved By
Signature:			
Name:			
NDT Level:			
Company:			
Date:			