



PII-PT

Liquid Penetrant Examination

PNDT-PT

Revision 01

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1.0 SCOPE

1.1 This procedure describes the requirements to be implemented by Prime Inspections Inc. for performing Type I (fluorescent) and Type II (visible dye) Liquid Penetrant (PT) examinations using Method A (water washable), Method B (post-emulsifiable lipophilic), Method C (solvent removable), and Method D (post-emulsifiable hydrophilic) penetrant techniques, in accordance with ASME Section V, Article 6 and ASTM E165.

1.2 This procedure may be used for the detection of discontinuities open to the surface in nonporous materials, equipment, components and welds, as applicable to client specifications, and/or applicable codes. The size and shape of objects to be examined are not limiting factors provided the area(s) under examination can be properly examined within the time intervals specified in this procedure and all applicable process parameters are met.

1.3 This procedure is applicable to pipeline and pressure-containing components inspected per API 1104, 21st Edition, Section 9 (Nondestructive Testing – Liquid Penetrant Testing) and ASME Section V, Article 6. It covers all penetrant material types, methods, and developer forms recognized by ASME Section V, Article 6.

1.4 The procedure is suitable for use on nonporous ferrous and nonferrous materials including but not limited to carbon steel, austenitic stainless steel, duplex stainless steel, titanium, nickel-base alloys, aluminum, copper, and their associated weldments. It is not applicable to porous materials where penetrant could enter the material matrix and produce non-relevant indications.

2.0 REFERENCES

2.1 ASME Section I – Power Boilers, 2025 Edition

2.2 ASME Section V – Nondestructive Examination, 2025 Edition, Article 6 – Liquid Penetrant Examination

2.3 ASME Section VIII – Pressure Vessels, Divisions 1 and 2, 2025 Edition

2.4 ASME B31.1 – Power Piping, 2024 Edition

2.5 ASME B31.3 – Process Piping, 2024 Edition

2.6 ASME B16.34 – Valves, Flanged, Threaded and Welding End, 2025 Edition

2.7 API 1104 – Welding of Pipelines and Related Facilities, 21st Edition

2.8 PII-WP-1 – Written Practice for the Qualification and Certification of NDE Personnel (SNT-TC-1A), 2024 Edition

2.9 ASTM E165 / E165M – Standard Test Method for Liquid Penetrant Examination

2.10 ASTM E3022 – Standard Specification for Light-Emitting Diode (LED) Sources Used for Fluorescent Liquid Penetrant Examination

2.11 ASNT SNT-TC-1A, 2020 Edition – Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

3.0 RESPONSIBILITY

3.1 Prime Inspections Inc. is responsible for the preparation, review, approval and control of this procedure. The Level III is responsible for the technical review and approval of this procedure.

3.2 Level III, II, and Level I examiners are responsible for implementing the requirements of this procedure. Level III and II examiners are responsible for the supervision of Level I examiners and trainees.

3.3 The Quality Manager is responsible to monitor compliance with this procedure.

3.4 Technicians are responsible to comply with this procedure and to complete all required records/reports. At any time while performing work with this procedure, should it become evident that the requirements herein cannot be met the technician shall immediately notify the Shift Supervisor for resolution.

3.5 Technicians are to ensure that the item being inspected receives 100% inspection of all accessible areas within the inspection zone. Accessible areas are defined as those where all test parameters can be applied in accordance with the NDE procedure and the results properly viewed for interpretation/evaluation. In addition, inspection zone areas that are found to be inaccessible are to be recorded in the report.

3.6 Prior to beginning work, all personnel are to read, understand and follow the requirements of the applicable Job Hazard Analysis (JHA). In addition, personnel are to observe and follow all site-specific safety requirements.

4.0 PERSONNEL QUALIFICATIONS

4.1 Personnel performing Liquid Penetrant examinations shall be qualified and certified in accordance with reference 2.8, which complies with SNT-TC-1A, 2020 Edition.

4.2 Personnel may also be qualified and certified to other certification schemes such as CP-189 or NAS-410, depending on applicable client requirements.

4.3 Personnel performing evaluations and/or reporting results in accordance with this procedure shall be certified Level II as a minimum.

4.4 Near-vision acuity shall be verified annually per SNT-TC-1A requirements. Personnel shall be capable of reading Jaeger No. 1 (or equivalent) at 12 inches minimum distance. Color vision shall be verified annually for personnel performing visible dye penetrant examinations.

4.5 Personnel shall be trained on this specific procedure and its applicable safety requirements prior to performing examinations under this procedure. Training records shall be maintained in accordance with P11-WP-1.

5.0 GENERAL REQUIREMENTS

5.1 Precautions for Personnel Safety

5.1.1 The liquid penetrant examination materials should be used in well-ventilated areas because they are highly volatile and flammable. The penetrant should not be heated above 125°F (52°C), or exposed to open flames or hot surfaces. Empty aerosol cans shall not be thrown into an open fire because of the explosive hazard.

5.1.2 Care shall be taken to avoid overheating of pressurized cans. If they must be heated to reach the required examination temperatures, heating shall be accomplished by using a hot water bath, never by direct flame or heat guns.

5.1.3 Prior to beginning work, all personnel are to read, understand and follow the requirements of the applicable Job Hazard Analysis (JHA). In addition, personnel are to observe and follow all site-specific safety requirements including the use of appropriate personal protective equipment (PPE) such as nitrile gloves, safety glasses, and respirators where required.

5.1.4 Should there be a question or a clarification needed to any safety requirement, the supervisor, lead technician or facility representative, as applicable, is to be contacted for resolution before beginning or resuming work.

5.2 Control of Contaminants

5.2.1 When examining austenitic or duplex stainless steels, titanium, or nickel base alloys, the total sulfur and total halogen (chlorine and fluorine) content shall not exceed 1% of the residue by weight. Certification of contaminant content for all liquid penetrant materials shall be obtained from the manufacturer and maintained. This certification shall include manufacturer's batch numbers and test results as required by the referencing Code Section.

5.2.2 All penetrant materials (penetrant, remover/emulsifier, and developer) shall be from a single manufacturer's qualified system. Materials from different manufacturers shall not be intermixed. Intermixing of penetrant materials from different family groups or different manufacturers is not permitted.

5.3 Calibration and System Performance Verification

5.3.1 Light meters, both visible and ultraviolet, shall be calibrated every six months or whenever the meter is repaired. If meters have not been used for six months or more, calibration shall be performed prior to use.

5.3.2 The penetrant system performance shall be verified using a known defect reference block (TAM Panel, PSM-5 Panel, or equivalent) at the start of each shift or when materials are changed. The results of this verification shall be documented on a Process Control Log.

5.3.3 UV light intensity (for Type I fluorescent) shall be measured at the start of each shift using a calibrated UV radiometer. The UV-A intensity shall achieve a minimum of 1000 $\mu\text{W}/\text{cm}^2$ on the surface of the part being examined throughout the examination.

5.3.4 Visible light intensity shall be measured at the start of each shift using a calibrated light meter. A minimum of 100 foot-candles (1076 lux) shall be achieved on the examination surface for Type II (visible dye) penetrant examinations.

6.0 TECHNIQUES AND MATERIALS

6.1 One or more of the following techniques shall be used:

6.1.1 Type I – Fluorescent Penetrant Examination

- (a) Method A – Water Washable
- (b) Method B – Post-Emulsifiable (Lipophilic)
- (c) Method C – Solvent Removable
- (d) Method D – Post-Emulsifiable (Hydrophilic)

6.1.2 Type II – Visible Dye Penetrant Examination

- (a) Method A – Water Washable
- (b) Method B – Post-Emulsifiable (Lipophilic)
- (c) Method C – Solvent Removable
- (d) Method D – Post-Emulsifiable (Hydrophilic)

6.2 Examination Technique Restrictions

6.2.1 Fluorescent penetrant examination shall not follow a visible (color contrast) penetrant examination on the same area, as residual visible dye may mask fluorescent indications.

6.2.2 Intermixing of penetrant materials from different family groups or different manufacturers is not permitted. The penetrant, remover/emulsifier, and developer shall be from the same manufacturer's product family.

6.2.3 Re-examination with water washable penetrants may cause loss of marginal indications due to contamination. When re-examination is necessary, the surface shall be thoroughly cleaned before reapplication.

6.2.4 With color-contrast (visible) penetrants, only a wet developer shall be used. With fluorescent penetrants, a wet or a dry developer may be used.

6.3 Standard Examination Temperature Range

6.3.1 The temperature of the penetrant materials and the surface of the material or weld under examination shall be maintained between 50°F (10°C) and 125°F (52°C) throughout the examination period. Local heating or cooling is permitted provided the temperatures remain within this range during the examination.

6.3.2 Surface temperature shall be verified using a calibrated surface thermometer or infrared thermometer prior to testing. The measured temperature shall be recorded on the examination report.

6.4 Qualification of Procedures for Non-Standard Temperatures

6.4.1 When liquid penetrant examination is required on a material or weld whose surface temperature deviates from the 50°F – 125°F (10°C – 52°C) range, then a nonstandard temperature procedure must be qualified in accordance with ASME Section V, Article 6, Mandatory Appendix I. The qualification shall be performed at the temperature to be used for the examination and shall be documented. (See Appendix II of this procedure.)

6.5 Time of Examination

6.5.1 When the time of examination is not specifically stated in the governing Code or job specifications, the liquid penetrant examination for acceptance shall be performed after the final post-weld heat treatment or final fabrication step that could alter surface conditions.

6.6 Approved Penetrant Materials

6.6.1 The following penetrant materials are approved for use with this procedure. Different penetrant materials may be used with approval of the Prime Inspections Inc. Level III. All materials shall be from a single manufacturer's qualified system.

TY PE	ME TH OD	MATERIAL	MANUFAC TURER	PENETRANT	REMOVER	DEVELOPER
I	A	Fluorescent, Water Washable	Magnaflux	ZL-15B, ZL-19, ZL-60D, ZL-67	Water	ZP-4B, ZP-9F, SKD-S2
I	A	Fluorescent, Water Washable	Sherwin	WB-200	Water	D-100
I	C	Fluorescent, Solvent Removable	Magnaflux	ZL-2C, ZL-27A	SKC-S, SKC-HF	ZP-4B, ZP-9F, SKD-S2
II	A	Visible, Water Washable	Magnaflux	SKL-WP, SKL-WP-1, SKL-WP-2	Water	SKD-S2
II	A	Visible, Water Washable	Ardrox	906, P6R	Water	9D1B, NQ1
II	C	Visible, Solvent Removable	Magnaflux	SKL-SP1, SKL-SP2	SKC-S, SKC-HF	SKD-S2
II	C	Visible, Solvent Removable	Ardrox	996/P300A	9PR50	9D1B, NQ1

6.7 Illumination

6.7.1 Visible Penetrants: Adequate white or natural illumination of 100 foot-candles (fc) (1076 lux) minimum is required on the examination surface to ensure adequate sensitivity during the examination and prior to the evaluation of indications. Direct natural sunlight 30 minutes after sunrise will exceed 100 fc (1076 lux).

6.7.2 Fluorescent Penetrants: With fluorescent penetrant, the examination shall be conducted in a darkened area using an ultraviolet "black light" (UV-A), with a minimum intensity of 1000 $\mu\text{W}/\text{cm}^2$ on the surface of the part being inspected. The examiner shall be in the darkened area for at least five (5) minutes prior to performing the examination to enable eyes to adapt to dark viewing. The black light shall be allowed to warm up for five (5) minutes prior to measurement of UV intensity and use.

6.7.3 The darkened area shall have a maximum ambient white light level of 2 fc (21.5 lux). The UV 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. Lenses should be checked and cleaned daily when in use. Cracked or broken lenses shall be replaced immediately. Photochromic or photosensitive lenses are not allowed for examiners who wear glasses.

6.7.4 Mercury vapor arc lamps produce UV-A wavelengths mainly at a peak 365 nm for inducing fluorescence. Light-emitting diode (LED) UV-A sources using a single UV-A LED or an array of UV-A LEDs shall have emission characteristics comparable to those of other UV-A sources. LED UV-A sources shall meet the requirements of SE-2297 and SE-3022. LED UV-A light sources shall be certified as meeting the requirements of SE-3022 and/or ASTM E3022.

7.0 SURFACE PREPARATION

7.1 In general, satisfactory results may be obtained when the surface is in the as-welded, as-rolled, as-cast, or as-forged condition, but surface preparation by grinding or machining or other methods may be necessary in some instances where surface irregularities could otherwise mask indications of unacceptable discontinuities. Shot, sand, grit, vapor blasting, or other metal peening or smearing operations may mask relevant indications and consideration must be taken when used.

7.2 Prior to liquid penetrant examination, the surface to be examined and all adjacent areas within at least one (1) inch shall be dry and free of any dirt, grease, lint, scale, welding flux, weld spatter, oil, paint, or other extraneous matter that could obscure surface openings or otherwise interfere with the examination.

7.3 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. The cleaning method used shall not adversely affect the penetrant materials or the surface being examined.

7.4 Grinding may be used to remove weld spatter or surface irregularities, provided the parent metal is not reduced below the minimum required wall thickness. Grinding marks shall not be oriented in a direction that could mask relevant indications. Weld crowns may be left as-welded if surface irregularities do not mask indications.

7.5 Drying of the surface to be examined shall be accomplished by normal evaporation, allowing at least one minute but not more than four hours for normal evaporation before application of the liquid penetrant. Drying may also be accomplished by warming the parts in drying ovens, with infrared lamps, forced warm air, or exposure to ambient temperature. Part temperatures shall not exceed 125°F (52°C) prior to application of penetrant.

7.6 The evaluation area shall extend a minimum of one (1) inch (25 mm) beyond the weld toe on each side, or as specified by the referencing Code or customer specification. If the entire component is not examined, the penetrant shall be applied to at least ½ inch (13 mm) of adjacent area beyond the examination zone.

8.0 PENETRANT APPLICATION

8.1 Penetrant Application Methods

8.1.1 The penetrant may be applied by 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 or dirt sediment that may have collected in the lines.

8.1.2 Small parts are quite often placed in suitable baskets and dipped into a tank of penetrant. On larger parts and those with complex geometries, penetrant can be applied effectively by brushing or spraying.

8.1.3 Both conventional and electrostatic spray guns are effective means of applying liquid penetrants to the part surfaces. Electrostatic spray application can eliminate excess liquid penetrant buildup on the part, minimize overspray, and prevent penetrant from entering hollow cored passages.

8.1.4 Aerosol sprays are also very effective and a convenient means of application. With spray application, the use of a spray booth and exhaust system is generally required. In no case shall the penetrant be allowed to become dry on the part. Additional application may be necessary to keep the penetrant wet during the dwell period.

8.1.5 The penetrant application shall completely cover the surface of the area under examination and at least ½ inch of adjacent area if the entire component is not examined.

8.2 Dwell Times

8.2.1 The penetrant dwell time shall be in accordance with the table below. The dwell time begins when the penetrant is applied to the surface and ends when the excess penetrant removal process begins.

8.2.2 Dwell times shall not exceed the manufacturer's recommended range unless demonstrated and documented on a similar part under inspection. Unless otherwise specified, the presence of cracks should be assumed, and additional dwell time may be required when parts of unfamiliar types are first examined.

Temperature Range	Minimum Dwell Time	Maximum Dwell Time
50°F – 125°F (10°C – 52°C)	10 minutes	60 minutes
40°F – 49°F (4°C – 9°C)	20 minutes	60 minutes

9.0 EXCESS PENETRANT REMOVAL

9.1 After the specified dwell time has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from possible discontinuities. The removal method shall be appropriate for the penetrant method used.

9.2 Regardless of the penetrant dwell time, the penetrant shall not be allowed to become dry, tacky, or difficult to remove from the surface. The area shall be cleaned and re-examined if the penetrant should become dry, tacky, or difficult to remove from the surface.

9.3 Removal of Excess Water Washable Penetrant (Method A)

9.3.1 The excess penetrant shall be removed with a water spray. The water pressure shall not exceed 40 psi (276 kPa), and water temperature shall not exceed 110°F (43°C). Excessive water pressure or temperature may remove penetrant from discontinuities.

9.3.2 If the fluorescent method is being used, the rinsing operation shall be performed under a black light (UV-A) so that it can be determined when the excess penetrant has been adequately removed. The rinse shall continue until the background fluorescence is at an acceptable level.

9.4 Removal of Excess Post-Emulsifiable Penetrant (Methods B and D)

9.4.1 After the penetrant dwell time has elapsed, an emulsifier shall be applied. The emulsifier (lipophilic for Method B, hydrophilic for Method D) shall be applied by spraying, flowing, or dipping. The emulsification time shall be per the manufacturer's recommendations and shall be controlled to prevent over-emulsification.

9.4.2 After the emulsification time has elapsed, the excess penetrant and emulsifier shall be removed with a water spray as described in Section 9.3. The water pressure shall not exceed 40 psi and water temperature shall not exceed 110°F.

9.4.3 If the fluorescent method is being used, the rinsing operation shall be performed under a black light (UV-A) so that it can be determined when the excess penetrant has been adequately removed.

9.5 Removal of Excess Solvent Removable Penetrant (Method C)

9.5.1 The excess penetrant, in so far as possible, shall be removed by wiping with a lint-free cloth or absorbent paper, repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by wiping the surface lightly with a dry, lint-free cloth or absorbent paper moistened with solvent remover.

9.5.2 Be careful of overuse of solvent. Flushing the surface with solvent, following the application of the penetrant and prior to developing, is not permitted. Direct spraying of solvent onto the examination surface shall not be performed. The solvent shall be applied to the clean cloth, not directly to the part surface.

9.5.3 If the fluorescent method is being used, the removal operation shall be performed under a black light (UV-A) so that it can be determined when the excess penetrant has been removed.

9.5.4 Do not over-clean. Excessive removal may remove penetrant from within discontinuities, causing false-negative results. Remove only the surface excess penetrant.

10.0 DRYING

10.1 Water Washable Penetrants (Method A) and Post-Emulsifiable (Methods B and D)

10.1.1 If dry or non-aqueous developer is to be used, the surface may be dried by blotting with a clean material or by using circulating warm air, provided the temperature of the surface is not raised above 125°F (52°C). The temperature in the dryer shall not exceed a range that will cause the temperature on the surface of the part to exceed 125°F.

10.1.2 Do not allow parts to remain in the drying oven any longer than is necessary to dry the part. Excessive time in the dryer can cause damage to the part as well as evaporation of the penetrant, which can impair the sensitivity of the inspection. Drying time will vary with size, nature and number of parts under inspection.

10.1.3 If aqueous developer is to be used, it may be applied to the part immediately after the excess penetrant has been removed and prior to drying, and shall be dried by circulating warm air. Blotting is not permitted for aqueous developer. The temperature in the dryer shall not exceed a range that will cause the temperature on the surface of the part to exceed 125°F.

10.1.4 The precise drying time is dependent upon dimensions and geometry, drying procedure, and humidity, but the minimum drying time shall be 10 minutes. Maximum drying time shall be 30 minutes for warm air driers and 2 hours for blotting.

10.2 Solvent Removable Penetrants (Method C)

10.2.1 The surface may be dried by normal evaporation or forced air. The drying time shall be a minimum of 1 minute and a maximum of 30 minutes. Do not use forced air that may redeposit contaminants onto the examination surface.

10.2.2 The developer shall be applied as soon as possible after the surface has dried, but the time interval shall not be less than the minimum nor more than the maximum drying times specified.

11.0 DEVELOPER APPLICATION

11.1 Developer Forms

11.1.1 The following developer forms are recognized by ASME Section V, Article 6:

- (a) Form a – Dry Powder
- (b) Form b – Water Soluble
- (c) Form c – Water Suspendable
- (d) Form d – Non-aqueous (Solvent) Suspendable
- (e) Form e – Solvent Removable

11.2 Fluorescent Penetrant – Developer Application

11.2.1 For dry developer (Form a), the surface of the part shall be dry prior to application. The developer may be applied by a soft brush, a hand powder bulb, or a powder gun. Parts can be immersed or dipped into a container of dry developer or dusted with the powder through a hand powder bulb or powder gun. The most effective way to apply dry powder is in an enclosed dust chamber, which creates an effective and controlled dust cloud.

11.2.2 For wet developer (Forms b, c, and d), the developer shall be thoroughly agitated to ensure adequate dispersion of the suspended particles prior to applying to the surface. Water solutions or suspensions shall be applied by dipping, brushing or spraying to obtain a thin coating over the entire surface being examined.

11.2.3 For non-aqueous developers (Form d), application shall be by spraying, except where safety, health, 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. Dipping or flooding parts with non-aqueous developers is prohibited since it will flush the penetrant from within the discontinuities through its solvent action.

11.3 Visible Penetrant – Developer Application

11.3.1 Either an aqueous or a non-aqueous wet developer may be used. Prior to applying the wet developer to the surface, the developer shall be thoroughly agitated to ensure adequate dispersion of the suspended particles. With visible penetrants, only a wet developer shall be used.

11.3.2 For aqueous developer, the surfaces of the part may be dry or wet prior to application. Water solutions or suspensions shall be applied by dipping, brushing, or spraying to obtain a thin coating over the entire surface. After the aqueous developer has been applied, the part shall be dried prior to examination in such a manner that the temperature on the surface of the part does not exceed 125°F (52°C).

11.3.3 For non-aqueous developer, the surface of the part shall be dry prior to application. Solvent suspensions shall be applied by spraying except where safety, health, or restricted access preclude it. Under such conditions, solvent suspended developer may be applied by brushing. Dipping or flooding parts with non-aqueous developers is prohibited since it will flush the penetrant from within the discontinuities through its solvent action.

11.3.4 When using aerosol developer spray cans, shake vigorously for a minimum of 30 seconds before use to ensure proper dispersion of the developer particles. Hold the spray can 8–12 inches from the surface. Do not puddle or pool developer. Apply a thin, uniform coat.

11.4 Developing Time

11.4.1 The developing time required to draw penetrant from discontinuities into the dried developer on the surface shall be a minimum of 7 minutes and a maximum of 60 minutes. Interpretation of examination results for acceptance purposes must be made within this time period.

11.4.2 If bleed-out does not alter the examination results, longer periods are permitted. If the surface to be examined is so large as to preclude complete examination within the prescribed time, only portions of the surface shall be examined at any one time.

Developer Form	Minimum Development Time	Maximum Development Time
Form a – Dry Powder	7 minutes	60 minutes
Form b – Water Soluble	7 minutes	60 minutes
Form c – Water Suspending	7 minutes	60 minutes
Form d – Non-aqueous (Solvent)	7 minutes	60 minutes
Form e – Solvent Removable	7 minutes	60 minutes

11.4.3 The surface being examined should be observed during the developing period in order to detect the nature of certain indications which might tend to bleed out profusely. Precautions should be taken to prevent any object from touching the dry developer film because it is very brittle, loosely held and easily damaged.

11.5 Final Cleaning

11.5.1 Final cleaning shall be accomplished with an approved manufacturer's cleaner or a cleaner approved by the referencing Code Section or customer specification. Post-examination cleaning shall be performed as soon as practical after completion of the examination and evaluation.

11.5.2 Cleaning may be accomplished using detergents, organic solvents, plain water rinse, brushing, or ultrasonic cleaning methods. The cleaning method shall not adversely affect the part or subsequent processing.

12.0 EXAMINATION AND INTERPRETATION

12.1 The examination surface shall be viewed during and after the minimum development time to detect indications of discontinuities. The examination shall be performed under the appropriate lighting conditions for the penetrant type used.

12.2 For Type II (visible dye) penetrant, the examination shall be performed under adequate white light illumination of 100 foot-candles (1076 lux) minimum on the examination surface. The examination surface shall be viewed with the naked eye or with the aid of a magnifier (3–5×) where additional resolution is required.

12.3 For Type I (fluorescent) penetrant, the examination shall be performed in a darkened area under UV-A light with a minimum intensity of 1000 $\mu\text{W}/\text{cm}^2$ on the examination surface. The examiner shall be dark-adapted for at least 5 minutes prior to performing the examination. Ambient white light shall not exceed 2 fc (21.5 lux).

12.4 Examination Coverage: All examinations shall be conducted with sufficient overlap to assure 100% coverage at the required sensitivity. At least two (2) separate examinations shall be performed on each area when geometry permits, to ensure complete coverage.

12.5 Preliminary Examination: Prior to conducting the liquid penetrant examination, a visual examination of the surface shall be conducted under white light illumination to locate any visible surface openings or conditions that might interfere with the penetrant examination.

12.6 Interpretation of Indications

12.6.1 Visible (Color Contrast) Penetrants: With this type penetrant, the developer forms a reasonably uniform white coating. Surface discontinuities are indicated by bleeding-out of the penetrant, which is normally of a deep red color that stains the developer. Indications with a light pink color may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult.

12.6.2 Fluorescent Penetrants: The developer forms a more or less uniform white coating. Surface discontinuities are indicated by bleeding-out of the penetrant which is colored by fluorescent dyes, and fluoresce when illuminated by a black light (UV-A). Inadequate cleaning may leave an excessive background making interpretation difficult.

12.7 Non-relevant Indications

12.7.1 Any indication which is believed to be non-relevant shall be regarded as an imperfection unless it is shown by re-examination by the same method or by the use of other nondestructive methods and/or by surface conditioning that no unacceptable imperfection is present. Broad areas of fluorescence or pigmentation which could mask indications of discontinuities are unacceptable, and such areas shall be cleaned and re-examined.

12.8 Relevant Indications

12.8.1 Relevant indications are those which result from mechanical imperfections open to the surface. 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.

12.8.2 Linear indications are those in which the length is more than three (3) times the width. Rounded indications are those which are circular or elliptical with the length less than or equal to three (3) times the width. Exact definitions may vary by Code.

12.8.3 Aligned indications are a group of three (3) or more indications which touch a straight line connecting any two (2) of the group. The spacing criteria for aligned indications varies by applicable Code Section.

13.0 EVALUATION

13.1 Localized surface irregularities due to machining marks or other surface conditions which produce non-relevant indications or broad areas of penetrant accumulation which could mask indications of discontinuities are unacceptable; these areas shall be cleaned and re-examined in accordance with the referencing Code or customer specification.

13.2 All other indications that are judged to be non-relevant shall be regarded as unacceptable until the indications are either eliminated by surface conditioning or are re-examined by liquid penetrant or another type of nondestructive examination and the indication is demonstrated to be non-relevant in accordance with the referencing Code or customer specification.

13.3 Relevant indications are those which result from unacceptable mechanical imperfections. In general, linear indications are those indications in which the length is three (3) times the width or more. Rounded indications are indications which are circular or elliptical with the length less than three (3) times the width. Exact descriptions vary by Code.

13.4 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 for acceptance or rejection.

13.5 When doubt exists about the type of imperfection being disclosed by an indication, verification may be obtained by using other NDT methods such as magnetic particle testing (where applicable), ultrasonic testing, or radiographic testing.

14.0 STANDARDS OF ACCEPTANCE

14.1 ASME Section I (Power Boilers) Acceptance Criteria

14.1.1 Only indications with major dimensions greater than 1/16 in. (1.6 mm) shall be considered relevant. A linear indication is one having a length greater than three times the width. A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width. Any questionable or doubtful indications shall be re-examined to determine whether or not they are relevant.

14.1.2 Welds – All surfaces to be examined shall be free of: (a) Relevant linear indications; (b) Relevant rounded indications greater than 3/16 inch; (c) Four (4) or more relevant rounded indications in a line separated by 1/16 inch or less (edge to edge).

14.1.3 Castings – Surface indications are unacceptable if they exceed the following: (a) All cracks and hot tears; (b) Any group of more than six linear indications other than those in (a) above in any rectangular area of 1½ in. × 6 in. or less, or any circular area having a diameter of 3½ in. or less; (c) Other linear indications more than ¼ in. long for thicknesses up to ¾ in. inclusive, more than one-third of the thickness in length for thicknesses from ¾ in. to 2¼ in., and more than ¾ in. long for thicknesses over 2¼ in.; (d) All indications of nonlinear imperfections that have any dimension exceeding 3/16 in.

14.2 ASME Section VIII (Pressure Vessels) Acceptance Criteria

14.2.1 Only indications which have any dimension greater than 1/16 in. (1.6 mm) shall be considered relevant. A linear indication is one having a length greater than three times the width. A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width. Any questionable or doubtful indications shall be re-examined to determine whether or not they are relevant.

14.2.2 All surfaces to be examined shall be free of:

- (a) Relevant linear indications.
- (b) Relevant rounded indications greater than 3/16 in. (4.8 mm).
- (c) Four or more relevant rounded indications in a line separated by 1/16 in. (1.6 mm) or less, edge to edge.

14.3 ASME B31.1 (Power Piping) Acceptance Criteria

14.3.1 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.

14.3.2 Any indication which is believed to be non-relevant shall be regarded as a defect and shall be re-examined to verify whether or not actual defects are present. Surface conditioning may precede the re-examination. Non-relevant indications and broad areas of pigmentation which would mask indications of defects are unacceptable.

14.3.3 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.

14.3.4 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.

14.3.5 Castings – Acceptance standards for castings shall be in accordance with ASME B31.1 paragraph 102.4.6.

14.3.6 Welds – Indications whose major dimensions are greater than 1/16 in. shall be considered relevant and may be caused by cracks, undercut, porosity, slag inclusions, lack of fusion or incomplete penetration. The following relevant indications are unacceptable:

- (a) Any cracks or linear indications.
- (b) Rounded indications with dimensions greater than 3/16 in. (4.8 mm).
- (c) Four or more rounded indications in a line separated by 1/16 in. (1.6 mm) or less, edge to edge.
- (d) Ten or more rounded indications in any 6 sq. in. of surface with the major dimension of this area not to exceed 6 in. with the area taken in the most unfavorable location relative to the indications being evaluated.

14.4 ASME B31.3 (Process Piping) Acceptance Criteria

14.4.1 Castings – Examination of castings is covered in ASME B31.3 paragraph 302.3.3.

14.4.2 Welds and Components Other than Castings – Liquid Penetrant indications are caused by a bleed-out of visible or fluorescent dye from a surface discontinuity in the area under test. However, all such indications are not necessarily imperfections, since surface roughness, poor surface preparation, etc., may produce non-relevant indications. Inadvertent 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.

14.4.3 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. Only indications that have any dimension greater than 1/16 in. (1.6 mm) shall be considered relevant.

Indication Type	Definition	Unacceptable If:
Linear	Length > 3× width	Any relevant linear indication
Rounded	Length ≤ 3× width	Diameter > 3/16 in. (4.8 mm)
Aligned rounded	4 or more in a line	Separated by ≤ 1/16 in. (1.6 mm), edge to edge

14.4.4 All surfaces to be examined shall be free of: (1) Relevant linear indications; (2) Relevant rounded indications greater than 3/16 in.; (3) Four or more relevant rounded indications in a line separated by 1/16 in. or less, edge to edge.

14.5 ASME B16.34 (Valves, Flanged, Threaded and Welding End) Acceptance Criteria

14.5.1 Castings – Maximum acceptable indications are as follows:

(a) Linear Indications:

- (1) 8 mm (0.3 in.) long for materials up to 13 mm (0.5 in.) thick.
- (2) 13 mm (0.5 in.) long for materials 13 mm to 25 mm (0.5 in. to 1.0 in.) thick.
- (3) 18 mm (0.7 in.) long for materials over 25 mm (1.0 in.) thick.

Note: For linear indications, the indications must be separated by a distance greater than the length of an acceptable indication. A linear indication is one with length in excess of three times the width.

(b) Rounded Indications:

- (1) 8 mm (0.3 in.) diameter for materials up to 13 mm (0.5 in.) thick.
- (2) 13 mm (0.5 in.) diameter for materials over 13 mm (0.5 in.) thick.

Note: Four or more rounded indications in a line separated by 1.5 mm (0.06 in.) or less edge to edge are unacceptable. Rounded indications are those that are not defined as linear indications.

14.5.2 Forgings and Rolled or Wrought Material – Maximum acceptable indications are as follows:

(a) Linear Indications:

- (1) 5 mm (0.2 in.) long for materials up to 13 mm (0.5 in.) or less thick.
- (2) 10 mm (0.4 in.) long for materials over 13 mm to 25 mm (0.5 in. to 1.0 in.) thick.
- (3) 15 mm (0.6 in.) long for materials over 25 mm (1.0 in.) thick.

Note: For linear indications, the indications must be separated by a distance greater than the length of an acceptable indication. A linear indication is one with length in excess of three times the width.

(b) Rounded Indications:

- (1) 5 mm (0.2 in.) diameter for materials up to 13 mm (0.5 in.) thick.
- (2) 8 mm (0.3 in.) diameter for materials over 13 mm (0.5 in.) thick.

Note: Four or more rounded indications in a line separated by 1.5 mm (0.06 in.) or less edge to edge are unacceptable. Rounded indications are those that are not defined as linear indications.

14.5.3 An indication may be larger than the imperfection that causes it. However, the size of the indication is the basis for acceptance evaluation.

14.6 API 1104 – Welding of Pipelines and Related Facilities, 21st Edition Acceptance Criteria

14.6.1 Liquid Penetrant Testing – Classification of Indications

14.6.1.1 Indications produced by liquid penetrant testing are not necessarily imperfections. Machining marks, scratches, and surface conditions may produce indications that are similar to those produced by imperfections but that are not relevant to acceptability. The following criteria shall apply when indications are evaluated.

(a) Any indication with a maximum dimension of 1/16 in. (1.6 mm) or less shall be classified as non-relevant. Any larger indication believed to be non-relevant shall be regarded as relevant until re-examined by liquid penetrant or another NDT method to determine whether or not an actual imperfection exists. The surface may be ground or otherwise conditioned before re-examination. After an indication is determined to be non-relevant, other non-relevant indications of the same type need not be re-examined.

(b) Relevant indications are those caused by imperfections. Linear indications are those in which the length is more than three times the width. Rounded indications are those in which the length is three times the width or less.

14.6.2 Acceptance Standards

14.6.2.1 Relevant indications shall be considered defects should any of the following conditions exist:

- (a) Linear indications are evaluated as crater cracks or star cracks and exceed 5/32 in. (4 mm) in length.
- (b) Linear indications are evaluated as cracks other than crater cracks or star cracks – any length is unacceptable.
- (c) Linear indications are evaluated as IF (incomplete fusion) and exceed 1 in. (25 mm) in total length in a continuous 12 in. (300 mm) length of weld or 8% of the weld length.

14.6.2.2 Rounded indications shall be evaluated according to the criteria of 9.3.9.2 and 9.3.9.3 of API 1104, as applicable. For evaluation purposes, the maximum dimension of a rounded indication shall be considered its size.

Note: When doubt exists about the type of imperfection being disclosed by an indication, verification may be obtained by using other NDT methods.

Type of Indication	Unacceptable If:
Cracks (all types)	Any crack, regardless of length
Linear indications (crater cracks, star cracks)	Length > 5/32 in. (4 mm)
Linear indications (other than crater or star cracks)	Any length – all linear indications evaluated as cracks other than crater or star cracks are unacceptable
Linear indications (IF)	Total length > 1 in. (25 mm) in a continuous 12 in. (300 mm) length of weld or > 8% of weld length
Rounded indications	Maximum dimension > 1/8 in. (3 mm) per criteria of 9.3.9.2 and 9.3.9.3
Aligned rounded indications	4 or more in a line, separated by 1/16 in. (1.6 mm) or less, edge to edge

14.6.3 Base Material Imperfections

14.6.3.1 Imperfections in the base material detected by liquid penetrant testing shall be reported to the company. The disposition of these imperfections shall be as directed by the company.

15.0 PROCEDURE QUALIFICATION

15.1 When procedure qualification is required, any change to a requirement identified as an essential variable (see Table T-621.1 of ASME Section V, Article 6) shall require requalification of this procedure by demonstration. Where a range is specified for an essential variable, the bounding values of the range shall be qualified by demonstration. A change of a requirement identified as a non-essential variable does not require requalification of the written procedure.

15.2 All changes of essential or non-essential variables from those in this procedure shall require a revision of, or an addendum to, the procedure. The essential and non-essential variables for liquid penetrant examination are listed in the table below.

Variable	Essential	Nonessential
Penetrant type (Type I or II)	X	
Removal method (A, B, C, D)	X	
Developer form (a, b, c, d, e)	X	
Surface temperature range	X	
Dwell time (penetrant)	X	
Drying time	X	
Development time	X	
UV light intensity (Type I)	X	
Visible light intensity	X	
Penetrant material manufacturer	X	
Application method (spray, brush, dip)		X
Equipment manufacturer		X
Personnel qualification		X

16.0 RECORDS

16.1 The record of the liquid penetrant examination is to be documented on a standardized Liquid Penetrant Examination Report.

16.2 The information reported shall include, but is not limited to, the following:

- (a) Procedure number (including revision)
- (b) Applicable Code reference
- (c) Material type and thickness
- (d) Penetrant technique type (visible or fluorescent)
- (e) Type (number or letter designation) of each penetrant, remover/emulsifier, and developer used
- (f) Manufacturer of penetrant materials
- (g) Lighting equipment and verification (visible light or UV-A intensity measurements)
- (h) Surface temperature at time of examination
- (i) Dwell times (penetrant and developer)
- (j) Map or record of rejectable indications including type (linear or rounded), location and extent (length or diameter or aligned)
- (k) Identification of all components, parts or welds examined and accepted, including weld number, serial number or other identifier
- (l) Date and time examinations were performed
- (m) Examination personnel identity and qualification level
- (n) Acceptance/rejection determination

16.3 Unless otherwise specified, all PT records and reports shall be maintained in accordance with Prime Inspections Inc. retention policies and the referencing Code Section requirements.

16.4 Documentation of Personnel and Procedure Demonstrations

16.4.1 Personnel or procedure demonstrations performed shall be performed and documented as specified by the referencing Code Section.

16.4.2 When documentation requirements for personnel or procedure demonstrations performed are not specified by the referencing Code Section, the following information shall be recorded as a minimum:

- (a) Name of the organization responsible for preparation and approval of the examination procedure
- (b) Examination method applied
- (c) Procedure number and designation
- (d) Number and date of most recent revision
- (e) Date of the demonstration
- (f) Name and certification level (if applicable) of personnel performing the demonstration

APPENDIX I

Penetrant Material System Check – TAM Panel / PSM-5 Reference Block

The penetrant system performance shall be verified using a known defect reference block such as a TAM Panel (Figure T-672.1) or PSM-5 Panel at the start of each shift or when materials are changed. The reference block shall contain known surface cracks of the type and size appropriate for the sensitivity level of the penetrant materials being used.

- 1.0 The reference block shall be processed using the same penetrant materials, processing parameters, and techniques used for the examination. The entire process (penetrant application, dwell, removal, drying, developer application, and development) shall be performed on the reference block in the same manner as on production parts.
- 2.0 After development, the reference block shall be examined under the appropriate lighting conditions (UV-A for fluorescent, white light for visible). The indications on the known cracks shall be clearly visible and comparable to the baseline established during the initial system qualification.
- 3.0 If the indications on the reference block are not clearly visible or are significantly reduced from the baseline, the penetrant system shall not be used for production examination. The cause of the loss of sensitivity shall be determined and corrected before proceeding. This may include replacement of penetrant materials, cleaning of equipment, or adjustment of processing parameters.
- 4.0 The results of each system performance check shall be documented on a Process Control Log. The documentation shall include: date, time, material lot numbers, type of reference block used, observed results, and the name of the technician performing the check.

APPENDIX II

Non-Standard Temperature Qualification Procedure

When liquid penetrant examination is required on a material or weld whose surface temperature is below 50°F (10°C) or above 125°F (52°C), a non-standard temperature procedure must be qualified in accordance with ASME Section V, Article 6, Mandatory Appendix I. The qualification procedure is as follows:

- 1.0 Qualification at temperatures from 40°F (4°C) to 50°F (10°C): The procedure shall be qualified by processing an aluminum, brass, or titanium reference block with known cracks at the intended temperature. The penetrant dwell time shall be increased to a minimum of 20 minutes. The entire process shall be performed at the non-standard temperature, and the results shall be documented.
- 2.0 Qualification at temperatures below 40°F (4°C): A special qualification shall be performed demonstrating that the penetrant system can detect the known cracks at the intended temperature. The qualification shall be documented and approved by the Level III prior to use.
- 3.0 Qualification at temperatures above 125°F (52°C): The procedure shall be qualified by processing a reference block with known cracks at the intended temperature. Care shall be taken to ensure that the penetrant materials do not flash dry or degrade at the elevated temperature. The penetrant manufacturer's recommendations shall be followed.
- 4.0 All non-standard temperature qualifications shall be documented on a Non-Standard Temperature Qualification Record. The record shall include: date, temperature range, reference block type and identification, materials used, dwell times, development times, results, and the name and certification level of the person performing the qualification.
- 5.0 The qualified non-standard temperature procedure shall be attached to this procedure as an addendum and shall be approved by the Level III prior to use.

APPENDIX III

Contaminant Control for Austenitic Stainless Steel, Titanium, and Nickel-Base Alloys

When liquid penetrant examination is performed on austenitic stainless steels, titanium, or nickel-base alloys, the penetrant materials shall be controlled for sulfur and halogen content as follows:

- 1.0 The total sulfur and total halogen (chlorine and fluorine) content of the penetrant materials shall not exceed 1% of the residue by weight. This applies to the penetrant, remover/emulsifier, and developer.
- 2.0 Certification of contaminant content shall be obtained from the penetrant material manufacturer for each batch of material used. The certification shall include manufacturer's batch numbers and test results.
- 3.0 The contaminant certifications shall be maintained on file and shall be available for review by the customer or regulatory representative.
- 4.0 Materials that do not meet the 1% maximum sulfur and halogen content shall not be used on austenitic stainless steels, titanium, or nickel-base alloys. Alternative materials with acceptable contaminant levels shall be selected.
- 5.0 Penetrant materials used on these materials shall be from a low-halogen, low-sulfur product line specifically designated by the manufacturer as suitable for use on stainless steels and titanium.

APPENDIX IV

Light Intensity Verification and UV-A Source Requirements

This appendix provides the requirements for verification of light intensity and UV-A source performance for liquid penetrant examination.

1.0 Visible Light Intensity (Type II Visible Penetrants)

- 1.1 The visible light intensity on the examination surface shall be a minimum of 100 foot-candles (1076 lux) as measured with a calibrated visible light meter.
- 1.2 The light meter shall be calibrated at least every six months or whenever the meter is repaired. Calibration records shall be maintained.
- 1.3 The light intensity shall be measured at the examination surface at the start of each shift and recorded on the examination report.

2.0 UV-A Light Intensity (Type I Fluorescent Penetrants)

- 2.1 The UV-A intensity on the examination surface shall be a minimum of 1000 $\mu\text{W}/\text{cm}^2$ as measured with a calibrated UV radiometer.
- 2.2 The UV radiometer shall be calibrated at least every six months or whenever the meter is repaired. Calibration records shall be maintained.
- 2.3 The UV-A intensity shall be measured at the start of each shift, whenever the light's power source is interrupted or changed, and at the completion of the examination or series of examinations.
- 2.4 Ambient white light in the darkened examination area shall not exceed 2 foot-candles (21.5 lux) as measured with a calibrated visible light meter.
- 2.5 LED UV-A sources shall meet the requirements of ASTM E3022 and shall be certified as meeting those requirements. Mercury vapor arc lamps and LED sources shall produce UV-A wavelengths at a peak of 365 nm.

3.0 UV-A Source Warm-Up and Maintenance

3.1 Mercury vapor arc UV-A lamps shall be allowed to warm up for a minimum of 5 minutes prior to measurement of UV intensity and use. LED UV-A sources may require less warm-up time per manufacturer's recommendations.

3.2 Reflectors, filters, and lenses shall be checked and cleaned daily when in use. Cracked, broken, or degraded filters and lenses shall be replaced immediately.

3.3 Examiner Dark Adaptation: The examiner shall be in the darkened area for at least 5 minutes prior to performing the examination to enable eyes to adapt to dark viewing. Photochromic or photosensitive lenses are not permitted for examiners who wear glasses.

END OF DOCUMENT