



Prime Inspections, Inc.

Conventional (Film) Radiographic (RT) Examination of Welds X-ray and Iridium-192 Gamma-Ray Sources

Procedure No.: PII-TC-RT | Revision: 1 | Effective: 2026-07-28

Applicable Project: TC Energy (USA)

Technical Approval

**Joshua de Monbrun, CEng -
Consultant**

Quality Approval

Oscar Gonzales - VP of Quality

Company Approval for Use

Code & Specification Basis

- API 1104, Welding of Pipelines and Related Facilities — 21st Edition (with current addenda) — Section 11.1 Radiographic Testing; Section 9.6 Acceptance Standards.
- ASME BPVC Section V, Article 2 — Radiographic Examination (2025 Edition), including Mandatory Appendix IX.
- ASME BPVC Section V, Article 22 — Radiographic Standards (SE-94, SE-747, SE-999, SE-1025, SE-1742).
- ASTM E94 — Standard Guide for Radiographic Examination.
- ASTM E747 — Wire Image Quality Indicators (IQI).
- ASTM E999 — Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing.
- ASTM E1815 — Classification of Film Systems for Industrial Radiography.
- ISO 11699-1 — Film Classification; ISO 19232-1 — Wire-Type IQIs; ISO 14096-2 — Digitization.
- TC Energy TES-NE-RT-GL — Radiographic Examination of Welds (CAN-US-MEX), Rev. 08.
- TC Energy TEN-NE-NDT-GL — Nondestructive Testing Standard (CAN-US-MEX), Rev. 01.
- 10 CFR Parts 19, 20, 30, 34 (USNRC); 49 CFR Parts 107, 171, 172 (DOT); USNRC / Agreement State licensing.

Revision History

Rev	Date	Prepared / Approved	Description of Change
0	2026-07-28	J. de Monbrun / O. Gonzales	Initial issue of Prime Inspections, Inc. (PII) controlled procedure under the PII Quality Management System. Issued as Rev 0 — no prior PII revision history. Aligned with API 1104 21st Edition (with current addenda), ASME BPVC Section V (2025 Edition), and the current TC Energy TES/TEN/TEP series specifications applicable to the project scope.
1	2026-07-28	J. de Monbrun / O. Gonzales	Procedure revised for TC Energy TES-NE-RT-G Rev.08

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1.0 Scope

- 1.1. This procedure establishes the requirements for conventional film radiographic examination of welding-procedure qualification welds, welder and welding-operator qualification welds, and production welds in natural-gas pipeline applications on TC Energy projects in the United States.
- 1.2. For tanks and pressure vessels, the applicable external specification, such as API 650, API 653, or API 510, shall govern.
- 1.3. Use of this procedure is limited to materials, wall-thickness ranges, joint geometries, exposure configurations, radiation sources, equipment, and essential variables documented on a Company-approved technique sheet. Conditions outside an approved range require revised qualification and Company approval before use. HOLE-TYPE IQIs SHALL NOT be used; wire-type IQIs per ASTM E747 or ISO 19232-1 are mandatory.
- 1.4. Where this procedure, API 1104, ASME Section V, or the applicable TC Energy specification does not explicitly address a required condition, PII shall identify the gap, notify TC Energy, apply the more conservative interpretation, and document the method used. Where requirements conflict, the more stringent shall govern.
- 1.5. Digital Radiography (DR) and Real-time-Radiography (RTR) are governed by PII-TC-DR and Appendix A of TES-NE-RT-G Rev. 08. Computed Radiography shall not be used on pressure-containing components. CR in any other application requires prior written TC Energy NDE SME approval and documented system validation.

2.0 References (Latest Editions Unless Stated Otherwise)

2.1. Industry Codes and Standards

- 2.1.1. API 1104, 21st Edition, §11.1 Radiographic Testing; §9.6 Acceptance Standards.
- 2.1.2. ASME BPVC Section V, Article 2 (2025 Ed.), Radiographic Examination, including Mandatory Appendix IX for digital image acquisition.
- 2.1.3. ASME BPVC Section V, Article 2, SE-94 (Guide), SE-747 (Wire IQIs), SE-999 (Film Processing), SE-1025 (Hole-Type IQIs not used), SE-1742 (Wire IQI image quality).
- 2.1.4. ASTM E94, Standard Guide for Radiographic Examination.
- 2.1.5. ASTM E747, Wire-Type Image Quality Indicators.
- 2.1.6. ASTM E999, Controlling the Quality of Industrial Radiographic Film Processing.
- 2.1.7. ASTM E1815, Classification of Film Systems for Industrial Radiography.
- 2.1.8. ASTM E1936, Reference Radiograph for Evaluating the Performance of Radiographic Digitization Systems.
- 2.1.9. ISO 11699-1, Film Classification.
- 2.1.10. ISO 19232-1, Wire-Type Image Quality Indicators.
- 2.1.11. ISO 14096-2, Radiographic Film Digitization (when applicable).

2.1.12. ANSI N43.3, General Radiation Safety for Installations Using Non-Medical X-Ray and Sealed-Source Equipment.

2.1.13. ASNT SNT-TC-1A (2024); ANSI/ASNT CP-189; ISO 9712.

2.2. Regulatory References

2.2.1. 10 CFR Part 19, Notices, Instructions, and Reports to Workers (USNRC).

2.2.2. 10 CFR Part 20, Standards for Protection Against Radiation (USNRC).

2.2.3. 10 CFR Part 30, Rules of General Applicability to Domestic Licensing of Byproduct Material.

2.2.4. 10 CFR Part 34, Licenses for Industrial Radiography.

2.2.5. 49 CFR Parts 107, 171, 172, 173; DOT Hazardous Materials Regulations (radioactive material transport).

2.2.6. 49 CFR Part 192 (Natural Gas), PHMSA pipeline safety.

2.2.7. USNRC and Agreement State radioactive materials licenses; reciprocal recognition (Form NRC-241 or state equivalent).

2.3. TC Energy Specifications

2.3.1. TES-NE-RT-G, Radiographic Examination of Welds (CAN-US-MEX), Item ID 003671368, Rev. 08.

2.3.2. TEN-NE-NDT-GL, Nondestructive Testing Standard (CAN-US-MEX), Item ID 1001828336, Rev. 01.

2.3.3. TEP-NE-ADT-GLE, Nondestructive Examination Audits (CAN-US-MEX), Item ID 003797402.

2.3.4. TC Energy Operator Qualification Program (Item ID 004504739), applicable Covered Tasks.

2.3.5. TC Energy Controlled Document Library Variance Procedure, Item ID 007728702.

2.4. PII Internal Documents

2.4.1. PII-WP-1, Written Practice (SNT-TC-1A 2024 Ed.).

2.4.2. PII-RT-OEP-1, Operating & Emergency Procedures for Industrial Radiography (USNRC / state license appendix).

2.4.3. PII-RT-CAL-01, Densitometer Calibration Record.

2.4.4. PII-QM-01, Quality Manual.

3.0 Definitions and Acronyms

3.1. Definitions and Acronyms — Table 3-1

Term	Definition
ACCP	ASNT Central Certification Program.
Area of Interest	The full welded area extending 6.4 mm (0.250 in) from either side of the toe of the weld cap to include the heat-affected zone.
CEDO	Certified Exposure Device Operator (Canada — CNSC).
Company	TC Energy and its affiliates.

Term	Definition
Contractor	Prime Inspections, Inc., is engaged to perform RT work under this procedure.
DWE/DWV (DWDI)	Double-wall exposure, double-wall view (Double Wall Double Image).
DWE/SWV (DWSI)	Double-wall exposure, single-wall view (Double Wall Single Image).
FFD / SFD	Focal spot to film distance/source to film distance.
H&D	Hurter and Driffield density units.
IQI	Image Quality Indicator (wire-type per ASTM E747 or ISO 19232-1).
OFD	Object to film distance.
SWE/SWV (SWSI)	Single-wall exposure, single-wall view (Single Wall Single Image).
Ug	Geometric Unsharpness = $f \times d / D$, where f = source size, d = object-to-film distance, D = source-to-object distance.

4.0 Responsibilities

- 4.1. PII VP of Quality – Owns preparation, control, and issuance of this procedure.
- 4.2. PII ASNT Level III (RT) – The PII Level III performs PII internal technical review and approval. Internal approval does not replace TC Energy NDE SME review, approval, Company consent of the applicable technique shot, or Approved-for-Use status.
- 4.3. Site Supervisor / Technical Lead – Verifies certifications, OQ, equipment calibration, and current radioactive materials license/reciprocity for the work jurisdiction. The Technical Lead or Supervisor shall coordinate daily operations with the Company-designated Welding Inspector and NDE Auditor and shall confirm that only Company-approved procedures and techniques are used.
- 4.4. Radiographer (Level II/2 or III/3) – Performs RT, interprets film, completes reports, ensures 100% circumferential coverage of each weld assigned for RT and documents and reports any limitation before results are accepted; halts work when any requirement cannot be met.
- 4.5. Level I/1 Personnel – Level I personnel may assist only under direct Level II or III supervision and shall not independently perform exposures, interpret or disposition radiographic images, or sign examination reports.
- 4.6. Radiation Safety Officer (RSO) – Maintains the radiation safety program, oversees personnel monitoring, and ensures compliance with all applicable USNRC, Agreement State, CNSC, or NOM regulations.

- 4.7. When required by the Project, PII shall submit a project-specific implementation plan and quality management plan before mobilization. When requested by the Company, PII shall provide a minimum one-day orientation for Company Inspectors on PII techniques and the radiographic management system before production welding begins.

5.0 Personnel Qualifications

- 5.1. Radiographers shall be qualified and certified per PII-WP-1 (which implements ASNT SNT-TC-1A 2024 Ed.) to Level II/2 or higher in the radiographic method. Certifications to ANSI/ASNT CP-189, ACCP, or ISO 9712 are acceptable as equivalent.
- 5.2. Level III RT — Qualified to ISO 9712 Level 3, ASNT ACCP, or ASNT Level III in the RT method; current certification records on file.
- 5.3. For Digital Applications — Additional training and certification per ASME V, Article 1, Mandatory Appendix II is required for personnel performing image acquisition, processing, or interpretation of digital radiographs (see PII-TC-DR Rev 0).
- 5.4. Operator Qualification (TC Energy U.S.) — Personnel shall complete the applicable Covered Tasks per the TC Energy OQ Program (Item ID 004504739) prior to performing work on TC Energy projects.
- 5.5. Vision — Personnel performing final interpretation or signing radiographic reports shall have a valid annual Jaeger J-1 or equivalent acuity examination.
- 5.6. Records — The examination results, certification, training, experience, and OQ records shall be provided to the Company before work and maintained current.
- 5.7. Each radiographic crew shall have immediate access to a complete current copy of all applicable codes, specifications, approved procedures, approved techniques, and project requirements.

6.0 Safety Requirements

- 6.1. A minimum of two (2) qualified people shall be present during any radiographic exposure operation (per 10 CFR §34.41).
- 6.2. All personnel operating X-ray or gamma equipment shall: protect and monitor each person near the radiation source; comply with USNRC (or CNSC / NOM-025-NUCL-2015) for safety, transport, and certification; always maintain a written Radiation Safety Plan on-site and available upon request.
- 6.3. Prior to commencement of work, all personnel must review and understand the Job Hazard Analysis (JHA), site-specific safety rules, and Personnel Protective Equipment (PPE) per project requirement; controlled-area boundary established per 10 CFR §20.1601 (2 mR/hr).

6.4. Personnel dosimetry: TLD/OSL badge + electronic alarming ratemeter + pocket dosimeter, and survey meter(s); dose records per 10 CFR §20.2106.

7.0 Techniques and Source Selection

7.1. Technique selection shall consider weld type, bevel geometry, weld configuration, applicable pipe wall thickness, and the requirements of Table 7-1.

7.2. **Single Wall Exposure/Single Wall Viewing (SWE/SWV)** (See Figure 10)

7.2.1. SWSI shall be used whenever practical.

7.2.2. One exposure is adequate for the radiographic inspection of a completed butt-weld when the source is centered in the pipe.

7.3. **Double Wall Exposure/Single Wall Viewing (DWE/SWEV)** (See Figure 11)

7.3.1. When the radiographic source is outside but not more than 1/2in from the weld surface, at least three exposures separated by 120° shall be made for the radiographic inspection of a completed weld.

7.3.2. When the radiographic source is outside and more than 1/2in from the weld face, at least four exposures separated by 90° shall be made for the radiographic inspection of a complete weld.

7.4. **Double Wall Exposure/Double Wall Viewing (DWE/DWV)** (See Figure 11)

7.4.1. When the outside diameter of the pipe containing the weld is 3.5 in (89mm) or less, this technique may be used when:

7.4.1.1. The radiation beam is offset so that the source-side and film-side portions of the weld do not overlap in the areas of the radiograph being evaluated (ellipse), and at least two exposures separated by 90° are made for the radiographic inspection of the completed weld.

7.4.1.2. The radiation beam is centered so that the source-side and film-side portions of the weld are superimposed, and at least three exposures separated by 60° are made for the radiographic inspection of the completed weld.

7.4.1.3. When a smaller diameter, thicker-walled pipe is radiographed, additional exposures should be made to minimize the distortion of imperfection images at the ends of the radiographs.

Table 7-1: NDT Techniques Based on Weld Type and Pipe Thickness

Row	Weld Description and Pipe Thickness	NDT Technique Description
1	Pipe diameters > NPS 24 and/or thickness > 12.7 mm (0.500 in.)	X-ray tubes: minimum rating 300 kV and 3 mA. When Ir-192 sources are used, recommended curie strength: ≥ 30 Ci (NPS 8 to <16); ≥ 50 Ci (≥ NPS 16). Curie strength shall sustain the required production rate.

Row	Weld Description and Pipe Thickness	NDT Technique Description
2	Mainline girth welds, pipe $\geq$ NPS 16	Welds shall be radiographed using a true radial-beam X-ray crawler and SWE/SWV, SWSI. Substitution of a directional-beam X-ray tube requires the company's permission. Alternatives reviewed per contract.
3	Assembly girth welds, pipe $\geq$ NPS 16	Welds shall (wherever practicable) be radiographed using X-ray or Ir-192 gamma with SWE/SWV, SWSI. If not achievable, DWE/SWV, DWSI X-ray, or Ir-192 gamma may be used.
4	Mainline girth welds, NPS $8 \leq$ diam < NPS 16	DWE/SWV, DWSI X-ray or Ir-192 gamma. Alternatively, SWE/SWV SWSI using an Ir-192 gamma crawler.
5	Assembly girth welds, NPS $8 \leq$ diam < NPS 16	DWE/SWV DWSI X-ray or Ir-192 gamma; OR SWE/SWV SWSI Ir-192 gamma.
6	Assembly welds, NPS $2 \leq$ diam < NPS 8	DWE/SWV DWSI Ir-192 gamma. If not achievable due to quality concerns, NPS 3 and smaller may use DWE/DWV DWDI Ir-192 gamma. For $\leq$ NPS 4, finer-grain film (e.g., Structurix D3) and four exposures may be required.
7	Assembly welds, pipe < NPS 2	Elliptical or superimposed DWE/DWV DWDI Ir-192 gamma. A source-side IQI shall be used. Elliptical = 2 exposures 90° apart; Superimposed = 3 exposures 60° or 120° apart. Practical SFD $\geq$ 10 pipe diameters.
8	Tie-in welds, replacement welds, repair welds (manual/semi-automatic)	X-ray or Ir-192 gamma; source selected for material thickness and latitude (especially across thickness transitions).
9	Self-Shielded Flux-Cored Arc Welding (FCAW-S)	A company-permitted procedure is required for Barium-slag detection. Minimum 50 Ci gamma OR $\geq$ 300 kV X-ray.
10	Gas Metal Arc Welding and Metal Core Arc Welding	Due to the defect types associated with these welding processes, welds require additional volumetric NDE using ultrasonic testing. RT does not replace the supplementary UT requirement.
11	Transition welds (different wall thicknesses)	Either (a) separate radiographs to achieve density per §10.0 for each wall thickness, OR (b) double-loaded cassettes using two complementary-speed films per Table 10-1 to achieve the required density across the transition.

[Reference: TES-NE-RT-GL Table 4-1; API 1104 §11.1.4 and §11.1.5.]

8.0 Equipment Requirements

- 8.1. PII shall provide all radiographic units required. Each unit on a pipeline project shall be classified as “Fabrication”, “Mainline”, “Mini-Mainline”, “Tie-In”, or “Repair”, and shall be equipped with:
 - 8.1.1. Self-contained vehicle with climate-controlled darkroom for film processing and drying.
 - 8.1.2. Mainline / mini-mainline units: at least one self-propelled crawler, an experienced crawler operator, and sufficient consumables to keep pace with welding production set by the Company or pipeline contractor.
 - 8.1.3. Tie-in/repair units: X-ray tubes and/or Ir-192 (or, with Company consent, Selenium-75 for piping $\leq$ NPS 3 without further consent).
- 8.2. For isotopes other than Ir-192 or Se-75 (e.g., Co-60), prior Authorized Representative consent is required.
- 8.3. Sufficient spare parts (including a complete working spare crawler when applicable), viewers, dosimeters, film, chemicals, and consumables shall be on-site to ensure continuity of work without interruption.
- 8.4. Backup capability for liquid-penetrant, magnetic-particle, and UT thickness examination should be readily available on each work site.
- 8.5. The equipment’s condition and maintenance shall be subject to the Company's audit and consent.

9.0 Surface Preparation

- 9.1. Material surfaces shall meet the applicable material specification, with additional conditioning where surface irregularities would mask or be confused with discontinuity images.
- 9.2. Weld ripples and surface irregularities (ID, where accessible, and OD) shall be removed to a degree that the resulting radiographic image cannot be confused with discontinuity images.
- 9.3. Reinforcement shall not exceed the limits specified by the governing code; the finished surface may be flush with the base material or have a reasonably uniform crown within the code limit.
- 9.4. Any surface conditioning process beyond routine preparation shall be approved by the Company / Authorized Representative before use.

10.0 Film Qualifications and Density Requirements

10.1. Acceptable Film Types — Table 10-1

Manufacturer	Gamma (Ir-192)	X-Ray
Carestream ¹ (formerly Kodak)	DR-50, M100, MX125	DR-50, M100, MX125, T200
Agfa Gevaert ²	D2, D3, D4	D2, D3, D4, D5
Fuji Film	IX25, IX50	IX25, IX50, IX80

NOTE: ¹ Carestream brand 'Industrex'. ² Agfa brand 'Structurix'. Use of alternative brands/types requires prior written consent from the Company.

10.2. Film Classification — Films shall be classified in accordance with ISO 11699-1 and ASTM E1815.

10.3. Higher-Speed Gamma Films (D5 / IX80 / T200) – For gamma exposures, D5, IX80, or T200 may be used without further Company consent under the conditions:

10.3.1. Material thickness $\leq$ 25 mm (1 in.); AND

10.3.2. Piping $\geq$ NPS 20.

10.3.3. Gap Shots

10.4. Authorized Representative consent IS required before use of D5/IX80/T200 for gamma exposures when any of the following exist:

10.4.1. Back-bevel transitions or pipe-to-fitting welds with false bevels.

10.4.2. Tie-in welds made with all-cellulosic consumables or delayed-inspection exposures per welding specification.

10.4.3. Projects with weld repair rate $>$ 5%.

10.4.4. Projects where cracking has occurred.

10.4.5. Materials with specified yield strength 70,000 (486 MPa) or greater.

10.5. Film Width and Coverage — Film shall provide $\geq$ 25 mm (1 in.) coverage on each side of the weld cap where practicable; minimum 6.4 mm (0.250 in.) when 1 in. cannot be achieved.

10.6. Films must be exposed so that a film density throughout the area of interest falls within the ranges provided in Table 10-2.

10.7. Density Requirements — Table 10-2

Region of Film	Acceptable H&D Density
Transition welds — area of interest	2.0 to 4.0 H&D
Unexposed (base) density	$\leq$ 0.30 H&D
Localized area not exceeding 50.8 mm (2 in.)	1.8 to 4.0 H&D

10.8. Unexposed base density shall be checked at least once daily and documented with: date, film brand/type, NDT Tech name, measured H&D permanently marked on the film strip, and entry in the daily inspection log.

10.9. Density of radiographs shall not vary by more than –15% or +30% anywhere through the weld and HAZ.

10.10. Geometric Unsharpness (Ug)

10.10.1. The minimum distance between the source or focal spot and the source side of the object being radiographed shall be determined by the formula, $D = St/k$ Where:

10.10.1.1. D = minimum distance, in inches (mm), between the source or focal spot and the source side of the object being radiographed. The minimum source-to-object distance shall be determined using the above formula. The distance from the source or focal spot to the film shall be D plus the thickness specified in 10.9.2 or 10.9.3, as applicable;

10.10.1.2. S = size, in inches, of the effective source or x-ray tube focal spot. Source sizes shall be from 0.090 in to 0.300 in. Source sizes outside of this range require specific approval by an RT Level III.

10.10.1.3. t = thickness of the weld, in inches (mm), including reinforcement (see section 9.3), plus the distance between the film side of the weld and the film. This thickness shall be determined by direct or calculated measurement based on the object being radiographed.

10.10.1.4. k = geometric unsharpness factor

10.10.2. When t is determined for SWE/SWV and DWE/SWV procedures, the thickness of the single wall and its weld reinforcement shall be used.

10.10.3. When t is determined for DWE/DWV procedures, the outside diameter of the weld (that is, the outside diameter of the pipe plus twice the average height of the weld crown) shall be used.

10.10.4. k is defined as 0.020 in. (0.5mm) for material with a thickness of less than or equal to 2.000 in (50.8mm).

10.10.5. UG shall be kept to a minimum and shall not exceed values permissible by the prevailing code (API 1104 §11.1.5.3 and ASME V Article 2 T-274.2).

[Reference: TES-NE-RT-GL §6; API 1104 §11.1.5; ASME V Art. 2 T-282.]

11.0 Intensifying Screens

11.1. Intensifying Screens — Table 11-1

Item	Requirement
Material	Lead only. Fluorescent, fluorometallic, and calcium-tungstate screens are PROHIBITED.
Minimum thickness	Front and back ≥ 0.13 mm (0.005 in.).

Item	Requirement
Gamma back screen	Recommended 0.26 mm (0.010 in.) to account for backscatter.
Relative thickness	Back-screen thickness $\geq$ front-screen thickness.
Center screen	When double-loading cassettes, a recommended 0.26 mm (0.010 in.).
Damaged screens	Shall be discarded.
Vacuum-sealed packs	Pre-packaged film between lead screens in sealed flexible cassettes may use thinner screens if ALL quality requirements of this Procedure and governing Code are met.

12.0 Radiographic Procedure and Technique Qualification

12.1. All PII radiographic procedures and associated technique sheets shall be uniquely identified and revision-controlled. Before use, each procedure shall be submitted to the TC Energy NDE SME for review and approval and shall be listed by the Company as “Approved for Use.” Only Company-approved radiographic technique shots shall be used. Each technique shall be qualified on the first available weld before production radiography. The first production shot may serve as the technique qualification shot when clearly identified as such on the Company-approved technique sheet. Re-qualification is required when there are any of the following changes:

- 12.1.1. Film brand or type (e.g., Agfa $\rightarrow$ Carestream; D4 $\rightarrow$ D3).
- 12.1.2. Type of radiation (X-ray $\leftrightarrow$ gamma).
- 12.1.3. Exposure geometry — DWDI $\leftrightarrow$ DWSI $\leftrightarrow$ SWSI.
- 12.1.4. Material P-No. (e.g., carbon steel $\rightarrow$ stainless).
- 12.1.5. Radiographer.
- 12.1.6. Project.

12.2. The written technique shall address, as a minimum:

- 12.2.1. Material type and thickness range.
- 12.2.2. Joint bevel design, weld type.
- 12.2.3. Single-wall or double-wall exposure/view.
- 12.2.4. Type of radiation; effective source size or X-ray equipment voltage.
- 12.2.5. SFD/OFD/FFD, geometric unsharpness U_g , radiation angle to the weld, and film.
- 12.2.6. ASTM E747 or ISO 19232-1 IQI: material group, set identification, essential wire, location.
- 12.2.7. Position of radiation source (external/internal crawler).
- 12.2.8. Intensifying screen type, thickness, and position; any filters used.

- 12.2.9. Sketch of geometric arrangement showing minimum SFD and radiation angle.
 - 12.2.10. Film type and brand; film length and width; number of films per weld.
 - 12.2.11. Exposure conditions (mA·min or curie·min).
 - 12.2.12. X-ray voltage/input voltage and current.
 - 12.2.13. Exposure time; processing time, temperature, and chemistry (per ASTM E999).
 - 12.2.14. Stop bath / rinse / fixing / wash / drying parameters.
 - 12.2.15. Manual or automatic processing.
 - 12.2.16. Density range (min/max) achieved.
 - 12.2.17. Sensitivity (%) achieved.
 - 12.2.18. Heat shields: material, thickness, and standoff distance.
- 12.3. TC Energy reserves the right to require re-qualification when there are any variable changes or when any doubt exists regarding the technique's ability to produce an acceptable radiograph.
- 12.4. The test radiograph shall be reviewed and consented to by the TC Energy Representative/Inspector based on: film quality (fog level, processing, density, sensitivity, definition, contrast); identification system; technique and setup; adequacy of written description and shooting sketches.

[Reference: TES-NE-RT-GL §6.3 and §6.4; API 1104 §11.1.7.]

13.0 Production Radiography

- 13.1. The qualified procedure, technique, and test radiograph shall be on site and available for review.
- 13.2. When more than one film is used to inspect a complete circumferential weld:
- 13.2.1. Complete weld identification shall appear on each film segment.
 - 13.2.2. Adjacent films shall overlap by a minimum of 50.8 mm (2 in.).
 - 13.2.3. The same circumferential location marker shall appear on both adjacent films at the overlap, as evidence of complete coverage.
 - 13.2.4. When more than one cassette is used for a single exposure, the sealed end of the first cassette shall be in contact with the pipe surface, and the flap end of the next cassette shall overlap the first; subsequent cassettes shall follow the same configuration.
- 13.3. Radiation Angle — The central beam shall be as near to perpendicular to the weld and film as possible, with a maximum deviation of 5°, except when a superimposed DWE/DWV DWDI procedure is used.

[Reference: TES-NE-RT-GL §7.1.]

14.0 Image Quality Indicators (IQI) and Sensitivity

- 14.1. Radiographic sensitivity shall be measured using a wire-type IQI conforming to ASTM E747 or ISO 19232-1. HOLE-TYPE IQIs ARE PROHIBITED.
- 14.2. Where permissible by the governing code, ISO 19232-1 IQIs are preferred because the additional overlap wires provide flexibility when alternate sensitivity is required.
- 14.3. Thickness Used for IQI Selection — Equal to the nominal pipe wall thickness PLUS the average internal + external weld reinforcement allowed by the governing code. When working to API 1104, total reinforcement applied in IQI selection shall not exceed the lesser of 3.2 mm (0.125 in.) or the maximum allowed by the code of construction.
- 14.4. Number, Placement, and Sensitivity — Per the governing code. Film-side IQIs shall be identified with a lead letter 'F'.
- 14.5. The image of the IQI identifying style number and ASTM set letter (or ISO designation) shall appear clearly on the film. The IQI shall be placed across the weld with the long axis of the wires perpendicular to the weld axis. The image of the essential wire diameter shall appear clearly across the entire area of interest.
- 14.6. All wires shall completely cross the weld. Damaged wire sets shall be discarded. Where the weld cap width exceeds IQI length, IQIs shall be placed from both perpendicular directions.
- 14.7. For transition welds between two wall thicknesses, the thinner wall shall be used to determine the required sensitivity.

15.0 Densitometers and Film Processing

15.1. Densitometers

- 15.1.1. Each contractor-operated darkroom shall be equipped with a calibrated densitometer having a valid calibration certificate and a certified density strip traceable to a national standard.
- 15.1.2. Densitometer shall hold a current valid calibration certificate (PII-RT-CAL-01).
- 15.1.3. A certified density step strip (traceable to a national standard) shall be provided for each darkroom; step ranges 0.30 to 4.0 H&D.
- 15.1.4. Use of a film strip alone (without a densitometer) to estimate density is PROHIBITED.
- 15.1.5. Farmer's Reagent or similar density-reduction chemicals are PROHIBITED.

15.2. Film Processing — Per ASTM E999

- 15.2.1. Sight development is PROHIBITED.
- 15.2.2. Time and temperature for development, stop, rinse, and fix shall be per the chemistry manufacturer and ASTM E999.
- 15.2.3. Film shall be fully fixed; time in fixer $\geq 2 \times$ clearing time, but not less than 3 minutes.

- 15.2.4. Manual wash time $\geq$ 20 minutes whenever practicable.
- 15.2.5. Wash water shall be changed at least once per day, and as needed.
- 15.2.6. Thermometers and timers shall be provided for all inspection units.
- 15.2.7. Date of solution changes shall be posted in the darkroom and recorded in a project log.
- 15.2.8. All darkrooms used for film processing shall be equipped with forced-air film dryers.
- 15.2.9. Final film interpretation shall be performed only on fully dried film.
- 15.2.10. Chemical disposal shall be in accordance with environmental regulations and the manufacturer's SDS.

16.0 Backscatter and Blemishes

- 16.1. A lead letter 'B', minimum 1/2 in. (13 mm) high $\times$ 1/16 in. (1.6 mm) thick, shall be attached to the back of each film cassette, in an area representing the area of viewing interest. If a LIGHT image of the 'B' appears on a darker background of the radiograph, backscatter protection is insufficient, and the radiograph shall be considered unacceptable. A DARK image of 'B' on a lighter background is NOT cause for rejection.
- 16.2. Radiographs presented for interpretation shall be free from blemishes or film defects that might mask or be confused with material imperfections. Typical blemishes (rejecting causes when masking) include:
 - 16.2.1. Fogging from light leaks or defective safelights.
 - 16.2.2. Exposure marks from improper processing or old film.
 - 16.2.3. Mechanical processing defects (streaking, air bubbles, watermarks, chemical stains).
 - 16.2.4. Dirt-in-cassette artifacts; pressure marks, lead marks, scratches, gouges, fingerprints, crimps, static discharge.
 - 16.2.5. Loss of detail from poor film-to-screen contact.

17.0 Delayed Inspection and Repair Welds

- 17.1. Delayed Inspection — When mandated by the Company, the weld may be radiographed initially for code compliance; the final-acceptance (delayed) inspection occurs after the required delay time. If defects are found during the initial inspection, repairs may be made — the delay period begins again after the repairs are completed.
- 17.2. The time of radiography shall be marked on the pipe near the weld; the time of examination shall be identified on the radiographic report.
- 17.3. Repair Welds — When a repaired weld is radiographed, an additional IQI shall be placed across each repaired area.

18.0 Film Identification, Location Markers, and Storage

18.1. Film Identification — Minimum Information (Table 18-1)

Item	Requirements
Film identification	Weld identifier; diameter and nominal wall thickness; code of construction; date; Project ID; any additional information requested by the Company. Lead numbers/letters or flash cards permitted.
Location markers	Placed on the pipe downstream side of the weld so numbers are read clockwise when viewed from the upstream side. Identification and location markers shall be clearly visible on the radiograph and shall not encroach on the weld image or area of interest. Identifier characters $\geq 3/32$ in. (2.4 mm) high. (See Figure 1)
Marker separation	Maximum 50 mm (2 in.) for $\leq$ NPS 16; maximum 150 mm (6 in.) for $>$ NPS 16.
Zero location	Number corresponding to the 12 o'clock position on the pipe, wherever practicable.

18.2. If film identification is incorrect, the correct information may be marked with a permanent marker or by replacing the flash on the film. Revised information shall be placed OUTSIDE the readable weld area; edits shall be noted on the daily report. Recurring identification errors may require all welds to be re-radiographed at PII's expense.

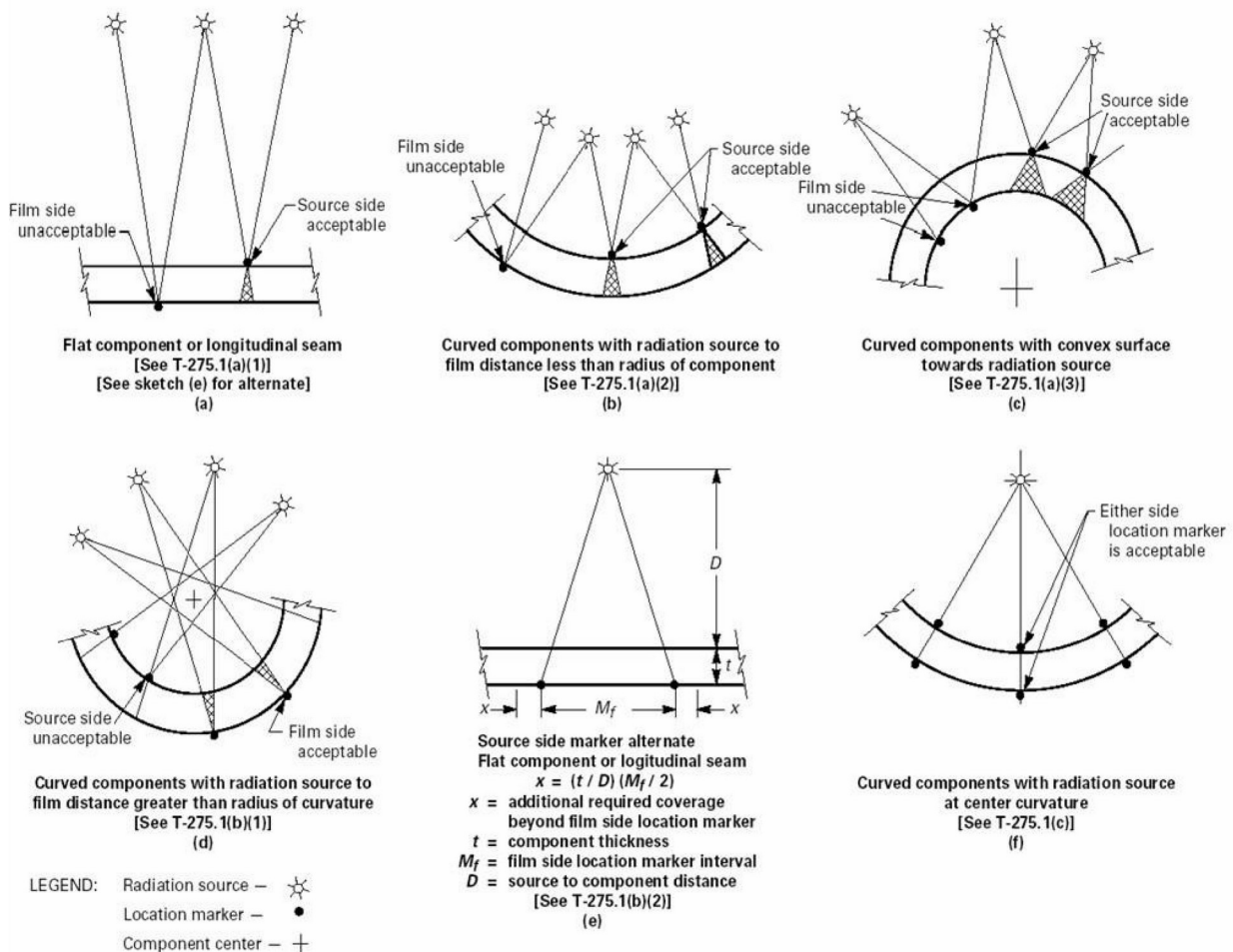


Figure 1: Location Markers

NOTE: The drawings/sketches and paragraph numbers in Figure 1 are for illustrative purposes and are the same as depicted in ASME Section V Article 2.

18.3. Marker Placement — Single-Wall Viewing

18.3.1. Source-Side Markers — Required on the source side for: piping components with concave side toward the source AND source-to-material distance less than the inside radius; curved or spherical components with concave side toward the source.

18.4. Marker Placement — Double-Wall Viewing

18.4.1. At least one location marker shall be placed on the outside surface adjacent to the weld for each image.

18.5. Storage

- 18.5.1. All radiographic film and associated documentation become the property of TC Energy.
- 18.5.2. Duplicate production radiographs shall not be produced without prior Company written authorization.
- 18.5.3. Electronic transfer of production radiographs requires prior Company consent.

Table 18-2: Processing Film for Storage (key requirements)

Item	Requirements
Wash Film	PII must ensure that all films are thoroughly washed and dried before packaging, and all films are packaged in sequential order with a copy of the daily radiographic report.
Catalogue	a. Completed radiographs cataloged and packaged in cardboard boxes (supplied by PII) or, for fabrication or oversize, in suitably sized envelopes; contents clearly identified. b. For cubicle boxes, radiographs must be inserted into each cubicle in sequence, starting from the left side of the first row toward the right, and then from the right side of the second row toward the left, and so on. c. The bottom of each cubicle must be clearly marked with the film number, i.e., the weld number that must occupy that space after the radiograph has been interpreted.
Processing Radiographs of Repaired Welds	a. Radiographs of repaired welds must be rolled or inserted with the original radiograph such that both films are stored in the same cubicle, or when envelopes are used, they must be included in the same envelope or box b. Should the entire weld, including repairs, not fit into the cubicle or envelope, a separate box or envelope dedicated to repair welds only may be used and identified as such.
Processing Radiographs of Replaced Cut-out Welds	a. Radiographs of cut-out welds must be placed in the same cubicle or envelope as the original film. b. If there is not enough room, the original film may be removed and filed in a box or envelope identified as a cut-out box or cut-out envelope.
Removal of Staples	All staples used to hold film(s) together must either be removed or an alternative approach to prevent film damage during storage be established before storage.
Interpretation Sheets	a. Clear and legible interpretation sheets must be included inside the boxes for those films cataloged in the corresponding boxes. b. Each time a new box is started, a new interpretation sheet must be started. c. These sheets must then be inserted inside the corresponding box or envelope. d. All interpretation sheets must have the printed name and signature of the technician interpreting the film.

Item	Requirements
Labeling	a. PII must supply labels for the radiographic boxes. The boxes and labels must be numbered sequentially, starting from number one. As films are being processed, Prime Inspections Inc. must complete the labels with the following information: • project name, location, or spread number • range of weld numbers • range of chainage, for pipeline projects when requested by the Company • range of dates exposed • box number • Contractor's name • other specific information required by the Project b. The complete labels must be applied to the same location on the side of each completed radiographic box.
Storage	a. Radiographic film and associated reports must be forwarded to the Company for storage. b. Film processing must be adequate to permit storage without deterioration for at least seven years.

19.0 Film Digitization (Optional)

- 19.1. When digitization of film is performed under this procedure, the following shall apply:
- 19.1.1. Reviewed by Authorized Representative.
 - 19.1.2. Processing per ISO 14096-2.
 - 19.1.3. Class DS imaging shall be achieved.
 - 19.1.4. Performance checks using ASTM E1936 reference radiograph shall be performed at the beginning and end of each shift.
 - 19.1.5. Final digital images shall be in DICOM format (ASTM E2339).
 - 19.1.6. Images free of system-induced artifacts in the area of interest that could mask or be confused with discontinuity images.
 - 19.1.7. Each digital file metadata shall include the information captured on the original radiographic flash.
 - 19.1.8. Electronic records are categorized in a logical file structure agreed upon between TC Energy and PII.
 - 19.1.9. Image review software with quality measurement capability (spatial resolution, grey scale, SNR, flaw sizing).

NOTE: Original radiographs may be retained by PII in an environmentally controlled room for up to two (2) years from receipt. Disposal records, when applicable, shall be supplied to the Company upon expiration of the storage period or upon notice from the Company.

20.0 Interpretation

- 20.1. Facilities for Viewing Radiographs

Viewing facilities shall provide subdued background lighting of an intensity that will not cause troublesome reflections, shadows, or glare on the radiograph.

20.2. Film Viewing Equipment

Equipment used to view radiographs for interpretation shall provide a light source sufficient to make the essential wire visible within the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

20.3. For final film interpretation, PII shall provide a variable-luminosity high-intensity viewer of sufficient screen size to allow adequate viewing of films up to H&D 4.0. Upon request, PII shall provide a second identical viewer and a calibrated densitometer for use by TC Energy in the field office.

20.4. Interpretation shall be performed in subdued background lighting that does not cause reflections or glare on the film. Final disposition of each weld shall be recorded on the Daily Radiographic Report.

20.5. Imperfections exceeding 50% of the allowable flaw dimension shall be documented in the weld record, including the flaw type and measured size.

21.0 Acceptance Standards

21.1. Unless otherwise specified by the project, weld acceptance shall be per API 1104, 21st Edition, §9.6 (Acceptance Standards for Nondestructive Testing).

21.2. Indications shall be classified using the API 1104 indication types (IP, IPD, ICP, IF, IFD, IC, BT, HB, CP, and pipe/fitting imperfections per §9.7).

21.3. For ASME B31.3: ASME B31.3 §344.5 (with §341.3.2 severity classification when invoked).

21.4. A Project-Specific Acceptance Addendum shall be developed where required by the customer; without such guidance, TC Energy shall be consulted.

21.5. API 1104 Accept/Reject Criteria

21.5.1. Inadequate Penetration without High-Low

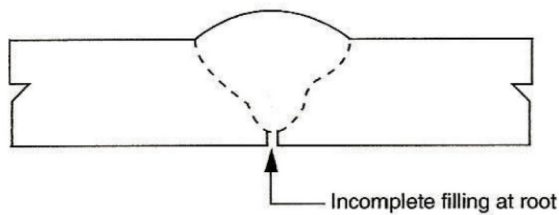
Inadequate penetration without high-low (IP) is defined as the incomplete filling of the weld root. This condition is shown schematically in Figure 2 shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of IP exceeds 1in (25mm).
- b. The aggregate length of indications of IP in any continuous 12in (300mm) of weld exceeds 1in (25mm).
- c. The aggregate length of indications of IP exceeds 8% of the weld length in any weld less than 12in (300mm) in length.

21.5.2. Inadequate Penetration Due to High-Low

Inadequate penetration due to high-low (IPD) is defined as the condition in which one edge of the root is exposed (or unbonded) because adjacent pipe or fitting joints are misaligned. This condition is shown schematically in Figure 3. IPD shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of IPD exceeds 2in (50mm).
- b. The aggregate length of indications of IPD in any continuous 12in (300mm) length of weld exceeds 3in (75mm).



**Figure 2: Inadequate Penetration (IP)
High-Low (IPD)**

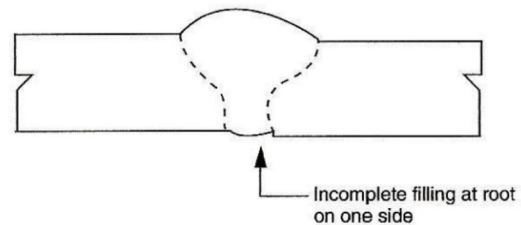


Figure 3: IP Due to

21.5.3. Inadequate Cross Penetration

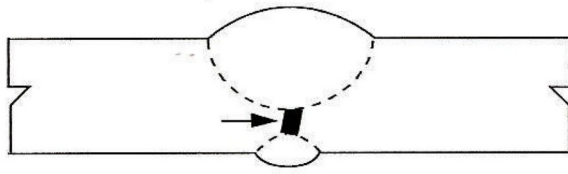
Inadequate cross penetration (ICP) is defined as a subsurface imperfection between the first inside pass and the first outside pass that is caused by inadequately penetrating the vertical land faces. This condition is shown schematically in Figure 4. ICP shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of ICP exceeds 2in (50 mm).
- b. The aggregate length of ICP in any continuous 12in (300mm) length of weld exceeds 2in (50mm).

21.5.4. Incomplete Fusion

Incomplete fusion (IF) is defined as a surface imperfection between the weld metal and the base material that is open to the surface. This condition is shown schematically in Figure 5. IF shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of IF exceeds 1in (25mm).
- b. The aggregate length of indications of IF in any continuous 12in (300mm) length of weld exceeds 1in (25 mm).
- c. The aggregate length of indications of IF exceeds 8% of the weld length in any weld less than 12in (300mm) in length.



**Figure 4: Inadequate Cross Penetration (ICP)
Incomplete Fusion (IF)**

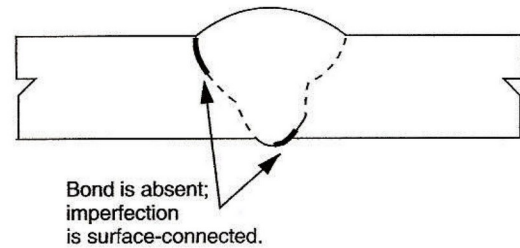


Figure 5:

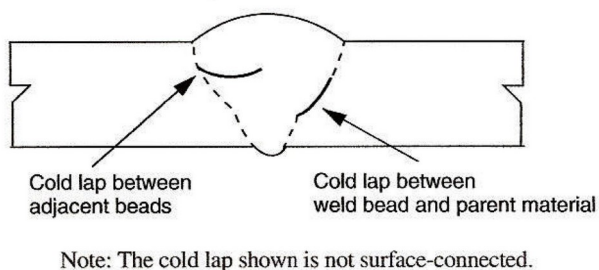
21.5.5. Incomplete Fusion Due to Cold Lap

Incomplete fusion due to cold lap (IFD) is defined as an imperfection between two adjacent weld beads or between the weld metal and the base metal that is not open to the surface. This condition is shown schematically in Figure 6. IFD shall be considered a defect should any of the following conditions exist:

- The length of an individual indication of IFD exceeds 2in (50mm)
- The aggregate length of indications of IFD in any continuous 12in (300mm) length of weld exceeds 2in (50mm)
- The aggregate length of indications of IF exceeds 8% of the entire weld length.

21.5.6. Internal Concavity

Internal concavity (IC) is shown schematically in Figure 7. Any length of internal concavity is acceptable, provided the density of the radiographic image of the internal concavity does not exceed that of the thinnest adjacent parent material. For areas that exceed the density of the thinnest adjacent parent material, the criteria for burn-through (see 21.7.7) are applicable.



**Figure 6: Incomplete Fusion Due to Cold Lap (IFD)
Concavity (IC)**

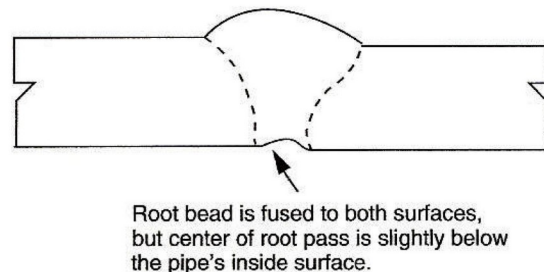


Figure 7: Internal

21.5.7. Burn-Through

A burn-through (BT) is defined as a portion of the root bead where excessive penetration has caused the weld puddle to be blown into the pipe.

21.5.7.1. For a pipe with an outside diameter greater than or equal to 2.375in (60.3mm), a BT shall be considered a defect should any of the following conditions exist:

- a. The maximum dimension exceeds 1/4in (6mm) and the density, in any portion of the BT's image, exceeds that of the thinnest adjacent parent material.
- b. The maximum dimension exceeds the thinner of the nominal wall thicknesses joined, and the density, in any portion of the BT's image, exceeds that of the thinnest adjacent parent material.
- c. The sum of the maximum dimensions of separate BT's whose image density, for any portion of BT's, exceeds that of the thinnest adjacent parent material and exceeds 1/2in (13 mm) in any continuous 12in (300 mm) length of weld, or the total weld length, whichever is less.

21.5.7.2. For a pipe with an outside diameter less than 2.375in (60.3mm), a BT shall be considered a defect when any of the following conditions exist:

- a. The maximum dimension exceeds 1/4in (6 mm), and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material.
- b. The maximum dimension exceeds the thinner of the nominal wall thicknesses joined, and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material.
- c. More than one BT of any size is present, and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material.

21.5.8. Slag Inclusions

A slag inclusion is defined as a nonmetallic solid entrapped in the weld metal or between the weld metal and the parent material. Elongated slag inclusions (ESI's), continuous or broken slag lines, or wagon tracks are usually found at the fusion zone. Isolated slag inclusions (ISI's) are irregularly shaped and may be located anywhere in the weld. For evaluation purposes, when the size of a radiographic indication of slag is measured, the indication's maximum dimension shall be considered its length.

21.5.8.1. For a pipe with an outside diameter greater than or equal to 2.375in (60.3mm), slag inclusions shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of ESI exceeds 2in (50mm).
- b. The aggregate length of indications of ESI in any continuous 12in (300mm) length of weld exceeds 2in (50mm).
- c. The width of an ESI indication exceeds 1/16in (1.6mm)
- d. The aggregate length of ISI indications in any continuous 12in (300mm) length of weld exceeds 1/2in (13mm)
- e. The width of the ISI indication exceeds 1/8in (3mm)
- f. More than four ISI indications with the maximum width of 1/8in (3mm) are present in any 12in (300mm) length of weld.
- g. The aggregate length of ESI and ISI indications exceeds 8% of the entire weld length.

21.5.8.2. For a pipe with an outside diameter less than 2.375in (60.3mm), slag inclusions shall be considered a defect should any of the following conditions exist:

- a. The length of an ESI indication exceeds three times the thinner of the nominal wall thicknesses joined.
- b. The width of an ESI indication exceeds 1/16in (1.6mm).
- c. The aggregate length of ISI indications exceeds two times the thinner of the nominal wall thicknesses joined, and the width exceeds one-half the thinner of the nominal wall thicknesses joined.
- d. The aggregate length of ESI and ISI indications exceeds 8% of the entire weld length.

NOTE: *Parallel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single indication unless the width of either of them exceeds 1/32in (0.8 mm). In that event, they shall be considered separate indications.*

21.5.9. Porosity

Porosity is defined as gas trapped in the solidifying weld metal before it has a chance to rise to the surface of the molten puddle and escape. Porosity is generally spherical but may be elongated or irregular in shape, such as piping (wormhole) porosity. When the size of the radiographic indication produced by a pore is measured, the maximum dimension of the indication shall apply to the criteria given below:

21.5.9.1. Individual or scattered porosity (P) shall be considered a defect should any of the following conditions exist:

- The size of an individual pore exceeds 1/8in (3mm).
- The size of an individual pore exceeds 25% of the thinner of the nominal wall thicknesses joined.
- The distribution of scattered porosity exceeds the concentration permitted by Figures 8 or 9.

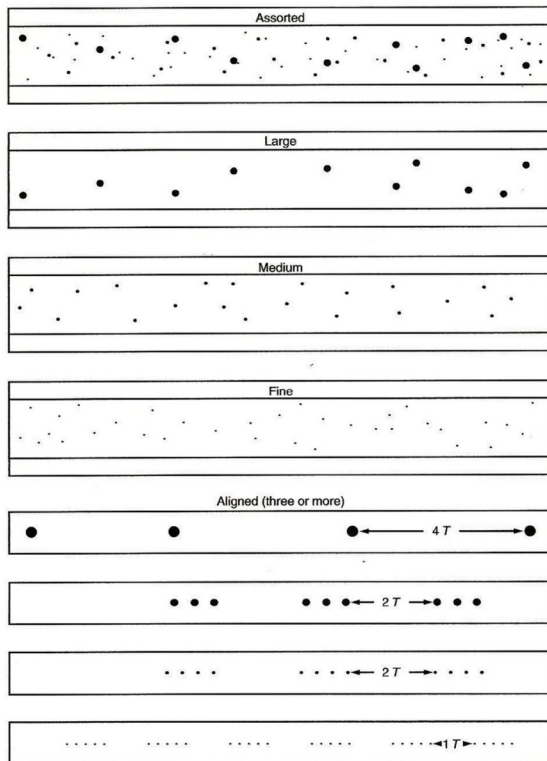


Figure 8: Max Distribution of Porosity ≤ 0.500 in (12.7mm)

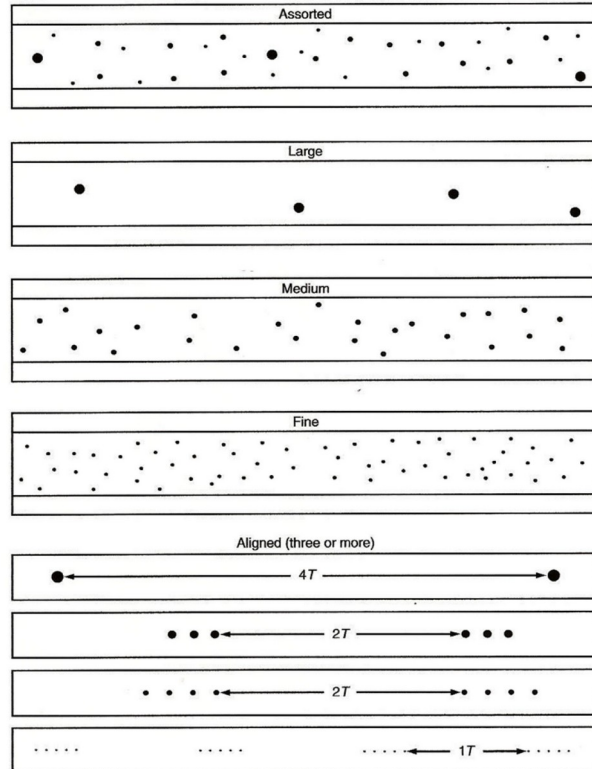


Figure 9: Max Distribution of Porosity > 0.500 in (12.7mm)

21.5.9.2. Cluster porosity (CP) that occurs in any pass except the finish pass shall comply with the criteria stated in 21.7.9.1. CP that occurs in the finished pass shall be considered a defect should any of the following conditions exist:

- The diameter of the cluster exceeds 1/2in (13mm).
- The aggregate length of CP in any continuous 12in (300mm) length of weld exceeds 1/2in (13mm).

21.5.9.3. Hollow-bead Porosity (HB) is defined as elongated linear porosity that occurs in the root pass. HB shall be considered a defect should any of the following conditions exist:

- a. The length of an individual indication of HB exceeds 1/2in (13mm).
- b. The aggregate length of indications of HB in any continuous 12in (300mm) length of weld exceeds 2in (50mm).
- c. Individual indications of HB, each greater than 1/4in (6mm) in length, are separated by less than 2in (50mm).
- d. The aggregate length of all indications of HB exceeds 8% of the entire weld length.

21.5.10. Cracks

Cracks (C) shall be considered a defect should any of the following conditions exist:

- a. The crack, of any size or location in the weld, is not a shallow crater crack or star crack.
- b. The crack is a shallow crater crack or star crack with a length that exceeds 5/32in (4mm)

NOTE: *Shallow crater cracks or star cracks are located at the stopping point of weld beads and are the result of weld metal contraction during solidification.*

21.5.11. Undercutting

Undercutting is defined as grooves melted into the parent material adjacent to the toe or root of the weld and left unfilled by weld metal. Undercutting adjacent to the cover pass (EU) or root pass (IU) shall be considered a defect should any of the following conditions exist:

- a. The aggregate length of indications of EU and IU, in any combination, in any continuous 12in (300mm) length of weld exceeds 2in (50mm).
- b. The aggregate length of indications of EU and IU, in any combination, exceeds 1/8 of the weld length.

NOTE: *See Visual Inspection Procedure for acceptance standards for undercutting when visual and mechanical measurements are employed.*

21.5.12. Accumulation of Imperfections

Excluding incomplete penetration due to high-low and undercutting, any accumulation of imperfections (AI) shall be considered a defect should any of the following conditions exist:

- a. The aggregate length of indications in any continuous 12in (300mm) length of weld exceeds 2in (50mm).
- b. The aggregate length of indications exceeds 8% of the entire weld length.

21.5.13. Pipe or Fitting Imperfections

Imperfections in the pipe or fittings detected by radiographic testing shall be reported to the customer. Their disposition shall be as directed by the customer.

21.6. ASME B31.3 Accept/Reject Criteria

Criteria (A to M) for Types of Welds and for Service Conditions - Note (1)										Weld Imperfections
Normal and Category M Fluid Service			Severe Cyclic Conditions			Category D Fluid Service				
Girth, Miter Groove, and Branch Connection Welds Note (2)	Longitudinal Groove Weld Note (3)	Fillet Weld Note (4)	Girth, Miter Groove, and Branch Connection Welds Note (2)	Longitudinal Groove Weld Note (3)	Fillet Weld Note (4)	Girth & Miter Groove Welds	Longitudinal Groove Weld Note (3)	Fillet Weld Note (4)	Branch Connection Weld Note (2)	
A	A	A	A	A	A	A	A	A	A	Crack
A	A	A	A	A	A	C	A	NA	A	Lack of Fusion
B	A	NA	A	A	NA	C	A	NA	B	Incomplete Penetration
E	E	NA	D	D	NA	N/A	N/A	N/A	N/A	Rounded Indications
G	G	NA	F	F	NA	N/A	N/A	N/A	N/A	Linear indications
H	A	H	A	A	A	I	A	H	H	Undercutting
A	A	A	A	A	A	A	A	A	A	Surface porosity or exposed slag inclusion Note (5)
NA	NA	NA	J	J	J	NA	NA	NA	NA	Surface Finish
K	K	NA	K	K	NA	K	K	NA	K	Concave surface, concave root, or burn-through
L	L	L	L	L	L					Weld reinforcement or internal protrusion

General Notes:

(a) Weld imperfections are evaluated by one or more of the types of examination methods given, as specified in B31.3 paragraphs. 341.4.1, 341.4.2, 341.4.3, and M341.4, or by the engineering design.

(b) "N/A" indicates the Code does not establish acceptance criteria or does not require evaluation of this kind of imperfection for this type of weld.

(c) Check (✓) indicates examination method generally used for evaluating this kind of weld imperfection.

(d) Ellipsis (. . .) indicates examination method not generally used for evaluating this kind of weld imperfection.

Notes:

(1) Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also ASME B31.3, paras. 341.5 and 341.5.3.

(2) Branch connection weld includes pressure-containing welds in branches and fabricated laps.

(3) Longitudinal groove weld includes straight and spiral (helical) seam. Criteria are not intended to apply to welds made in accordance with a standard listed in ASME B31.3 Table A-1, Table A-1M, or Table 326.1. Alternative Leak Test requires examination of these welds; see ASME B31.3 para. 345.9.

(5) These imperfections are evaluated only for welds $3/16\text{in} \leq 5\text{ mm}$ ($\leq 5\text{ mm}$) in nominal thickness.

(4) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports.

Criterion		Acceptable Value Limits - Note (1)
Symbol	Measure	
A	Extent of imperfection	Zero (no evident imperfection)
B	Cumulative length of incomplete penetration	$\leq 1.5\text{in}$ (38mm) in any 6in (150mm) weld length or 25% of total weld length, whichever is less
C	Cumulative length of lack of fusion and incomplete penetration	$\leq 1.5\text{in}$ (38mm) in any 6in (150mm) weld length or 25% of total weld length, whichever is less
D	Size and distribution of rounded indications	See Appendix 1 and Figures 4, 5, and 6.0 - 6.5. Note (2)
E	Size and distribution of rounded indications	For $T_w \leq 1/4\text{in}$ (6mm), limit is same as D - Note (2) For $T_w > 1/4\text{in}$ (6mm), limit is 1.5D - Note (2)
F	Linear indications Individual length Individual width Cumulative length	$\leq T_w / 3$ $\leq 3/32\text{in}$ (2.5mm) and $\leq T_w / 3$ $\leq T_w$ in any 12 T_w weld length - Note (2)
G	Linear indications Individual length Individual width Cumulative length	$\leq 2T_w$ $\leq 1/8\text{in}$ (3mm) and $\leq T_w / 2$ $\leq 4T_w$ in any 6in (150mm) weld length - Note (2)
H	Depth of undercut Cumulative length of internal and external undercut	$\leq 1/32\text{in}$ (1mm) and $\leq T_w / 4$ $\leq 1.5\text{in}$ (38mm) in any 6in (150mm) weld length or 25% of total weld length, whichever is less
I	Depth of undercut Cumulative length of internal and external undercut	$\leq 1/16\text{in}$ (1.5mm) and $\leq [T_w / 4 \text{ or } 1/32\text{in} (1\text{mm})]$ $\leq 1.5\text{in}$ (38mm) in any 6in (150mm) weld length or 25% of total weld length, whichever is less
J	Surface roughness	$\leq 500 \mu\text{in}$ (12.5 μm) Ra in accordance with ASME B46.1
K	Depth of surface concavity, root concavity, or burn-through	Total joint thickness, including weld reinforcement $\geq T_w$ Notes (3) and (4)
L	Height of reinforcement or internal protrusion in any plane through the weld shall be within limits of the applicable height value in the tabulation shown in Appendix 2 for ASME B31.3. Weld metal shall merge smoothly into the component surfaces.	See Appendix 2: Maximum Permissible Weld Reinforcement
M	Height of reinforcement or internal protrusion as described in L.	See Appendix 2: Maximum Permissible Weld Reinforcement

NOTES:

(1) Where two limiting values are separated by “and,” the lesser of the values determines acceptance. Where two sets of values are separated by “or,” the larger value is acceptable. T_w is the nominal wall thickness of the thinner of the two components joined by a butt weld.

(2) Porosity and inclusions such as slag or tungsten are defined as rounded indications where the maximum length is three times the width or less. These indications may be circular, elliptical, or irregular in shape; may have tails; and may vary in density. Indications where the length is greater than three times the width are defined as linear indications and may also be slag, porosity, or tungsten.

(3) For circumferential groove welded joints in pipe, tube, and headers made entirely without the addition of filler metal, external concavity shall not exceed the lesser of 1/32in or 10% of the joint nominal thickness. The contour of the concavity shall blend smoothly with the base metal. The total joint thickness, including any reinforcement, shall not be less than the minimum wall thickness, t_m .

(4) For radiography, acceptability may be determined by comparing the density of the image through the affected area to the density through the adjacent base metal (Tw).

22.0 Documentation and Reporting

- 22.1. Project Log — When required by contract, PII shall keep a logbook reviewed and consented to by TC Energy for traceability of all welds and repairs. At project completion, the logbook is delivered to TC Energy.
- 22.2. Daily Radiographic Reports — At the end of each day, PII shall supply TC Energy with details of all radiographic inspections completed that day. Reports shall include, as a minimum:
 - 22.2.1. Inspection date (Month / Day / Year).
 - 22.2.2. Film type used.
 - 22.2.3. Technique used (e.g., SWE/SWV SWSI Ir-192).
 - 22.2.4. Source strength (curies, or mA / kV).
 - 22.2.5. Pipe diameter and wall thickness.
 - 22.2.6. IQI identification.
 - 22.2.7. Company, project name, and number.
 - 22.2.8. Code of construction per project requirements.
 - 22.2.9. Company specification and acceptance criteria used.
 - 22.2.10. Spool number (if applicable).
 - 22.2.11. Weld number.
 - 22.2.12. Disposition (accept/reject / cut-out/repair), flaw type and measured size when indication exceeds 50% of allowable dimension.
 - 22.2.13. Technician name and certification level/number, and signature.
 - 22.2.14. Company representative authorization.
 - 22.2.15. Density measurement of daily unexposed base film.
- 22.3. Weld Repair List — Provided to the Company in electronic and hardcopy format each working day, at a cut-off time specified by the Company and agreed by PII.
- 22.4. Records shall be retained per the prevailing Code Section and 49 CFR §192.709 (minimum 7 years or asset life, whichever is greater).

23.0 Variances

Any deviation from this procedure or TES-NE-RT-G shall be processed through the TC Energy Controlled Document Library Variance Procedure (CAN-US-MEX), Item ID 007728702. Internal PII variances shall be recorded in PII-QM-VAR with Level III concurrence.

24.0 Compliance Cross-Reference Matrix

Procedure §	Subject	Governing Code / Specification Reference
5.0	Personnel Qualification	ASNT SNT-TC-1A; ANSI/ASNT CP-189; ACCP; ISO 9712; CGSB 48.9712; PII-WP-1
6.0	Radiation Safety, Two-Person Rule, Surveys	10 CFR §20 / §34; ANSI N43.3; 49 CFR §172.700; CNSC NSRDR; NOM-025-NUCL-2015
7.0	Techniques & Source Selection	TES-NE-RT-GL Table 4-1; API 1104 §11.1.4-§11.1.5; ASME V Art. 2 T-271-T-274
10.0	Film Classification & Density	ISO 11699-1; ASTM E1815; ASME V Art. 2 T-282; API 1104 §11.1.5.4
11.0	Intensifying Screens	ASME V Art. 2 T-233.1; TES-NE-RT-GL Table 7-1
12.0	Procedure / Technique Qualification	API 1104 §11.1.7; ASME V Art. 2 T-281; TES-NE-RT-GL §6.3
14.0	Wire IQI / Sensitivity	ASTM E747; ISO 19232-1; ASME V Art. 2 T-276; API 1104 §11.1.5.5; TES-NE-RT-GL §7.5
15.0	Densitometers & Film Processing	ASTM E999; ASME V Art. 2 T-283; TES-NE-RT-GL Table 7-1
16.0	Backscatter / Blemishes	ASME V Art. 2 T-223; TES-NE-RT-GL §7.6
18.0	Film Identification, Markers, Storage	ASME V Art. 2 T-275; TES-NE-RT-GL §8; 49 CFR §192.709
19.0	Film Digitization	ISO 14096-2; ASTM E1936; ASTM E2339 (DICONDE)
21.0	Acceptance	API 1104 §9.6; ASME B31.3 §344.5;
23.0	Variance Process	TC Energy Item ID 007728702

25.0 Figures (Additional)

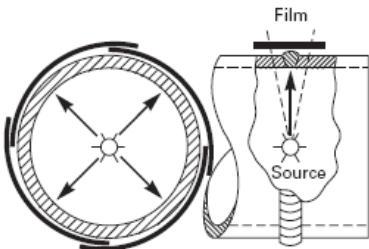
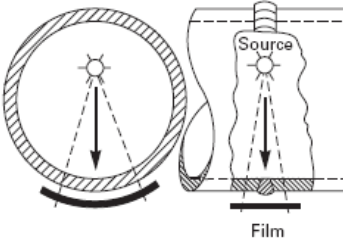
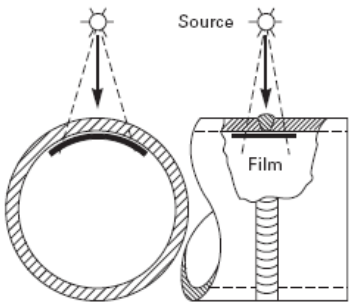
O.D.	Exposure Technique	Radiograph Viewing	Source-Weld-Film Arrangement		IQI		Location Marker Placement
			End View	Side View	Selection	Placement	
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — A		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Either Side T-275.3 T-275.1(c)
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — B		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1 (b)(1)
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — C		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Source Side T-275.1 (a)(3)

Figure 10: Standard Single Wall Radiographic Techniques

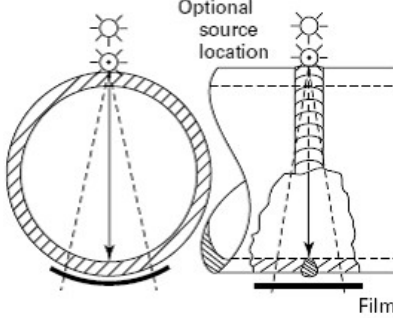
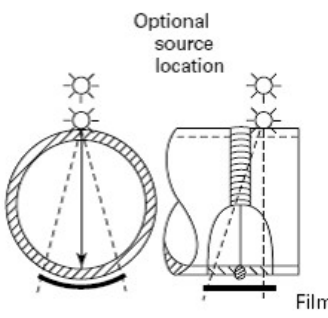
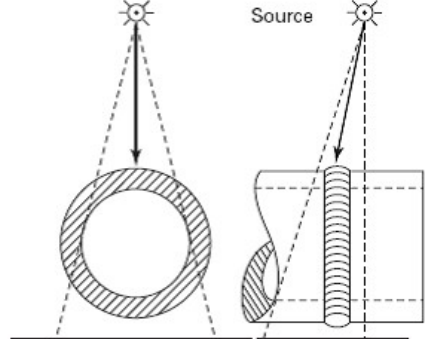
O.D.	Exposure Technique	Radiograph Viewing	Source-Weld-Film Arrangement		IQI		Location Marker Placement
			End View	Side View	Selection	Placement	
Any	Double-Wall: T-271.2(a) at Least 3 Exposures 120 deg to Each Other for Complete Coverage	Single-Wall	 Exposure arrangement — D		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1 (b)(1)
Any	Double-Wall: T-271.2(a) at least 3 Exposures 120 deg to Each Other for Complete Coverage	Single-Wall	 Exposure arrangement — E		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1 (b)(1)
3½ in. (88 mm) or Less	Double-Wall T-271.2(b)(1) at Least 2 Exposures at 90 deg to Each Other for Complete Coverage	Double-Wall (Ellipse): Read Off-set Source Side and Film Side Images	 Exposure arrangement — F		T-276 and Table T-276	Source Side T-277.1(a)	Either Side T-275.2

Figure 11: Standard Double Wall Radiographic Techniques

27.0 Radiographic Examination Technique Sheet



Radiographic Procedure Qualification Record (Film)

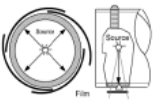
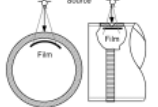
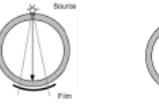
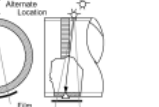
1621 Primewest Parkway | Katy, TX 77449 | P: (281) 578-6523; info@rae.com

primeinspections.com

Client: _____ Date: _____ Page: _____ of _____
AFE/IR/PO No: _____
Location: _____ UTQ Job No: _____

Code/Specification	Procedure & Rev	Acceptance Criteria
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Material Type: _____ Weld Joint Type: _____ Bevel: _____ Diameter (NPS): _____ Thickness: _____ Reinforcement (Est.): _____	IQI Type: ☐ Wire ☐ Plaque Designation: _____ Material: _____ Placement: ☐ Source Side ☐ Film Side Essential Wire / Hole: _____	Screens Material: _____ Thickness Front: _____ Back: _____ Back Scatter Indicator: _____ Backing Material: _____
Radiation Source Type: ☐ Ir ¹⁹² ☐ Co ⁶⁰ ☐ Se ⁷⁵ ☐ X-Ray Strength: _____ (Ci) _____ (kV) _____ (mA) Focal Size: _____		
Film Manufacturer: _____ Type & Size: _____ Load: ☐ Single ☐ Double Limit of Coverage: _____ No. of Exposures _____	Setup Source to Film Distance: _____ Dist. Source Side of Object to Film: _____ Source to Object Distance: _____ Ug (Geometric Unsharpness): _____ Exposure Time: _____ Curie-Minute: _____	Film Density Verification Densitometer Mfg: _____ Model/ SN: _____ Calibration Due Date: _____ Density (Min/Max): _____ Sensitivity (%): _____

Technique ☐ SWE/SWV (Panoramic) ☐ SWE/SWV (Single Wall) ☐ DWE/SWV (Contact) ☐ DWE/DWV (External Offset)    	Sketch
Processing Type: ☐ Automatic ☐ Manual Manufacturer: _____ Fog Check Density: _____ Developer Time: _____ Temp: _____ Stop/Rinse Time: _____ Temp: _____ Fixer Time: _____ Temp: _____ Wash Time: _____ Temp: _____ Drying Type: ☐ Automatic / Oven ☐ Air Drying Time: _____ Temp: _____	
Comments _____ _____ _____ _____	Heat Shields Type: _____ Material: _____ Thickness: _____ Distance (Film Side of HS to Object): _____

Technician Print Name & Level _____ Sign _____ Date _____	Client Representative: Print Name & Title _____ Sign _____ Date _____
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Radiographic Procedure Qualification [RPQ]

PII-RTFORM-TS-Rev0 – 7/28/2026

— END OF DOCUMENT —