

OWNER

Nondestructive Examination



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TORUS

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ISSUE SUMMARY AND APPROVAL

This page records each issue of SPC-SPC-008. The preparer, reviewer and approver sign for each revision.

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Contributors

Rev.	Discipline	Prepared by	Reviewed by	Approved by
A	Specifications			

SECTION PC-SPC-008 NONDESTRUCTIVE EXAMINATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes the nondestructive examination (NDE) of welds and base metal for all station piping between IJ-101 and IJ-102 and for the outlet lateral from IJ-102 to the tap valve flange of (the receiving pipeline operator), performed by an independent NDE subcontractor engaged by the Contractor:
1. Radiographic testing (RT) on film and digital media (computed radiography and digital detector arrays).
 2. Automated ultrasonic testing (AUT), and manual or phased-array ultrasonic testing (UT, PAUT), where specified or approved as an alternative to RT.
 3. Magnetic particle testing (MT) and liquid penetrant testing (PT).
 4. Ultrasonic lamination checks of field-cut pipe ends and of base metal at branch connections.
 5. Ultrasonic wall thickness measurement.
 6. Reporting, weld map linkage, independent Owner review of 100 % of radiographic images, and radiation safety.
 7. Positive material identification (PMI) and ferrite measurement of the class S1 stainless vent and blowdown piping and VS-101, and PT of S1 welds.
- B. Related sections: SPC-SPC-001, General Requirements and Definitions; SPC-SPC-006, Piping Fabrication and Installation; SPC-SPC-007, Welding; SPC-SPC-011, Hydrostatic Testing, Dewatering and Drying; SPC-SPC-017, Mechanical Equipment Setting; SPC-SPC-019, Inspection and Test Plan; SPC-SPC-020, Construction Records and Turnover.
- C. Work by others: NDE of welds on the trunkline and the hot tap fitting is by the receiving pipeline operator. Vendor NDE of ASME Section VIII items is by the vendors under their purchase orders.

1.02 EXTENT OF EXAMINATION

- A. The extent of examination shall be as Table 1-1 shows. It meets the Basis of Design requirement for 100 % RT or AUT of all butt welds and 100 % MT or PT of fillet and socket welds, which exceeds the sampling of 49 CFR 192.243 and ASME B31.8 paragraph 826; the Owner requires it because the station operates at a design factor of 0.50 at a custody transfer point and the records must support the maximum allowable operating pressure without reliance on sampling.

Table 1-1: Extent of Examination

Weld or item	Extent	Primary method	Supplementary
Butt (girth) welds NPS 2 and larger, carbon steel classes A6, A1 and D1, shop and field	100 % of welds, full circumference	RT, or AUT where approved	Visual 100 %
Butt welds NPS 1-1/2 and smaller	100 % of welds	RT, double-wall double-image	
Tie-in welds and any approved untested closure weld	100 % of welds	RT and UT, both	MT of root and cap
Repaired welds	Repaired length plus 2 in each side	Original method	MT of the finished repair
Branch connections (MSS SP-97 outlets)	100 % of welds	MT of root or first pass and of cap	PAUT of the groove weld where geometry permits
Socket, fillet, seal and attachment welds to pressure parts	100 % of welds	MT, or PT where MT is impractical	
Weld-neck flange to pipe butt welds	100 % of welds	RT	
Field-cut line pipe ends	100 % of ends, 1 in band	UT lamination scan	MT of the bevel face where a lamination is indicated
Base metal at branch locations	100 %, before welding	UT lamination scan	
Arc burn removal, grind repairs, removed temporary attachments	100 % of welds	MT after grinding and etching	UT wall thickness
Field cold bends	First bend of each size and pipe source, then 10 %	UT wall at the outside of the bend	
S1 stainless butt welds, including orifice downstream flanges and VS-101, shop and field	100 % of welds, full circumference	RT, or UT where RT is impractical and the EOR approves the technique	Visual 100 %; PT of root and cap
S1 socket, fillet, branch and attachment welds	100 % of welds	PT (MT does not apply to austenitic stainless steel)	
S1 PMI	100 % of pipe lengths, fittings, flanges and orifice plates; one per bolting lot; 100 % of welds	X-ray fluorescence (3.12)	MTR review for low-carbon grade

Weld or item	Extent	Primary method	Supplementary
S1 weld ferrite	First production weld of each welder and WPS, then 10 % of welds	Ferrite gauge (3.12)	
ASME Section VIII vendor items (V-101, PR-101, H-101 coil manifolds)	Per vendor code and purchase order	Vendor method	Records reviewed under SPC-SPC-017; Owner spot verification at its option

1.03 REFERENCES

A. Codes and standards:

1. 49 CFR 192.241 (inspection and test of welds) and 192.243 (nondestructive testing).
2. API Standard 1104, 22nd Edition, Welding of Pipelines and Related Facilities: Clause 9 (acceptance standards for NDT) and Clause 11 (procedures for NDT). Annex A (alternative acceptance standards) shall not be used.
3. ASME B31.8-2022, paragraph 826 (inspection of welds); ASME B31.3-2022, Table 341.3.2, where PIP-SPC-001 assigns class S1 to ASME B31.3.
4. ASME Boiler and Pressure Vessel Code, Section V (Articles 2, 4, 6 and 7) and Section VIII Division 1 (UW-51, Appendices 6, 8 and 12) for vendor items.
5. ASTM E94, E747, E1025, E1742 and E1815 (film radiography and image quality indicators); ASTM E2033, E2445, E2446, E2698 and E2737 (digital radiography).
6. ASTM E1961 (mechanized ultrasonic examination of girth welds), E2700 (phased array), E797 (thickness), A435 and A578 (lamination scanning).
7. ASTM E709 (magnetic particle) and E165 (liquid penetrant).
8. API RP 578, Guidelines for a Material Verification Program; AWS A4.2 (ferrite number measurement).
9. ASNT SNT-TC-1A (2020), or ANSI/ASNT CP-189, personnel qualification.
10. 10 CFR Parts 20 and 34, and 252:410 (Department of Environmental Quality radiation management).

B. Project documents: GEN-DB-001, Basis of Design; PIP-SPC-001, Piping Material Specification; MEC-LST-001, Line List; MEC-CAL-001, Pipe Wall Thickness; CON-RPT-003, Construction HSE Plan.

1.04 DEFINITIONS

- A. NDE subcontractor: an independent NDE company engaged by the Contractor and not affiliated with the welding crews.
- B. Owner's NDE reviewer: an ASNT Level II (radiographic interpretation) or Level III engaged by the Owner, independent of the Contractor and the NDE subcontractor.
- C. IQI: image quality indicator.

D. SWSI, DWSI and DWDI: single-wall single-image, double-wall single-image and double-wall double-image radiographic techniques.

E. SNR and BSR: signal-to-noise ratio and basic spatial resolution of a digital radiographic image.

F. Rejectable indication: an indication that exceeds the acceptance criteria of 3.15 to 3.17.

1.05 SUBMITTALS

A. The Contractor shall submit the items in Table 1-2 for the action shown.

Table 1-2: Submittal Schedule

No.	Submittal	Timing	Action
08-01	NDE subcontractor qualification: company, written practice, Level III name and certificates, radioactive material license or reciprocity, equipment list	30 days before NDE	Owner approval
08-02	NDE procedures for each method and technique, signed by the Level III	21 days before use	EOR and Owner approval
08-03	RT technique sheets for each diameter, wall and technique: source, source-to-film distance, exposure, film or detector, IQI selection and placement, number of exposures	14 days before production RT	Owner approval
08-04	Technique demonstration images for each technique sheet, with IQI sensitivity and density or SNR achieved	Before production	Owner approval
08-05	AUT qualification report, if AUT is proposed: calibration block design, zone set-up, qualification trials, sizing accuracy and probability of detection	30 days before AUT production	EOR and Owner approval
08-06	Personnel certificates for every technician, and eye examinations (near vision Jaeger J1 or equivalent and color contrast) within the previous 12 months	Before each technician works	Owner review
08-07	Equipment calibration: densitometer and step wedge (90 days), UT instruments (6 months), MT yoke lift test (daily, and calibration within 6 months), light meters	Before use	Owner review
08-08	Radiation safety plan: boundaries, survey meters, dosimetry, notifications, emergency procedure, night work	14 days before RT	Owner approval
08-09	Daily NDE reports and weekly NDE register	Reports within 24 hours; register weekly	Owner review
08-10	Final NDE dossier: all reports and images (film originals, and digital files in native format with a viewer), register reconciled to the weld map	At mechanical completion of each test section	Owner and EOR review

1.06 QUALITY ASSURANCE

A. Personnel shall meet Table 1-3. Procedures shall be qualified and personnel trained and qualified in the procedure and equipment used, as 49 CFR 192.243(b) requires.

Table 1-3: NDE Personnel

Activity	Minimum qualification
Procedure approval, AUT set-up approval, disputed interpretation	ASNT Level III in the method
RT interpretation, AUT and UT evaluation, MT and PT evaluation	Level II in the method; for RT, at least 2 years of pipeline weld interpretation
Exposure, processing and scanning	Level I under direct supervision of a Level II, or Level II
AUT operator	Level II UT, with system-specific training and a documented qualification on the project calibration block
Radiographers	Qualified under 10 CFR 34.43 and 252:410, with a radiographer's assistant present
S1 PT and RT	Level II under the same written practice; RT technique sheets for thin-wall stainless steel with the stainless IQI material group of ASTM E747

B. Hold and witness points shall be as listed in 3.13 and in SPC-SPC-019.

1.07 MEASUREMENT AND PAYMENT

A. Pay item 08.01, NDE of all welds: lump sum. The price shall include all examination of the extent in 1.02, including S1 PT, RT, PMI and ferrite measurement, technique demonstrations, AUT qualification if proposed, re-shoots for image quality, re-examination of repairs and cut-outs, radiation safety, reports, register and dossier. The Owner's independent reviewer is provided by the Owner.

B. Pay item 08.02, Additional NDE ordered by the Owner beyond the specified extent: unit price per RT exposure, or per weld for UT, MT and PT, only for examinations ordered in writing by the Owner beyond 1.02 (for example verification of vendor welds). Repairs of rejected welds and their re-examination shall be at the Contractor's cost, and an Owner-ordered examination that finds a rejectable Contractor weld shall not be paid.

PART 2 PRODUCTS

2.01 RADIOGRAPHIC EQUIPMENT AND MEDIA

A. Sources shall be Ir-192 for walls of 0.25 to 2.5 in, or X-ray tubes and crawlers where access and throughput allow (preferred for NPS 10 and NPS 12 straight runs, single-wall single-image). Se-75 is acceptable for walls up to 1.0 in where the technique demonstration meets the IQI requirement.

B. Film shall be ASTM E1815 Class I or Class II with lead screens, processed to ASTM E999 with records of chemistry and temperature.

C. Computed radiography plates shall be qualified to ASTM E2446 and E2445, and digital detector arrays to ASTM E2737. Viewing software shall have calibrated measurement tools, and images shall be stored in native format with DICOM or equivalent metadata.

- D. IQIs shall be ASTM E747 wire type (preferred), or hole type per API 1104 Clause 11, of a material group matching the pipe.

2.02 ULTRASONIC, MAGNETIC PARTICLE AND PENETRANT EQUIPMENT

- A. Ultrasonic flaw detectors, phased array or conventional, shall be calibrated to ASTM E2700 and API 1104 Clause 11 on project-specific reference blocks made from project pipe material and wall.
- B. Magnetic particle equipment shall be AC yokes with a lift of at least 10 lb, with wet fluorescent or visible (color contrast) particles and white contrast paint where needed.
- C. Penetrant materials shall be solvent-removable visible dye (Type II, Method C) or fluorescent, from one manufacturer family. For use on 316 stainless items and all S1 stainless, the materials shall carry certificates showing total halogens and total sulfur each not more than 1 % by weight of residue, because halogen and sulfur residues promote stress corrosion of austenitic steel.

2.03 PMI AND FERRITE EQUIPMENT

- A. PMI shall use a handheld energy-dispersive X-ray fluorescence analyzer with an alloy grade library, verified at the start and end of each shift on certified 304L and 316L reference standards.
- B. Ferrite shall be measured with a magnetic induction ferrite gauge calibrated to AWS A4.2 with secondary standards and verified daily.
- C. All NDE materials and equipment shall be furnished by the NDE subcontractor.

PART 3 EXECUTION

3.01 TIMING AND SEQUENCE

- A. NDE of each weld shall be performed after the weld has cooled to ambient temperature, and not earlier than 12 hours after completion for welds with a cellulosic root on any heat with CE(IIW) over 0.40 and for all tie-in and repair welds, because delayed hydrogen cracking may not be present earlier.
- B. Results shall be reported within 24 hours of examination. Welding may continue ahead of NDE, but no more than 25 welds, or two days of production, whichever is less, shall be unexamined at any time.
- C. No weld shall be coated, painted, lowered in, backfilled or pressure tested until the Owner's NDE reviewer has accepted it (hold point HP-08-05).

3.02 RADIOGRAPHIC TESTING

- A. Techniques shall be as Table 3-1 shows.

Table 3-1: Radiographic Techniques

Configuration	Technique
NPS 10 and NPS 12 straight runs and the outlet lateral where a crawler can travel	SWSI with internal crawler or centered panoramic source, one exposure
Spools, tie-ins and welds near fittings, NPS 2 to NPS 12	DWSI, at least 3 exposures at 120° on NPS 3-1/2 and larger, or more where the technique sheet requires for full coverage at the required sensitivity
NPS 3 and smaller	DWDI elliptical, 2 exposures at 90° (or 3 superimposed at 60°)

- B. The essential wire (or hole) of the IQI shall be selected from the API 1104 Clause 11 tables for the weld thickness (wall plus reinforcement) and placed on the source side, across the weld, at each end of the area of interest. Film-side placement, with a lead “F” marker and an IQI one size smaller, shall be used only where source-side placement is impossible. The essential wire shall be visible along its full length across the weld.
- C. Film density in the area of interest (the weld and 1/2 in of adjacent base metal) shall be 1.8 to 4.0, measured with a calibrated densitometer, and shall be within -15 % and +30 % of the density at the IQI, as API 1104 Clause 11 requires.
- D. Digital images shall meet the IQI requirement above, and the procedure shall set minimum normalized SNR values (typically 70 for computed radiography and 130 for digital detector arrays in the base metal) and a basic spatial resolution appropriate to the wall (typically 160 µm or finer for walls up to 0.5 in) under ASTM E2698 and E2033. Processing shall be limited to window, level and the filters documented in the procedure, and the unprocessed image shall be retained.
- E. Lead location markers shall be placed every 2 in or at each film position, with the weld ID and date on every image, a zero point at top dead center (or a documented reference above grade) and the flow direction marked.
- F. Geometric unsharpness shall not exceed 0.020 in for walls up to 2 in.
- G. A lead “B” shall be attached to each cassette in each new set-up. A light “B” image on a darker background shall reject the film for backscatter.
- H. Pressure marks, static, streaks or other artifacts in the area of interest shall require a re-shoot.

3.03 AUTOMATED AND MANUAL ULTRASONIC TESTING

- A. AUT may be proposed for the outlet lateral and for any NPS 10 and larger butt weld as an alternative to RT, subject to EOR approval of the qualification (hold point HP-08-02). AUT shall be performed to API 1104 Clause 11 and ASTM E1961 (zonal discrimination), with phased array and time-of-flight diffraction channels.
- B. Qualification shall use a project-specific calibration block made from project pipe, with flat-bottom holes and notches in each zone (fill, hot pass, root, cap, volumetric), and a trial on at least 10 welds with seeded or natural defects compared with macro sections. Height sizing accuracy of ± 0.04 in and length accuracy of ± 0.12 in at 80 % tolerance, and the probability of detection, shall be demonstrated.

- C. AUT acceptance shall follow the ultrasonic workmanship criteria of API 1104 Clause 9. Alternative (engineering critical assessment) acceptance under Annex A shall not be used.
- D. Manual PAUT shall be used on branch connection groove welds, on tie-in welds in addition to RT, and to resolve radiographic indications of uncertain nature, to ASTM E2700 with a Level III-approved scan plan covering the full weld volume and heat-affected zone.
- E. Calibration shall be verified at the start of work, every 4 hours, at the end of the shift, and after any change of equipment, cable or probe. If a check shows a sensitivity change of more than 2 dB, all welds since the last good check shall be re-examined.
- F. Couplant shall be compatible with fusion-bonded epoxy and the field joint coating and shall be removed after examination.

3.04 LAMINATION SCANS

- A. A 1 in band next to every field-cut bevel, over the full circumference, and a band equal to the outlet OD plus 1 in around each branch location before welding, shall be scanned with a dual-element straight-beam probe calibrated on project pipe.
- B. A lamination longer than 1/4 in circumferentially within the band, or any lamination that intersects the bevel face, shall be rejected. The rejected end shall be cut back at least 2 in beyond the lamination and rescanned. Results shall be recorded on QF-08-04.

3.05 MAGNETIC PARTICLE TESTING

- A. MT shall be performed to ASTM E709 and API 1104 Clause 11 with an AC yoke in two perpendicular directions at each location, by the wet fluorescent method (UV-A at least 1,000 $\mu\text{W}/\text{cm}^2$ at the surface, ambient visible light no more than 2 fc) or the visible method on a white background (visible light at least 100 fc).
- B. The weld and 1/2 in of adjacent base metal shall be examined at a surface temperature of 50 to 125 °F unless the particles are qualified otherwise.
- C. Branch welds shall be examined after the root or first pass and on the completed cap.
- D. The yoke lift test (at least 10 lb, AC) shall be performed daily before use.
- E. MT shall not be used on S1 austenitic stainless steel, which is not ferromagnetic; PT under 3.06 applies.

3.06 LIQUID PENETRANT TESTING

- A. PT shall be performed to ASTM E165 and API 1104 Clause 11 where MT cannot be applied, and for every S1 weld examination. On S1 the procedure shall also meet the code
PIP-SPC-001 assigns to S1 (ASME Section V Article 6 where ASME B31.3 governs).
- B. Surface temperature shall be 50 to 125 °F. Penetrant dwell shall be at least 10 minutes, or the manufacturer's value if greater, and developer dwell 10 to 60 minutes, with evaluation between 10 and 60 minutes.

- C. Penetrant residues shall be removed from S1 surfaces after examination with a halogen-free cleaner.

3.07 WALL THICKNESS MEASUREMENT

- A. Thickness shall be measured to ASTM E797 with calibration on a step block of the same material, recording the minimum reading in a grid of at least 4 readings per square inch over the ground area. The remaining wall shall not be less than the minimum wall for the line in MEC-CAL-001.

3.08 OWNER INDEPENDENT REVIEW

- A. The Owner's NDE reviewer shall review 100 % of radiographic images, 100 % of AUT and UT records, and at least 10 % of MT and PT in the field.
- B. Disagreement between the NDE subcontractor's Level II and the Owner's reviewer shall be resolved by the Owner's Level III, whose decision shall govern. The Contractor may request a re-examination at its own cost.
- C. Images that fail the quality requirements of 3.02 shall be re-shot at the Contractor's cost, and the weld shall not be accepted until an acceptable image has been reviewed.

3.09 REPORTING AND WELD MAP LINKAGE

- A. Each report shall state the report number, date, weld ID (SPC-SPC-007), line number, NPS and wall, WPS, welders, method and technique sheet, IQI and density or SNR achieved, indications (type, location from the zero point, length and depth where available), acceptance decision, technician name and level, and reviewer sign-off.
- B. The NDE register shall link every weld on the weld map to all its reports (original, repair R1, cut-out C1), and shall reconcile with the weld map weekly with no unmatched welds, and before the pressure test of each section (hold point HP-07-07 of SPC-SPC-007).
- C. Reports and images are maximum allowable operating pressure records and shall be retained for the life of the pipeline, as 49 CFR 192.243(f) and 192.517 require. They shall be delivered under SPC-SPC-020: film originals in archival envelopes, and digital files on two media and uploaded to the Owner's document system.

3.10 RADIATION SAFETY

- A. The NDE subcontractor shall hold an Department of Environmental Quality radioactive material license, or reciprocity recognition, for industrial radiography at temporary job sites, and shall comply with 10 CFR Part 34 and 252:410.
- B. Restricted area boundaries shall be set at the 2 mrem/h line, surveyed with a calibrated survey meter at every set-up, posted and roped, with a radiographer or assistant keeping the boundary under surveillance.

- C. Each radiographer and assistant shall wear a dosimeter badge, a direct-reading pocket dosimeter and an alarming ratemeter.
- D. The Owner's representative and all crews on site shall be notified at least 1 hour before exposures begin, a radiography schedule shall be posted daily, and a warning shall be given before each exposure series.
- E. Sources shall be kept in a locked, posted storage container and never left unattended, with source retrieval and emergency procedures on site.
- F. Radiography within 50 ft of the trunkline or its right-of-way shall require notice to the receiving pipeline operator (HOLD H-04). Night radiography shall require Owner approval and lighting of the boundaries.

3.11 EXAMINATION OF TIE-IN AND CLOSURE WELDS

- A. Tie-in welds, and any untested closure weld that the Owner and the EOR have approved under SPC-SPC-011 article 3.11, shall be examined by RT and by UT of the full weld volume, with MT of the root (where accessible) and of the cap, and shall meet the acceptance criteria of both methods (hold point HP-08-03). This examination does not substitute for a pressure test under 49 CFR 192; it is the examination the Owner's written procedure requires where a closure weld is approved.

3.12 PMI AND FERRITE MEASUREMENT OF CLASS S1

- A. PMI shall be performed with the method of API RP 578, at receipt (with the receiving inspection of SPC-SPC-006) and on every completed S1 weld cap after heat tint is cleaned. One reading shall be taken per component and per weld, and a second if the first is out of range. Each accepted item shall receive the PMI dot of SPC-SPC-006.
- B. X-ray fluorescence does not measure carbon, so the low-carbon grade shall be verified from the dual-certified MTR (carbon not more than 0.030 %).
- C. Deposit ferrite shall be measured on the cap of the first production weld of each welder and WPS, then on 10 % of S1 welds, as the average of 6 readings around the circumference.
- D. An item or weld that fails PMI shall be quarantined, and all items of the same heat or lot, and all welds by the same welder with the same filler lot on that day, shall then be examined 100 %.

3.13 FIELD QUALITY CONTROL

- A. The Contractor shall record the work on QF-08-01 (RT technique demonstration), QF-08-02 (RT report), QF-08-03 (UT, PAUT and AUT report), QF-08-04 (lamination and thickness record), QF-08-05 (AUT qualification), QF-08-06 (MT and PT report) and QF-08-07 (S1 PMI and ferrite record), with the NDE register and images, all turnover records under SPC-SPC-020.
- B. The hold and witness points in Table 3-2 apply. Party codes: C Contractor, O Owner, E EOR, W receiving pipeline operator; H hold, W witness, R review, S surveillance, P perform.

Table 3-2: Hold and Witness Points

ID	Activity	C	O	E	W	Record
HP-08-01	NDE subcontractor, procedures, technique sheets and radiation safety plan approved before any production NDE	P	H	R	-	Submittals 08-01 to 08-03, 08-08
HP-08-02	AUT qualification trial and approval, only if AUT is proposed	P	H	H	-	QF-08-05
WP-08-01	Technique demonstration for each RT technique sheet: IQI sensitivity, density or SNR	P	W	-	-	QF-08-01
WP-08-02	Lamination scans of field-cut bevels and branch locations (sampled)	P	S	-	-	QF-08-04
HP-08-03	NDE of tie-in welds and any approved untested closure weld (RT, UT and MT)	P	H	R	W	QF-08-02, QF-08-03
HP-08-04	Re-examination of each repaired or cut-out weld	P	H	-	-	QF-08-02
HP-08-05	Owner NDE reviewer acceptance of each weld before coating, lowering-in, backfill or pressure test	P	H	-	-	NDE register
HP-08-06	Final NDE dossier and register reconciled to the weld map for each test section	P	H	R	-	Submittal 08-10
HP-08-07	100 % PMI of S1 components and welds accepted before the S1 system is released for testing	P	H	-	-	QF-08-07
WP-08-03	S1 ferrite measurement on the first production weld of each welder and WPS	P	W	-	-	QF-08-07
HP-08-08	100 % RT (or approved UT) of every S1 butt weld, shop and field, accepted before the S1 system is released for testing	P	H	-	-	QF-08-02

3.14 ACCEPTANCE: GENERAL

- A. Butt, branch, fillet and socket welds in carbon steel classes shall be accepted to API 1104 Clause 9, 22nd Edition, with the Owner's additions in 3.16. The values in 3.15 summarize Clause 9 for bidding; the code governs where they differ.
- B. ASME Section VIII vendor items shall be accepted to ASME Section VIII Division 1: UW-51 for full radiography, and Appendices 6, 8 and 12 for MT, PT and UT.
- C. S1 stainless welds, PMI and ferrite shall be accepted to 3.17. API 1104 acceptance criteria do not apply to S1.

3.15 ACCEPTANCE: API 1104 RADIOGRAPHIC CRITERIA

- A. For welds 12 in or more in length, an imperfection shall be rejectable when it exceeds the limits in Table 3-3.

Table 3-3: API 1104 Clause 9 Radiographic Acceptance, Summary

Imperfection	Rejectable when
Inadequate penetration without high-low	Any individual indication longer than 1 in; aggregate over 1 in in any continuous 12 in; aggregate over 8 % of weld length in welds shorter than 12 in
Inadequate penetration due to high-low	Individual longer than 2 in; aggregate over 3 in in any continuous 12 in
Inadequate cross penetration	Individual longer than 2 in; aggregate over 2 in in any continuous 12 in
Incomplete fusion at the surface	Individual longer than 1 in; aggregate over 1 in in any continuous 12 in
Incomplete fusion due to cold lap	Individual longer than 2 in; aggregate over 2 in in any continuous 12 in
Internal concavity	Image density exceeds that of the thinnest adjacent base metal (any length is acceptable where it does not)
Burn-through, NPS 2-3/8 and larger	Maximum dimension over 1/4 in with density exceeding the thinnest adjacent base metal; more than one such burn-through in any 12 in; sum of maximum dimensions over 1/2 in in any 12 in
Elongated slag inclusions, NPS 2-3/8 and larger	Individual longer than 2 in; aggregate over 2 in in any continuous 12 in; parallel inclusions wider than 1/32 in
Isolated slag inclusions, NPS 2-3/8 and larger	Width over 1/8 in; aggregate over 1/2 in in any continuous 12 in; more than four inclusions of 1/8 in width in any 12 in
Porosity	Individual pore over 1/8 in or over 25 % of the thinner wall; distribution exceeding the API 1104 figures; cluster porosity over 1/2 in in diameter or aggregate over 1/2 in in 12 in; hollow-bead porosity individual over 1/2 in or aggregate over 2 in in 12 in
Cracks	Any crack (Owner requirement, 3.16)
Undercut, by visual and mechanical measurement	Depth over 1/32 in or 12.5 % of wall, whichever is smaller, at any length; depth over 1/64 in or 6 % of wall (whichever is smaller) up to 1/32 in or 12.5 %, with aggregate length over 2 in in any 12 in or over one-sixth of the weld length. Undercut of 1/64 in or 6 % of wall or less, whichever is smaller, is acceptable regardless of length
Accumulation of imperfections, excluding high-low penetration and undercut	Aggregate over 2 in in any continuous 12 in, or over 8 % of weld length

3.16 ACCEPTANCE: OWNER ADDITIONS

A. The Owner's additions in Table 3-4 are more stringent than API 1104 and shall govern.

Table 3-4: Owner Additions to API 1104 Acceptance

Item	Owner requirement
Cracks	Any crack of any size or type, including shallow crater and star cracks that API 1104 permits, is rejectable, and the weld shall be cut out under SPC-SPC-007
Arc burns	Not acceptable in finished pipe; removal verified by MT and UT
Tie-in and approved closure welds	Shall meet both the RT and the UT criteria
Alternative acceptance (API 1104 Annex A)	Not permitted
Laminations at the bevel	Per 3.04
Image quality	Essential IQI wire visible full length; density or SNR within limits; no artifacts in the area of interest
MT and PT, linear indications	Any linear indication evaluated as a crack is rejectable; on fillet, socket and branch welds, any other relevant linear indication longer than 1/16 in is rejectable
MT and PT, rounded indications	Maximum dimension over 1/8 in or over 25 % of the thinner wall is rejectable; distribution per the API 1104 porosity figures

3.17 ACCEPTANCE: CLASS S1 STAINLESS

A. S1 welds and materials shall meet Table 3-5.

Table 3-5: Class S1 Acceptance

Item	Criterion
RT and PT of S1 welds	Per the code PIP-SPC-001 assigns to S1 (ASME B31.3 Table 341.3.2, normal fluid service, where B31.3 governs): no cracks, no lack of fusion, no incomplete penetration beyond the code limit; PT with no relevant linear indications and rounded indications per the code
PMI, 304/304L	Cr 18.0 to 20.0 %, Ni 8.0 to 12.0 %, Mo 0.75 % maximum, within the instrument tolerance stated in the approved procedure
PMI, 316/316L	Cr 16.0 to 18.0 %, Ni 10.0 to 14.0 %, Mo 2.0 to 3.0 %
PMI, welds	308L type deposit Cr 19.5 to 22.0 %, Ni 9.0 to 11.0 %; 316L type deposit with Mo at least 2.0 %
Low-carbon grade	Carbon 0.030 % maximum on the MTR
Ferrite	Ferrite number 3 to 8

3.18 ACCEPTANCE: SUMMARY

A. NDE is complete for a test section when it meets Table 3-6.

Table 3-6: NDE Completion Criteria

Parameter	Criterion	Method
Extent	100 % of butt welds by RT or AUT; 100 % of fillet, socket and branch welds by MT or PT; 100 % of cut bevels by UT	NDE register against weld map
RT image quality	Essential IQI wire visible; film density 1.8 to 4.0; digital SNR and BSR per the procedure	Densitometer, software
Weld quality	3.15 to 3.17	RT, UT, MT, PT
Laminations	1/4 in or less within the 1 in band; none at the bevel face	UT
Wall after grinding	Not less than minimum wall	UT
Reporting	Within 24 hours; Owner review complete before coating, backfill or test	Register
Radiation boundary	2 mrem/h, surveyed at each set-up	Survey meter
S1 PMI and ferrite	100 % within Table 3-5; no carbon steel item	XRF, ferrite gauge

END OF SECTION

