The following proposal is based on the 2019 Edition of NC-5000 with the exception of NCD-5111.2, NCD-5211.2, NCD-5212.2, NCD-5221.2, NCD-5222.2, NCD-5231.2, NCD-5232.2, NCD-5241.2, NCD-5242.2, NCD-5263, NCD-5282.1(b), NCD-5282.4(b), NCD-5282.6(b), NCD-5283.1(b), NCD-5283.2(b), NCD-5283.5(b), NCD-5283.7(b), NCD-5321(f), NCD-5321(g), NCD-5322 and NCD-5400 which is based on the 2019 Edition of ND-5000. Changes to the text and numbering are identified in red from the base text. Verified references are highlighted Green. Unverified references are highlighted Yellow.

**NCD-5100 GENERAL REQUIREMENTS FOR EXAMINATION**

**NCD-5110 PROCEDURE, QUALIFICATION, AND EVALUATION**

**NCD-5111 General Requirements**

**NCD-5111.1 Class 2**

(a) Nondestructive examinations shall be conducted in accordance with the examination methods of Section V, except as they may be modified by the requirements of this Article. Radiographic examination shall be performed in accordance with Section V, Article 2, except that fluorescent screens are not permitted for film radiography, the geometric unsharpness shall not exceed the limits of Section V, Article 2, T-274.2, and the image quality indicators (IQIs) of Table NCD-5111.1 shall be used in lieu of those shown in Section V, Article 2, Table T-276. The requirements for the retention of electronic and digital radiographic images are the same as that for radiographic film. Ultrasonic examination shall be in accordance with Section V, Article 4; magnetic particle examination shall be in accordance with Section V, Article 7; liquid penetrant examination shall be in accordance with Section V, Article 6; and leak testing shall be in accordance with Section V, Article 10.

(b) Class 2 pressure vessels designed to the requirements of NCD-3200 shall meet the requirements of NCD-5250 in lieu of NCD-5210 through NCD-5240.

(c) Nondestructive examination requirements for tanks are given in NCD-5280.

(d) The examinations required by this Article, or by reference to this Article, shall be performed by personnel who have been qualified as required by this Article. The results of the examinations shall be evaluated in accordance with the acceptance standards of this Article.
NCD-5111.2 Class 3

(a) nondestructive examinations shall be conducted in accordance with the examination methods of Section V, except as they may be modified by the requirements of this Article. Radiographic examination shall be performed in accordance with Section V, Article 2, except that the geometric unsharpness shall not exceed the limits of Section V, Article 2, T-274.2. Ultrasonic examination shall be in accordance with Section V, Article 4; magnetic particle examination shall be in accordance with Section V, Article 7; liquid penetrant examination shall be in accordance with Section V, Article 6; and leak testing shall be in accordance with Section V, Article 10.

(b) The extent of radiography shall meet the requirements of NCD-3352 for the joint efficiency used in the design.

(c) The requirements for spot radiography are given in NCD-5400.

(d) Nondestructive examination requirements for tanks are given in NCD-5280.

(e) The examinations required by this Article, or by reference to this Article, shall be performed by personnel who have been qualified as required by this Article. The results of the examinations shall be evaluated in accordance with the acceptance standards of this Article.

NCD-5112 Nondestructive Examination Procedures

All nondestructive examinations required by this Article shall be performed in accordance with detailed written procedures which have been proven by actual demonstration to the satisfaction of the Inspector. The procedure shall comply with the appropriate Article of Section V for the particular examination method. The digitization of radiographic film and radioscopic images shall meet the requirements of Section V, Article 2, Mandatory Appendix III, "Digital Image Acquisition, Display and Storage for Radiography and Radioscopy." Written procedures and records of demonstration of procedure capability and personnel qualification shall be made available to the Inspector on request. At least one copy of the procedure shall be readily available to all applicable nondestructive examination personnel for reference and use.
NCD-5113 Post-Examination Cleaning

Following any nondestructive examination in which examination materials are applied to the piece, the piece shall be thoroughly cleaned in accordance with applicable materials or procedure specifications.

NCD-5120 TIME OF EXAMINATION OF WELDS AND WELD METAL CLADDING

Acceptance examinations of welds and weld metal cladding required by NCD-5200 shall be performed at the times stipulated in (a) through (d) below during fabrication and installation.

(a) Radiographic examination of welds shall be performed after an intermediate or final postweld heat treatment, when required, except as provided in (1) and (2) below.

(1) Radiographic examination of welds in items fabricated of P-No. 1 materials may be performed prior to any required postweld heat treatment.

(2) Radiographic examination of welds in P-No. 3 materials may be performed prior to an intermediate or final postweld heat treatment provided the welds are ultrasonically examined after an intermediate or the final postweld heat treatment. The ultrasonic examination and acceptance standards shall be in accordance with this Article.

(b) Magnetic particle or liquid penetrant examinations of welds shall be performed after any required postweld heat treatment, except that welds in P-No. 1 materials may be examined either before or after postweld heat treatment.

(c) All dissimilar metal weld joints such as in austenitic or high nickel to ferritic material or using austenitic or high nickel alloy filler metal to join ferritic materials that penetrate the wall shall be examined after final postweld heat treatment.

(d) The magnetic particle or liquid penetrant examination of weld surfaces that are to be covered with weld metal cladding shall be performed before the weld metal cladding is deposited. The magnetic particle or liquid penetrant examination of weld surfaces that are not accessible after a postweld heat treatment shall be performed prior to the operation which caused this inaccessibility. These examinations may be performed before PWHT.

(e) Ultrasonic examination of electroslag welds in ferritic materials shall be performed after a grain refining heat treatment, when performed, or after final postweld heat treatment.

NCD-5130 EXAMINATION OF WELD EDGE PREPARATION SURFACES FOR CLASS 2 ONLY

All full penetration weld edge preparation surfaces for joint Categories A, B, C, D, and similar joints in material 2 in. or more in thickness shall be examined by the magnetic particle or liquid penetrant method. Indications shall be evaluated in accordance with the acceptance standards of (a), (b), and (c) below.

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

(b) Laminar-type imperfections are acceptable without repair if they do not exceed 1 in. (25 mm) in length. The extent of all laminar-type imperfections exceeding 1 in. (25 mm) in length shall be determined by ultrasonic examination. Imperfections exceeding 1 in. (25 mm) in length shall be repaired by welding to a depth of 3/16 in. (10 mm) or the depth of the imperfection, whichever is less, unless the ultrasonic examination reveals that additional depth of repair is required to meet the ultrasonic examination requirement for the product form.

(c) Indications of nonlaminar imperfections of (1) through (3) below are unacceptable:

(1) any linear indications greater than 3/16 in. (5 mm) long;
(2) rounded indications with dimensions greater than 3/16 in. (5 mm);
(3) four or more indications, in a line separated by 1/16 in. (1.5 mm) or less, edge to edge.

(d) Weld repairs made to weld edge preparations for Categories A, B, C, D, and similar type welds shall be examined by the magnetic particle or liquid penetrant method before the surfaces become inaccessible. The examination may be performed before or after postweld heat treatment.

NCD-5140 EXAMINATION OF OPENINGS CUT IN VESSELS DESIGNED TO NCD-3200 FOR CLASS 2 ONLY
For nozzle connections with necks abutting the vessel wall (Figure NCD-4266(b)-1 sketches (a) and (b)) the radially disposed surfaces of the openings cut in the vessel walls shall be examined by either magnetic particle method or a liquid penetrant method in accordance with the requirements of this Article. Defects thus discovered shall be removed and repaired as required by the applicable Article.

NCD-5200 EXAMINATION OF WELDS

NCD-5210 CATEGORY A VESSEL WELDED JOINTS AND LONGITUDINAL WELDED JOINTS IN PIPING, PUMPS, AND VALVES

NCD-5211 Vessel Welded Joints

NCD-5211.1 Class 2

(a) Category A welded joints shall be fully radiographed when either of the members being joined exceeds 3/16 in. (5 mm) thickness.

(b) Category A welded joint surfaces may be examined by either the magnetic particle or liquid penetrant method as an alternative to the radiographic examination when the thickness of each member being joined is 3/16 in. (5 mm) or less.

NCD-5211.2 Class 3

(a) General Requirements.

1. Category A welded joints (NCD-3351.1) shall be fully radiographed when
   a. the thickness exceeds the limits of NCD-5211.2(b) or NCD-5211.2(c);
   b. the welds are based on a joint efficiency permitted by NCD-3352.1(a);
   c. the butt welds in nozzles or communicating chambers are attached to vessel sections or heads that are required to be fully radiographed by (a) or (b) above;
   d. the welds are made by the electroslag welding process.

2. Welds not required to be fully radiographed by (1) above shall be examined by spot radiography in accordance with the requirements of NCD-5111.2, except as permitted by (3) below. Spot radiography is required when a joint efficiency described in NCD-3352.1(b) is used.

3. No radiography is required when the vessel or part is designed for external pressure only or when the design complies with NCD-3352.1(c).

(b) Ferritic Materials. Complete radiography shall be performed at each butt-welded joint at which the thinner of the plate or vessel wall thickness at the welded joint exceeds the thickness limit above which full radiography is required in Table NCD-5211.2(b)-1.
Vessels or parts of vessels constructed of nonferrous materials shall be radiographed in accordance with the requirements of NCD-3352.

Welded butt joints in vessels constructed of materials covered by specifications SB-163 (Alloy 800 only), SB-333, SB-334, SB-335, SB-336, SB-407, SB-408, SB-409, SB-443, SB-444, and SB-446 shall be examined radiographically for their full length when the thinner of the plate or vessel wall thicknesses at the welded joint exceeds 3/8 in. (10 mm).

Vessels constructed of unalloyed titanium shall have all welded joints of Categories A and B fully radiographed.

All welds, both groove and fillet, in components constructed with materials SB-333, SB-334, SB-335, and SB-336 shall be examined for the detection of cracks by the liquid penetrant method.

All welded joints in vessels constructed of unalloyed titanium shall be examined by the liquid penetrant method.

All welded joints in components or parts constructed with materials SB-163 (Alloy 800 only), SB-407, SB-408, SB-409, SB-443, SB-444, and SB-446 not required to be radiographed shall be examined by the liquid penetrant method.

### NCD-5212 Piping, Pump, and Valve Welded Joints

#### NCD-5212.1 Class 2
Longitudinal butt welded joints, as defined in NCD-3351.1, shall be radiographed.

#### NCD-5212.2 Class 3
Longitudinal welded joints in piping greater than NPS 2 (DN 50) shall be examined by the requirements of NCD-5212.2. Longitudinal welded joints in pressure retaining parts of pumps and valves greater than NPS 2 (DN 50) shall be examined in accordance with the requirements of NCD-2500 for the applicable product form. Butt welds made by the electroslag welding process shall be radiographed for their entire length.

### NCD-5220 CATEGORY B VESSEL WELDED JOINTS AND CIRCUMFERENTIAL WELDED JOINTS IN PIPING, PUMPS, AND VALVES

#### NCD-5221 Vessel Welded Joints

##### NCD-5221.1 Class 2
(a) Category B welded joints shall be fully radiographed when either of the members being joined exceeds \( \frac{3}{16} \) in. (5 mm) thickness.

(b) Category B welded joint surfaces may be examined by either the magnetic particle or liquid penetrant method as an alternative to the radiographic examination when the thickness of each member being joined is \( \frac{3}{16} \) in. (5 mm) or less.

**NCD-5221.2 Class 3**

(a) Category B welded joints (NCD-3351.2) shall be fully radiographed when

1. the thickness exceeds the limits of NCD-5211.2(b) or NCD-5211.2(c), except as permitted in (b) below;
2. the welds are based on a joint efficiency permitted by NCD-3352.2(a), except as permitted in (b) below;
3. they are butt welds in nozzles or communicating chambers attached to vessel sections or heads that are required to be fully radiographed and exceed NPS 10 (DN 250) or 1 1/8 in. (29 mm) wall thickness;
4. the welds are made by the electroslag welding process.

(b) In accordance with (a)(2) above, any Category B and similar type welds not required to be fully radiographed by thickness or location as in (a) above shall as a minimum be partially radiographed. This shall consist of a radiographic examination at least 6 in. (150 mm) long of any section of the weld picked at random plus a similar examination of any intersection of the weld with all Category A and similar welds in either of the sections being connected. Acceptance standards for partially examined welds shall be as set forth in NCD-5221.

(c) The welds not required to be radiographed by (a) or (b) above shall be examined by spot radiography except as permitted by (d) below. Spot radiography is required when a joint efficiency described in NCD-3352.2(h) is used.

(d) No radiography is required when a vessel or part is designed for external pressure only or when a design complies with NCD-3352.1(c).

(e) The requirements of NCD-5211.2(b) and NCD-5211.2(c) shall be met.

**NCD-5222 Piping, Pump, and Valve Welded Joints**

**NCD-5222.1 Class 2**

(a) Butt welded joints shall be radiographed.

(b) Fillet and partial penetration welded joints shall be examined by either the magnetic particle or liquid penetrant method.

(c) Instrument tube butt welds qualified in accordance with NCD-4121 shall be examined by the liquid penetrant method.

**NCD-5222.2 Class 3**

Circumferential welded joints in piping, pumps, and valves greater than NPS 2 (DN 50) shall be examined by either the magnetic particle, liquid penetrant, or radiographic methods. Acceptance standards shall be those stated in NCD-5300.

**NCD-5230 CATEGORY C VESSEL WELDED JOINTS AND SIMILAR WELDED JOINTS IN OTHER COMPONENTS**

**NCD-5231 Vessel Welded Joints**

**NCD-5231.1 Class 2**

(a) Category C full penetration butt welded joints and similar welded joints in other components shall be fully radiographed when either of the members being joined exceeds \( \frac{3}{16} \) in. (5 mm) of thickness.

(b) Category C full penetration corner welded joints and similar welded joints in other components shall be ultrasonically or radiographically examined when either of the members being joined exceeds \( \frac{3}{16} \) in. (5 mm) of thickness.
(c) Category C welded joint surfaces and similar welded joints in other components may be examined by either the magnetic particle or liquid penetrant method as an alternative to the radiographic or ultrasonic examination when the thickness of each member being joined is 3/16 in. (5 mm) or less.

(d) Category C partial penetration and fillet welded joints and similar welded joints in other components shall be examined by the magnetic particle or liquid penetrant method on all accessible surfaces.

**NCD-5231 Class 3**

(a) Category C full penetration welds shall be fully radiographed when

(1) the thickness exceeds the requirements of NCD-5211.2(b) or NCD-5211.2(c);  
(2) they are butt welds in nozzles or communicating chambers attached to vessel sections or heads that are required to be fully radiographed and exceed NPS 10 (DN 250) or 1 1/8 in. (29 mm) wall thickness;  
(3) the welds are made by the electroslag process.

(b) Any Category C butt weld not required to be fully radiographed by thickness or location using the joint efficiency of NCD-3352.3(a) shall meet the requirements of NCD-5221.2(b).

(c) The welds not required to be fully radiographed by (a) above shall be examined by spot radiography, except as permitted by (d) below. Spot radiography is required when the butt welds are designed with a joint efficiency as described in NCD-3352.3(b).

(d) No radiography is required when the vessel or part is designed for external pressure only, when the design complies with NCD-3352.1(f), or when the joint is not a butt-welded joint.

**NCD-5232 Piping, Pumps, and Valve Welded Joints**

**NCD-5232.1 Class 2**

The requirements for welded joints similar to Category C shall be the same as given in NCD-5231.1.

**NCD-5232.2 Class 3**

The requirements for welded joints similar to Category C shall be the same as given in NCD-5222.2.

**NCD-5240 CATEGORY D VESSEL WELDED JOINTS AND SIMILAR WELDED JOINTS IN OTHER COMPONENTS**

**NCD-5241 Vessel Welded Joints**

**NCD-5241.1 Class 2**

(a) Category D full penetration butt welded joints and similar welded joints in other components shall be fully radiographed when either of the members being joined exceeds 3/16 in. (5 mm) of thickness.

(b) Category D full penetration corner welded joints and similar welded joints in other components shall be ultrasonically or radiographically examined when either of the members being joined exceeds 3/16 in. (5 mm) of thickness.

(c) Category D welded joint surfaces and similar welded joints in other components may be examined by either the magnetic particle or liquid penetrant method as an alternative to the radiographic or ultrasonic examination when the thickness of each member being joined is 3/16 in. (5 mm) or less.

(d) Category D partial penetration and fillet welded joints and similar welded joints in other components shall be examined by the magnetic particle or liquid penetrant method on all accessible surfaces.

**NCD-5241.2 Class 3**

(a) Full penetration butt welds of Category D (NCD-3351.4) shall be fully radiographed when located

(1) in a vessel or part that is designed with a joint efficiency as permitted by NCD-3352.1(a);  
(2) in nozzles or communicating chambers that are attached to vessel sections or heads required to be fully radiographed.

(b) Butt welds not required to be fully radiographed by (a) above shall be examined by spot radiography, except as permitted by (c) below.
No radiography is required for butt-welded joints when the vessel or part is designed for external pressure only or when the design complies with NCD-3352.1(c). Radiography is not required for nonbutt-welded joints.

**NCD-5242 Piping, Pumps, and Valves**  
**Welded Joints**

**NCD-5242.1 Class 2**

(a) Branch connections and nozzles exceeding NPS 4 (DN 100) shall be examined by radiography.

(b) Branch connections and nozzles NPS 4 (DN 100) and smaller shall have the external weld surface and the accessible internal weld surface examined by either the magnetic particle or liquid penetrant method.

**NCD-5242.2 Class 3**

The requirements for welded joints similar to Category D welded joints shall be as given in NCD-5242.2.

**NCD-5250 EXAMINATION OF WELDS FOR VESSELS DESIGNED TO NCD-3200 FOR CLASS 2 ONLY**

**NCD-5251 Category A Welded Joints**

Category A welded joints shall be fully radiographed.

**NCD-5252 Category B Welded Joints**

Category B welded joints shall be fully radiographed.

**NCD-5253 Category C Welded Joints**

(a) Category C full penetration butt welded joints shall be fully radiographed.

(b) Category C full penetration corner welded joints shall be ultrasonically or radiographically examined.

(c) For corner joint constructions as illustrated in Figure NCD-4265-1 sketches (b) and (c), except when dimension b is equal to or greater than t_s, the unstayed flat head, prior to welding, shall be 100% examined by the ultrasonic method in accordance with the requirements of SA-435, except that no lamination in the head is acceptable.

**NCD-5254 Category D Welded Joints**

(a) Category D full penetration butt welded joints shall be fully radiographed.

(b) Category D full penetration corner welded joints shall be ultrasonically or radiographically examined.

(c) Category D partial penetration or fillet welded joints shall be examined by either the liquid penetrant or magnetic particle method on all accessible surfaces.

**NCD-5257 Other Welded Joints for Vessels Designed to NCD-3200**

The requirements of NCD-5260, NCD-5270, and NCD-5280 also apply to vessels designed to NCD-3200.

**NCD-5260 FILLET, PARTIAL PENETRATION, SOCKET, AND ATTACHMENT WELDS, AND WELDED STAYED CONSTRUCTION**

**NCD-5261 Fillet, Partial Penetration, and Socket Welded Joints for Class 2 Only**

Fillet and partial penetration welds, except for nonstructural attachments (NCD-1132.1), and socket welds shall be examined by the magnetic particle or liquid penetrant method.

**NCD-5262 Structural Attachment Welded Joints for Class 2 Only**

Structural attachment welded joints made to pressure-retaining material shall be examined by either the magnetic particle or liquid penetrant method.

**NCD-5263 Welded Stayed Construction for Class 3 Only**

Welded staybolts need not be radiographed. When welded stays are used to stay jacketed vessels, the inside weld shall be visually examined before closing plates are attached.
**NCD-5270 SPECIAL WELDS**

**NCD-5271 Welds of Specially Designed Seals for Class 2 Only**
Welds of this type shall be examined by either the magnetic particle or liquid penetrant method.

**NCD-5272 Weld Metal Cladding**
Weld metal cladding shall be examined by the liquid penetrant method.

**NCD-5273 Hard Surfacing**
Hard surfacing shall be examined by the liquid penetrant method in accordance with NCD-2546, and the acceptance standards applicable to materials less than \( \frac{5}{8} \) in. (16 mm) thick shall apply. Penetrant examination is not required for hard surfacing on valves with inlet connections NPS 4 (DN 100) or less.

**NCD-5274 Tube-to-Tubesheet Welds**
Tube ‐ to ‐ tubesheet welds shall be examined by the liquid penetrant method.

**NCD-5275 Brazed Joints**
Flux and flux residue shall be removed from all surfaces prior to examination. Joints shall be visually examined on all accessible surfaces to determine whether there has been adequate flow of brazing metal through the joint. Optical aids may be employed for indirect visual examination of joints which cannot be directly examined.

**NCD-5276 Inertia and Continuous Drive Friction Welds**

(a) When radiographic examination is required by this Article, inertia and continuous drive friction welds shall also be examined by the ultrasonic method to verify bonding over the entire area.

(b) For Class 2 only, the materials used shall be those assigned a P ‐ Number by Section IX, but shall not include rimmed or semikilled steel.

(c) For Class 2 only, one of the two parts to be joined must be held in a fixed position and the other part rotated. The two faces to be joined must be symmetrical with respect to the axis of rotation.

(d) For Class 2 only, the weld between the two members shall be a full penetration weld.

**NCD-5278 Electroslag Welds**
In addition to the requirements for the type of weld being examined, all complete penetration welds made by the electroslag welding process in ferritic materials shall be ultrasonically examined.

**NCD-5279 Special Exceptions**
When the joint detail does not permit radiographic examination to be performed in accordance with this Article, ultrasonic examination plus liquid penetrant or magnetic particle examination of the completed weld may be substituted for the radiographic examination. The absence of suitable radiographic equipment shall not be justification for such substitution. The substitution of ultrasonic examination can be made, provided the examination is performed using a detailed written procedure that has been proven by actual demonstration to the satisfaction of the Inspector as capable of detecting and locating defects described in this Subsection. The nondestructive examinations shall be in accordance with NCD-5110 and meet the acceptance standards of NCD-5300.

**NCD-5280 WELD JOINTS IN STORAGE TANKS**

**NCD-5281 Examination Procedures for Class 2 Only**
Nondestructive examinations of welds in storage tanks shall be in accordance with the examination procedures of Section V.

**NCD-5282 Atmospheric Storage Tanks**

**NCD-5282.1 Sidewall Joints.**
For Class 2, Sidewall joints shall be fully radiographed.
For Class 3, Sidewall joints shall be examined in accordance with NCD-5211.2 and NCD-5221.2.

**NCD-5282.2 Roof Joints and Roof-to-Sidewall Joints.**

Roof joints and roof - to - sidewall joints shall be examined visually.

**NCD-5282.3 Bottom Joints.**

Bottom joints shall be examined from the inside of the tank by applying soapsuds to the joints and pulling a partial vacuum of at least 3 psi (20 kPa) by means of a vacuum box with transparent top.

**NCD-5282.4 Bottom-to-Sidewall Joints.**

(a) For Class 2, Bottom - to - sidewall joints shall be examined by the vacuum box method as detailed in NCD-5282.3 and by a magnetic particle or liquid penetrant surface examination.
(b) For Class 3, Bottom - to - sidewall joints shall be examined by the vacuum box method as required by NCD-5282.3. Alternatively, MT or PT examination may be substituted for the vacuum box tests, provided the outside of the joint is accessible for visual examination during the test required by Article NCD-6000.

**NCD-5282.5 Nozzle-to-Tank Joints.** Nozzle - to - sidewall or bottom joints shall be examined by either the magnetic particle or liquid penetrant method. Nozzle - to - roof joints shall be visually examined.

**NCD-5282.6 Joints in Nozzles.**

(a) For Class 2, All joints in roof nozzles shall be visually examined. Butt joints in other nozzles shall be examined by the radiographic method; other types of nozzle joints shall be examined by the liquid penetrant or magnetic particle method.
(b) For Class 3, All joints in roof nozzles shall be visually examined. Joints in other nozzles shall be examined by the liquid penetrant or magnetic particle method.

**NCD-5282.7 Other Joints.** Joints not specifically covered by NCD-5282 shall be examined in the same manner as similar weld joints in vessels as required by this subarticle.

**NCD-5283 Weld Joints in 0 psi to 15 psi (0 kPa to 100 kPa) Storage Tanks**

**NCD-5283.1 Sidewall Joints.**

(a) For Class 2, Sidewall joints shall be fully radiographed.
(b) For Class 3, Sidewall joints shall be examined in accordance with NCD-5211.2 and NCD-5221.2.

**NCD-5283.2 Roof Joints.**

(a) For Class 2, Roof joints shall be fully radiographed.
(b) For Class 3, Roof joints shall be examined in accordance with NCD-5211.2.

**NCD-5283.3 Roof-to-Sidewall Joints.** Roof - to - sidewall joints shall be fully radiographed in accordance with NCD-5211 if the design permits. If not radiographed, these joints shall be examined by the magnetic particle or liquid penetrant method.
**NCD-5283.4 Bottom Joints.** Joints in bottoms supported directly on grade shall be examined by the vacuum box method as detailed in NCD-5282. Joints not supported directly on grade shall be fully radiographed.

**NCD-5283.5 Bottom-to-Sidewall Joints.**

(a) For Class 2, Bottom-to-sidewall joints shall be examined by the vacuum box method as detailed in NCD-5282.3 and by either the magnetic particle method or the liquid penetrant method.

(b) For Class 3, Bottom-to-sidewall joints shall be examined by the vacuum box method as required by NCD-5282.3. Alternatively, MT or PT examination may be substituted for the vacuum box test, provided the outside of the joint is accessible for visual examination during the test required by Article NCD-6000.

**NCD-5283.6 Nozzle-to-Tank Joints.** Nozzle-to-tank joints shall be examined by either the magnetic particle or liquid penetrant method.

**NCD-5283.7 Joints in Nozzles.**

(a) For Class 2, Butt joints in nozzles shall be fully radiographed. Other joints shall be examined by magnetic particle or liquid penetrant methods.

(b) For Class 3, Joints in nozzles shall be examined by either the magnetic particle or the liquid penetrant method.

**NCD-5283.8 Other Joints.** Joints not specifically covered by NCD-5283 shall be examined in the same manner as similar weld joints in vessels as required by this subarticle.

**NCD-5300 ACCEPTANCE STANDARDS**

**NCD-5320 RADIOGRAPHIC ACCEPTANCE STANDARDS**

**NCD-5321 Evaluation of Indications**

Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions:

(a) any indication characterized as a crack or zone of incomplete fusion or penetration;

(b) any other elongated indication that has a length greater than
   (1) \( \frac{1}{3} \) in. (6 mm) for \( t \) up to \( \frac{3}{4} \) in. (19 mm), inclusive
   (2) \( \frac{1}{3}t \) for \( t \) from \( \frac{3}{4} \) in. to \( 2\frac{1}{4} \) in. (19 mm to 57 mm), inclusive
   (3) \( \frac{3}{4} \) in. (19 mm) for \( t \) over \( 2\frac{1}{4} \) in. (57 mm) where \( t \) is the thickness of the thinner portion of the weld;

(c) internal root weld conditions are acceptable when the density change or image brightness difference as indicated in the radiograph is not abrupt; elongated indications on the radiograph at either edge of such conditions shall be unacceptable as provided in (b) above;

(d) any group of aligned indications having an aggregate length greater than \( t \) in a length of \( 12t \) unless the minimum distance between successive indications exceeds \( 6L \), in which case the aggregate length is unlimited, \( L \) being the length of the largest indication;

(e) rounded indications in excess of those shown as acceptable in Section III Appendices, Mandatory Appendix VI;

(f) for Class 3 only, when a Category B or C butt weld, partially radiographed as required in NCD-5221.2(b) or NCD-5231.2(b), is acceptable in accordance with (a) through (e) above, the entire weld length represented by this partial radiograph is acceptable;

(g) for Class 3 only, when a Category B or C butt weld, partially radiographed as required in NCD-5221.2(b) or NCD-5231.2(b), has been examined and any radiograph discloses welding that does not comply with the minimum quality requirements of (a) through (e) above, one additional section at least 6 in. long for each radiograph disclosing such defective welding, but a minimum total of two, shall be radiographically
examined in the same weld unit at other locations. The location of these additional radiographs shall be acceptable to the Inspector.

(1) If the additional sections examined show welding which meets the minimum quality requirements of (a) through (e) above, the entire weld unit represented by the total number of radiographs is acceptable. The defective welding disclosed by the partial radiographs shall be removed and the area repaired by welding. The weld repaired areas shall be radiographically examined.

(2) If any of the additional sections examined shows welding that does not comply with the minimum quality requirements of (a) through (e) above, the entire unit of weld represented shall be rejected. The entire rejected weld represented shall be rewelded, or the entire unit of weld represented shall be completely radiographed and any part of the weld not meeting the requirements of (a) through (e) above shall be repaired and reexamined radiographically. The rewelded joint shall be partially radiographed as required in NCD-5221.2(b) or NCD-5231.2(b), or the weld repaired areas shall be radiographically reexamined.

NCD-5322 Evaluation of Indications (Spot Radiography): For Class 3 Only

The acceptability of welds examined by spot radiography shall be determined by (a), (b), and (c) below.

(a) Welds in which the radiograph shows any type of crack or zone of incomplete fusion or penetration shall be unacceptable.

(b) Welds in which the radiographs show slag inclusions or cavities shall be unacceptable if the length of any such imperfection is greater than \( \frac{2}{3}T \) where \( T \) is the thickness of the thinner plate welded. If several imperfections within the above limitations exist in line, the welds shall be judged acceptable if the sum of the longest dimensions of all such imperfections is not more than \( T \) in a length of \( 6T \) or proportionately for radiographs shorter than \( 6T \) and if the longest imperfections considered are separated by at least \( 3L \) of acceptable weld metal, where \( L \) is the length of the longest imperfection. The maximum length of acceptable imperfections shall be \( \frac{3}{4} \) in. \( (19 \text{ mm}) \). Any such imperfections shorter than \( \frac{1}{4} \) in. \( (6 \text{ mm}) \) shall be acceptable for any plate thickness.

(c) Rounded indications are not a factor in the acceptability of welds not required to be fully radiographed.

(d) Evaluation and Retests

(1) When an area which is spot radiographed is acceptable in accordance with (a) and (b) above, the entire weld length represented by this radiograph is acceptable.

(2) When a spot has been examined and the radiograph discloses welding that does not comply with the minimum quality requirements of (a) and (b) above, two additional spots shall be radiographically examined in the same weld unit at locations away from the original spot. The locations of these additional spots shall be determined by the Inspector or fabricator as provided for the original spot examination in NCD-5420(c).

a. If the two additional spots examined show welding that meets the minimum quality requirements of (a) and (b) above, the entire weld unit represented by the three radiographs is acceptable. The defective welding disclosed by the first of the three radiographs may be removed and the area repaired by welding, or it may be allowed to remain in the weld joint, at the discretion of the Inspector.

b. If either of the two additional spots examined shows welding that does not comply with the minimum quality requirements of (a) and (b) above, the entire unit of weld represented shall be rejected. The entire rejected weld shall be removed and the joint shall be rewelded or, at the fabricator’s option, the entire unit of weld represented shall be completely radiographed and defective welding only need be corrected.

c. Repair welding shall be performed using a qualified procedure and in a manner acceptable to the Inspector. The rewelded joint or the weld repaired areas shall be spot radiographically examined at one location in accordance with the foregoing requirements of NCD-5420.
All imperfections that produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such imperfections and evaluate them in terms of the acceptance standards as follows:

(a) Imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths exceeding:
   (1) \( \frac{1}{4} \) in. (6 mm) for \( t \) up to \( \frac{3}{4} \) in. (19 mm), inclusive
   (2) \( \frac{1}{3}t \) for \( t \) from \( \frac{3}{4} \) in. (19 mm) to \( 2\frac{1}{4} \) in. (57 mm), inclusive
   (3) \( \frac{3}{4} \) in. (19 mm) for \( t \) over \( 2\frac{1}{4} \) in. (57 mm), where \( t \) is the thickness of the weld being examined; if a weld joins two members having different thicknesses at the weld, \( t \) is the thinner of these two thicknesses.

(b) Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

NCD-5340 MAGNETIC PARTICLE ACCEPTANCE STANDARDS

NCD-5341 Evaluation of Indications

(a) Mechanical discontinuities at the surface are revealed by the retention of the examination medium. All indications are not necessarily defects, however, since certain metallurgical discontinuities and magnetic permeability variations may produce similar indications that are not relevant.

(b) Any indication that is believed to be nonrelevant shall be reexamined by the same or other nondestructive examination methods to verify whether or not actual defects are present. Surface conditioning may precede the reexamination. After an indication has been verified to be nonrelevant, it is not necessary to reinvestigate repetitive nonrelevant indications of the same type. Nonrelevant indications that would mask defects are unacceptable.

(c) Relevant indications are indications that result from imperfections. Linear indications are indications in which the length is more than three times the width. Rounded indications are indications that are circular or elliptical with the length equal to or less than three times the width.

NCD-5342 Acceptance Standards

(a) Only imperfections producing indications with major dimensions greater than \( \frac{1}{16} \) in. (1.5 mm) are required to be evaluated for acceptance.

(b) Imperfections producing the following indications are unacceptable:
   (1) linear indications with dimensions greater than \( \frac{1}{16} \) in. (1.5 mm);
   (2) rounded indications with dimensions greater than \( \frac{3}{16} \) in. (5 mm);
   (3) four or more rounded indications in a line separated by \( \frac{1}{16} \) in. (1.5 mm) or less edge to edge;
   (4) ten or more rounded indications in any 6 in.\(^2\) (4 000 mm\(^2\)) of surface, with the major dimension of this area not to exceed 6 in. (150 mm), with the area taken in the most unfavorable location relative to the indications being evaluated.

NCD-5350 LIQUID PENETRANT ACCEPTANCE STANDARDS

NCD-5351 Evaluation of Indications

(a) Mechanical discontinuities at the surface are revealed by bleeding out of the penetrant; however, localized surface discontinuities such as may occur from machining marks, surface conditions, or an incomplete bond between base metal and cladding may produce similar indications that are nonrelevant.

(b) Any indication that is believed to be nonrelevant shall be reexamined to verify whether or not actual defects are present. Surface conditioning may precede the reexamination. Nonrelevant indications and broad areas of pigmentation that would mask defects are unacceptable.

(c) Relevant indications are indications that result from imperfections. Linear indications are indications in which the length is more than three times the width. Rounded indications are indications that are circular or elliptical with the length equal to or less than three times the width.
NCD-5352 Acceptance Standards

(a) Only imperfections producing indications with major dimensions greater than 1/16 in. (1.5 mm) are required to be evaluated for acceptance.

(b) Imperfections producing the following indications are unacceptable:
   (1) linear indications with dimensions greater than 1/16 in. (1.5 mm);
   (2) rounded indications with dimensions greater than 3/16 in. (5 mm);
   (3) four or more rounded indications in a line separated by 1/16 in. (1.5 mm) or less edge to edge;
   (4) ten or more rounded indications in any 6 in.² (4000 mm²) of surface, with the major dimension of this area not to exceed 6 in. (150 mm), with the area taken in the most unfavorable location relative to the indications being evaluated.

NCD-5360 VISUAL ACCEPTANCE STANDARDS FOR BRAZED JOINTS

Braze metal shall give evidence of having flowed uniformly through a joint by the appearance of an uninterrupted, narrow, visible line of brazing alloy at the end of the joint.

NCD-5380 GAS AND BUBBLE FORMATION TESTING

For gas and bubble formation testing, the test procedure shall be in accordance with Section V, Article 10, T-1030. When vacuum box testing is used, the soak time shall be a minimum of 10 sec. Any indication of leaking, by the formation of bubbles or the breaking of the continuous soap film by leaks, shall be evidence of an unacceptable condition.

NCD-5400 SPOT EXAMINATION OF WELDED JOINTS

FOR CLASS 3 ONLY

NCD-5410 GENERAL REQUIREMENTS

Vessels and tanks that have butt-welded joints that are not radiographed for their full length and that are required to be spot examined by the rules of this Subsection shall be examined locally by spot radiography in accordance with this subarticle, except for those vessels or tanks designed for external pressure only.

NCD-5420 MINIMUM EXTENT OF SPOT RADIOGRAPHIC EXAMINATION

(a) One spot shall be examined in the first 50 ft (15.2 m) of welding in each vessel and one spot shall be examined for each additional 50 ft (15.2 m) of welding or fraction thereof, except that when identical vessels or tanks individually of less than 50 ft (15.2 m) seam length are being fabricated under the rules of this Subsection, 50 ft (15.2 m) increments of welding may be represented by one spot examination.

(b) Such additional spots as may be required shall be selected so that an examination is made of the welding of each welding operator or welder. Under conditions where two or more welders or welding operators make weld layers in a joint or on the two sides of a double welded butt joint, one spot examination may represent the work of both welders or welding operators.

(c) Each spot examination shall be made as soon as practicable after the completion of the increment of weld that is to be examined. The location of the spot shall be chosen by the Inspector, except that when the Inspector has been duly notified in advance and cannot be present or otherwise make the selection, the Certificate Holder may exercise his own judgment in selecting the spots.

NCD-5430 STANDARDS FOR SPOT RADIOGRAPHIC EXAMINATION

Spot examination by radiography shall be made in accordance with the technique prescribed in Section V, Article 2. The minimum length of spot radiograph shall be 6 in. (150 mm).

NCD-5440 EVALUATION AND RETESTS
When an area that is spot radiographed is acceptable in accordance with NCD-5322(a) and NCD-5322(b),
the entire weld length represented by this radiograph is acceptable. (a)

When an area that is spot radiographed has been examined and the radiograph discloses welding that
does not comply with the minimum quality requirements of NCD-5322(a) and NCD-5322(b), two
additional spots shall be radiographically examined in the same weld unit at locations away from the
original spot. The locations of these additional spots shall be determined by the Inspector or Certificate
Holder as provided for the original spot examination in NCD-5322(c). (b)

If the two additional spots examined show welding which meets the minimum quality requirements
of NCD-5322(a) and NCD-5322(b), the entire weld unit represented by the three radiographs is
acceptable. The defective welding disclosed by the first of the three radiographs may be removed and
the area repaired by welding, or it may be allowed to remain in the weld joint, at the discretion of the
Inspector. (1)

If either of the two additional spots examined shows welding that does not comply with the minimum
quality requirements of NCD-5322(a) and NCD-5322(b), the entire unit of weld represented shall be
rejected. The entire rejected weld shall be removed and the joint shall be rewelded, or, at the
Certificate Holder’s option, the entire unit of weld represented shall be completely radiographed and
defective welding only need be corrected. (2)

Repair welding shall be performed using a qualified procedure and in a manner acceptable to the
Inspector. The rewelded joint or the weld repaired areas shall be spot radiographically examined at
one location in accordance with the foregoing requirements of NCD-5400. (3)

NCD-5500 QUALIFICATIONS AND CERTIFICATION OF NONDESTRUCTIVE
EXAMINATION PERSONNEL

NCD-5510 GENERAL REQUIREMENTS

Organizations performing Code required nondestructive examinations shall use personnel competent and
knowledgeable to the degree specified by NCD-5520. When these services are subcontracted by the Certificate
Holder or Quality System Certificate Holder, he shall verify the qualification of personnel to the requirements of
NCD-5520. All nondestructive examinations required by this Subsection shall be performed by and the results
evaluated by qualified nondestructive examination personnel.

NCD-5520 PERSONNEL QUALIFICATION, CERTIFICATION, AND VERIFICATION

NCD-5521 Qualification Procedure

(a) Personnel performing nondestructive examinations shall be qualified in accordance with the
recommended guidelines of SNT-TC-1A. The ACCP Level II and III provisions for qualification and
certification and the ASNT administered Level II certification provision for qualification and certification
of NDE personnel shall not be used for Section III. The Employer’s written practice required by
paragraph 5 of SNT-TC-1A shall identify his requirements relative to the recommended guidelines. The
recommended guidelines of SNT-TC-1A shall be considered minimum requirements, except as modified in (1) through (5) below.

(1) Qualification of Level III nondestructive examination personnel shall be by examination.

a. The basic and method examinations, paragraphs 8.8.1 and 8.8.2 of SNT-TC-1A,
may be prepared and administered by the Employer, ASNT, or an outside agency.

b. The specific examination, paragraph 8.8.3 of SNT-TC-1A, shall be prepared and
administered by the Employer or an outside agency. The Employer or outside
agency administering the specific examination shall identify the minimum grade
requirement in the written program when the basic and method examinations have
been administered by ASNT, which issues grades on a pass/fail basis. In this case, the minimum grade for the specific examination may not be less than 80%.

1. The written practice identified in paragraph 5 of SNT-TC-1A and the procedures used for examination of personnel shall be referenced in the Employer’s Quality Program.

2. The number of hours of training and experience for nondestructive examination personnel who perform only one operation of a nondestructive examination method that consists of more than one operation, or perform nondestructive examination of limited scope, may be less than that recommended in Table 6.3.1 A of SNT-TC-1A. The training and experience times shall be described in the written practice, and any limitations or restrictions placed on the certification shall be described in the written practice and on the certificate. The minimum classroom training times for visual examination personnel identified in Table 6.3.1 A of SNT-TC-1A for Level II certification may be reduced from 16 hr to 8 hr.

3. For the near-vision acuity examination, the Jaeger Number 1 letters shall be used in lieu of the Jaeger Number 2 letters specified in paragraph 8.2.1 of SNT-TC-1A. The use of equivalent type and size letters is permitted.

4. An NDE Level I individual shall be qualified to properly perform specific setups, specific calibrations, specific NDE, and specific evaluations for acceptance or rejection determinations according to written instructions and to record results. The NDE Level I individual shall receive the necessary instruction and supervision from a certified NDE Level II or Level III individual. A Level I individual may independently accept the results of nondestructive examinations when the specific acceptance criteria are defined in the written instructions.

5. For nondestructive examination methods not covered by SNT-TC-1A documents, personnel shall be qualified to comparable levels of competency by subject to comparable examinations on the particular method involved.

The emphasis shall be on the individual’s ability to perform the nondestructive examination in accordance with the applicable procedure for the intended application.

For nondestructive examination methods that consist of more than one operation or type, it is permissible to use personnel qualified to perform one or more operations. As an example, one person may be used who is qualified to conduct radiographic examination and another may be used who is qualified to interpret and evaluate the radiographic film.

NCD-5522 Certification of Personnel

1. The Employer retains responsibility for the adequacy of the program and is responsible for certification of Levels I, II, and III nondestructive examination personnel.

2. When ASNT is the outside agency administering the Level III basic and method examinations [NCD-5521(a)(1)(a)], the Employer may use a letter from ASNT as evidence on which to base the certification.

3. When an outside agency is the examining agent for Level III qualification of the Employer’s personnel, the examination results shall be included with the Employer’s record.

NCD-5523 Verification of Nondestructive Examination Personnel Certification

The Certificate Holder has the responsibility to verify the qualification and certification of nondestructive examination personnel employed by Material Organizations qualified by them in accordance with NCA-3820 and subcontractors who provide nondestructive examination services to them.

NCD-5530 RECORDS

Personnel qualification records identified in paragraph 9.4 of SNT-TC-1A shall be retained by the Employer.
After the required pressure test of a component constructed of ferritic materials with properties enhanced by quenching and tempering, all pressure-retaining welded joints shall be examined by the magnetic particle or liquid penetrant method on all accessible surfaces.

The examinations stipulated in (a) through (f) below are required to verify the integrity of bellows expansion joints for installation in components.

(a) The formed bellows shall be determined to be free of defects such as notches, crevices, material buildup or upsetting, or weld spatter, which may serve as points of local stress concentration, by visual examination. Suspect surface areas shall be further examined by liquid penetrant examination in accordance with NCD-5110.

(b) The longitudinal seam welds in the bellows shall be examined by the liquid penetrant method in accordance with NCD-5110. When the individual ply thickness exceeds 1/8 in. (3 mm), the weld shall also be radiographed in accordance with NCD-5110. These examinations may be performed either before or after the bellows is formed.

(c) The circumferential attachment welds between the bellows and pipe or flange shall be examined by the liquid penetrant method in accordance with NCD-5110 when the total bellows thickness is 1/4 in. (6 mm) or less. When the total thickness exceeds this limit, the weld shall be radiographed in accordance with NCD-5110 except where radiography is not meaningful, such as when the weld thickness constitutes less than 20% of the total thickness being radiographed, liquid penetrant examination may be substituted.

(d) In the case of liquid penetrant examination of bellows welds, imperfections producing the following indications are unacceptable:
   (1) cracks or linear indications;
   (2) four or more rounded indications in a line separated by 1/16 in. (1.5 mm) or less edge to edge;
   (3) five or more randomly distributed rounded indications in a weld length of 6 in. (150 mm);
   (4) any rounded indication exceeding the lesser of one - half the bellows thickness or 1/16 in. (1.5 mm) in diameter.

(e) The examination of all other welds in the expansion joint shall comply with this Article.

(f) The variation of the cylindrical end thickness of the formed bellows from the nominal or specified thickness shall not exceed the values given in Table 2 of SA-480. Thinning of the bellows material during forming shall be considered in the design and selection of material thickness, but need not be limited to the values specified in Table 2 of SA-480.