Article NCD-4000
Fabrication and Installation

(a) Components, parts, and appurtenances shall be fabricated and installed in accordance with the rules of this Article and shall be manufactured from materials which meet the requirements of Article NCD-2000.

(b) (Class 2 only) Vessels designed to the requirements of NCD-3200 shall meet the requirements of this Article except for NCD-4240 and NCD-4433. In this case, the requirements of NCD-4260 apply.

(c) Atmospheric and 0 psig to 15 psig (0 kPa to 100 kPa) storage tanks shall be fabricated in accordance with the rules of this Article.

NC-NCD-4120 Certification of Materials and Fabrication by Component Certificate Holder

NC-NCD-4121 Means of Certification

The Certificate Holder for an item shall certify, by application of the appropriate Certification Mark and completion of the appropriate Data Report in accordance with Article NCA-8000, that the materials used comply with the requirements of Article NCD-2000 and that the fabrication or installation complies with the requirements of this Article.

NC-NCD-4121.1 Certification of Treatments, Tests, and Examinations.

If the Certificate Holder or Subcontractor performs treatments, tests, repairs, or examinations required by other Articles of this Subsection, the Certificate Holder shall certify that this requirement has been
fulfilled (NCA-3862 or NCA-8410). Reports of all required treatments and of the results of all required tests, repairs, and examinations performed shall be available to the Inspector.

**NC-NCD-4121.2 Repetition of Tensile or Impact Tests.**

If during the fabrication or installation of the item the material is subjected to heat treatment that has not been covered by treatment of the test coupons (NC-D-2200) and that may reduce either tensile or impact properties below the required values, the tensile and impact tests shall be repeated by the Certificate Holder on test specimens taken from test coupons which have been taken and treated in accordance with the requirements of Article NC-D-2000.

**NC-NCD-4121.3 Repetition of Surface Examination After Machining.**

During the fabrication or installation of an item, if materials for pressure-containing parts are machined, then the Certificate Holder shall reexamine the surface of the material in accordance with NC-D-2500 when:

(a) the surface was required to be examined by the magnetic particle or liquid penetrant method in accordance with NC-D-2500, and

(b) the amount of material removed from the surface exceeds the lesser of 1/8 in. (3 mm) or 10% of the minimum required thickness of the part.

**NC-NCD-4122 Materials Identification**

(a) Material for pressure-retaining parts shall carry identification markings which will remain distinguishable until the component is assembled or installed. If the original identification markings are cut off or the material is divided, either the marks shall be transferred to the parts cut or a coded marking shall be used to ensure identification of each piece of material during subsequent fabrication or installation. In either case, an as-built sketch or a tabulation of materials shall be made identifying each piece of material with the Certified Material Test Report, where applicable, and the coded marking. For studs, bolts, nuts, and heat exchanger tubes, it is permissible to identify the Certified Material Test Reports for material in each component in lieu of identifying each piece of material with the Certified Material Test Report and the coded marking. Material supplied with a Certificate of Compliance and welding and brazing materials shall be identified and controlled so that they can be traced to each component or installation of a piping system, or else a control procedure shall be employed which ensures that the specified materials are used.

(b) Material from which the identification marking is lost shall be treated as nonconforming material until appropriate tests or other verifications are made and documented to assure material identification. Testing is required unless positive identification can be made by other documented evidence. The material may then be remarked upon establishing positive identification.

**NC-NCD-4122.1 Marking Materials.**

Material shall be marked in accordance with NC-D-2150.

**NC-NCD-4123 Examinations**

Visual examination activities that are not referenced for examination by other specific Code paragraphs, and are performed solely to verify compliance with requirements of Article NC-D-4000, may be performed by the persons who perform or supervise the work. These visual examinations are not required
to be performed by personnel and procedures qualified to NC-5100 and NC-5500, respectively, unless so specified.

**NC-NCD-4125 Testing of Welding and Brazing Materials**

All welding and brazing materials shall meet the requirements of NC-2400.

**NC-NCD-4130 Repair of Material**

Material originally accepted on delivery in which defects exceeding the limits of NC-2500 are known or discovered during the process of fabrication or installation is unacceptable. The material may be used, provided the condition is corrected in accordance with the requirements of NC-2500 for the applicable product form, except that:

(a) the limitation on the depth of the weld repair does not apply;

(b) the time of examination of the weld repairs to weld edge preparations shall be in accordance with NC-5130 for Class 2 or NC-5120 for Class 3;

(c) radiographic examination is not required for weld repairs to seal membrane material when the material thickness is 3/4 in. (6 mm) or less;

(d) radiographic examination is not required for welded repairs in material used in storage tanks, provided that the welded joints in these materials are not required to be radiographed, the extent of the welded repair does not exceed 10 in.² (6500 mm²) of the surface area, and the magnetic particle or liquid penetrant examination of the repair is made as required by NC-2539.4.

**NC-NCD-4200 Forming, Cutting, and Aligning**

**NC-NCD-4210 Cutting, Forming, and Bending**

**NC-NCD-4211 Cutting**

Materials may be cut to shape and size by mechanical means, such as machining, shearing, chipping, or grinding, or by thermal cutting.

**NC-NCD-4211.1 Preheating Before Thermal Cutting.**

When thermal cutting is performed to prepare weld joints or edges, to remove attachments or defective material, or for any other purpose, consideration shall be given to preheating the material, using preheat schedules such as suggested in Section III Appendices, Nonmandatory Appendix D.

**NC-NCD-4212 Forming and Bending Processes**

Any process may be used to hot or cold form or bend pressure-retaining materials, including weld metal, provided the required dimensions are attained (see NC-4214 and NC-4220) and provided the impact properties of the materials, when required, are not reduced below the minimum specified values, or they are effectively restored by heat treatment following the forming operation. *Hot forming* is defined as forming with the material temperature higher than 100 °F (56°C) below the lower transformation temperature of the material. When required, the process shall be qualified for impact properties as
outlined in NC-NCD-4213. When required, the process shall be qualified to meet thickness requirements as outlined in NC-NCD-4223.1.

**NC-NCD-4213 Qualification of Forming Processes for Impact Property Requirements**

When impact testing is required by the Design Specifications, a procedure qualification test shall be conducted using specimens taken from materials of the same specification, grade or class, heat treatment, and with similar impact properties, as required for the material in the component. These specimens shall be subjected to the equivalent forming or bending process and heat treatment as the material in the component. Applicable tests shall be conducted to determine that the required impact properties of NC-NCD-2300 are met after straining.

**NC-NCD-4213.1 Exemptions.**

Procedure qualification tests are not required for material listed in (a) through (f) below:

(a) hot formed material, such as forgings, in which the hot forming is completed by the Material Organization prior to removal of the impact test specimens;

(b) hot formed materials represented by test coupons required in either NC-NCD-2211 or NC-NCD-4121.2 which have been subjected to heat treatment representing the hot forming procedure and the heat treatments to be applied to the parts;

(c) materials which do not require impacts in accordance with NC-NCD-2300;

(d) materials which have a final strain less than 0.5%;

(e) material where the final strain is less than that of a previously qualified procedure for that material;

(f) material from which the impact testing required by NC-NCD-2300 is performed on each heat and lot, as applicable, after forming.

**NC-NCD-4213.2 Procedure Qualification Test.**

The procedure qualification test shall be performed in the manner stipulated in (a) through (f) below.

(a) The tests shall be performed on three different heats of material, both before straining and after straining and heat treatment, to establish the effects of the forming and subsequent heat treatment operations.

(b) Specimens shall be taken in accordance with the requirements of Article NC-NCD-2000 and shall be taken from the tension side of the strained material.

(c) The percent strain shall be established by the following equations:

\[
\text{percent strain} = 50\left(1 - \frac{R_f}{R_o}\right)
\]
(2) For spherical or dished surfaces

\[
\% \text{ strain} = \frac{75t}{R_f} \left( 1 - \frac{R_f}{R_o} \right)
\]

(3) For pipe

\[
\% \text{ strain} = \frac{100r}{R}
\]

where

\begin{align*}
R & = \text{nominal bending radius to the center line of the pipe} \\
r & = \text{nominal radius of the pipe} \\
R_f & = \text{final radius to center line of shell} \\
R_o & = \text{original radius (equal to infinity for a flat part)} \\
t & = \text{nominal thickness}
\end{align*}

(d) The procedure qualification shall simulate the maximum percent surface strain, employing a bending process similar to that used in the fabrication of the material or by direct tension on the specimen.

(e) Sufficient Charpy V-notch \( C_v \)-test specimens shall be taken from each of the three heats of material to establish a transition curve showing both the upper and lower shelves. On each of the three heats, tests consisting of three impact specimens shall be conducted at a minimum of five different temperatures distributed throughout the transition region. The upper and lower shelves may be established by the use of one test specimen for each shelf. Depending on the product form, it may be necessary to plot the transition curves using both the lateral expansion and energy level data (NCN-2300). In addition, drop weight tests shall be made when required by NCN-2300.

(f) Using the results of the impact test data from each of three heats, taken both before and after straining, determine either:

1. the maximum change in NDT temperature along with
   
   (-a) the maximum change of lateral expansion and energy at the temperature under consideration; or
   
   (-b) the maximum change in temperature at the lateral expansion and energy levels under consideration; or

2. where lateral expansion is the acceptance criteria (NCN-2300), either the maximum change in temperature or the maximum change in lateral expansion.

\textbf{NC-NCD-4213.3 Acceptance Criteria for Formed Material.}

To be acceptable, the formed material used in the component shall have impact properties, before forming, sufficient to compensate for the maximum loss of impact properties due to the qualified forming procedure used.
**NC-NCD-4213.4 Requalification.**

A new procedure qualification test is required when any of the changes in (a), (b), or (c) below are made.

(a) The actual postweld heat treatment time at temperature is greater than previously qualified considering NC-NCD-2211. If the material is not postweld heat treated, the procedure must be qualified without postweld heat treatment.

(b) The maximum calculated strain of the material exceeds the previously qualified strain by more than 0.5%.

(c) Where preheat over 250°F (120 °C) is used in the forming or bending operation but not followed by a subsequent postweld heat treatment.

**NC-NCD-4214 Minimum Thickness of Fabricated Material**

If any fabrication operation reduces the thickness below the minimum required to satisfy the rules of NC-NCD-2124 and Article NC-NCD-3000, the material may be repaired in accordance with NC-NCD-4130.

**NC-NCD-4220 Forming Tolerances**

**NC-NCD-4221 Tolerance for Vessel Shells**

Cylindrical, conical, or spherical shells of a completed vessel, except formed heads covered by NC-NCD-4222, shall meet the requirements of the following subparagraphs at all cross sections.

**NC-NCD-4221.1 Maximum Difference in Cross-Sectional Diameters.**

(a) The difference in inches (millimeters) between the maximum and minimum diameters at any cross-section shall not exceed the smaller of

\[
\frac{D + 50}{200} \quad \text{and} \quad \frac{D}{100}
\]

\[
\frac{D + 1250}{200} \quad \text{and} \quad \frac{D}{100}
\]

where \(D\) is the nominal inside diameter, in. (mm), at the cross section under consideration. The diameters may be measured on the inside or outside of the vessel. If measured on the outside, the diameters shall be corrected for the plate thickness at the cross section under consideration (Figure NC-NCD-4221.1-1). When the cross section passes through an opening, the permissible difference in inside diameters given herein may be increased by 2% of the inside diameter of the opening.

(b) For Class 3 only: For vessels with longitudinal lap joints, the permissible difference in inside diameters may be increased by the nominal plate thickness.
NC-NCD-4221.2 Maximum Deviation From True Theoretical Form for External Pressure.

Vessels designed for external pressure shall meet the tolerances given in (a) through (e) below.

(a) The maximum plus or minus deviation from the true circular form of cylinders or the theoretical form of other shapes, measured radially on the outside or inside of the component, shall not exceed the maximum permissible deviation obtained from Figure NC-NCD-4221.2(a)-1. Measurements shall be made from a segmental circular template having the design inside or outside radius depending on where the measurements are taken and a chord length equal to twice the arc length obtained from Figure NC-NCD-4221.2(a)-2. For Figure NC-NCD-4221.2(a)-1, the maximum permissible deviation \( e \) need not be less than \( 0.3t \). For Figure NC-NCD-4221.2(a)-2, the arc length need not be greater than \( 0.30D_o \). Measurements shall not be taken on welds or other raised parts.

Figure NC-NCD-4221.2(a)-1 — Maximum Permissible Deviation \( e \) From a True Circular Form
The value of \( t \), in., at any cross section is the nominal plate thickness less corrosion allowance for sections of constant thickness and the nominal thickness of the thinnest plate less corrosion allowance for sections having plates of more than one thickness.

For Class 3 only: For vessels with longitudinal lap joints, \( t \) is the nominal plate thickness and the permissible deviation is \((t + e)\).

The value of \( L \) in Figures NC-D-4221.2(a)-1 and NC-D-4221.2(a)-2 is determined by (1), (2), and (3) below.

1. For cylinders, \( L \) is as given in NC-NCD-3133.2.

2. For cones, \( L \) is the axial length of the conical section if no stiffener rings are used or, if stiffener rings are used, the axial length from the head bend line at the large end of the cone to the first stiffener ring, with \( D_o \) taken as the outside diameter in inches (millimeters) of the cylinder at the large end of the cone.

3. For spheres, \( L \) is one-half of the outside diameter \( D_o \), in. (mm).

The dimensions of a completed vessel may be brought within the requirements by any process which will not impair the strength of the material.

Sharp bends and flat spots shall not be permitted unless provision is made for them in the design.
NC-NCD-4221.3 Deviations From Tolerances.
Deviations from the tolerance requirements stipulated in NC-NCD-4221.1 and NC-NCD-4221.2 are permitted, provided the drawings are modified and reconciled with the design calculations.

NC-NCD-4221.4 Tolerance Deviations for Vessel Parts Fabricated From Pipe.
Vessel parts subjected to either internal or external pressure and fabricated from pipe, meeting all other requirements of this Subsection, may have variations of diameter and deviations from circularity permitted by the specification for such pipe.

NC-NCD-4221.5 Localized Thin Areas.
Localized thin areas are permitted if the adjacent areas surrounding each have sufficient thickness to provide the necessary reinforcement according to the rules for reinforcement in NC-NCD-3330.

NC-NCD-4222 Tolerances for Formed Vessel Heads
The tolerance for formed vessel heads shall be as set forth in the following subparagraphs.

NC-NCD-4222.1 Maximum Difference in Cross-Sectional Diameters.
The skirt or cylindrical end of a formed head shall be circular to the extent that the difference in inches between the maximum and minimum diameters does not exceed the lesser of

\[
\begin{align*}
\text{(U.S. Customary Units)} & \quad \frac{D + 50}{200} \quad \text{and} \quad \frac{D + 12}{100} \\
\text{(SI Units)} & \quad \frac{D + 1.250}{200} \quad \text{and} \quad \frac{D + 300}{100}
\end{align*}
\]

where \(D\) is the nominal inside diameter, in. (mm), and shall match the cylindrical edge of the adjoining part within the alignment tolerance specified in NC-NCD-4232.

NC-NCD-4222.2 Deviation From Specified Shape.

(a) The inner surface of a torispherical or ellipsoidal head shall not deviate outside the specified shape by more than \(1\frac{1}{4}\%\) of \(D\), nor inside the specified shape by more than \(\frac{5}{8}\%\) of \(D\), where \(D\) is nominal inside diameter of the vessel. Such deviations shall be measured perpendicular to the specified shape and shall not be abrupt. The knuckle radius shall not be less than specified. For 2:1 ellipsoidal heads, the knuckle radius may be considered to be 17% of the diameter of the vessel.

(b) Hemispherical heads and any spherical portion of a formed head shall meet the local tolerances for spheres as given in NC-NCD-4221.2, using \(L\) as the outside spherical radius in inches (millimeters) and \(D_0\) as 2 times \(L\).

(c) Deviation measurements shall be taken on the surface of the base material and not on welds.

NC-NCD-4223 Tolerances for Formed or Bent Piping
The tolerances for formed or bent piping shall be as set forth in the following subparagraphs.
NC-NCD-4223.1 Minimum Wall Thickness.
In order to ensure that the wall thickness requirements of the design calculations are met, the actual thickness shall be measured, or the process shall be qualified by demonstrating that it will maintain the required wall thickness.

NC-NCD-4223.2 Ovality Tolerance.
Unless otherwise justified by the design calculations, the ovality of piping after bending shall not exceed 8% as determined by

$$100 \times \frac{(D_{\text{max}} - D_{\text{min}})}{D_o}$$

where

- \(D_{\text{min}}\) = the minimum outside diameter after bending or forming
- \(D_{\text{max}}\) = the maximum outside diameter after bending or forming
- \(D_o\) = the nominal pipe outside diameter

NC-NCD-4224 Tolerances for Storage Tanks

The horizontal circular cross section of storage tanks shall be sufficiently true to round so that the difference between the maximum and minimum diameters measured inside or outside at any section in a cylindrical wall shall not exceed 1% of the average diameter or 12 in. (300 mm), whichever is less, measured 6 ft (2 m) or one plate width from the top and bottom juncture, respectively, if these junctures are of a type which offers serious restraint when the tank is filled or under the specified maximum vapor pressure. At any section in a sidewall having double curvature, this difference in diameter shall not exceed \(\frac{1}{2}\)% of the average diameter or 6 in. (150 mm), whichever is less.

NC-NCD-4224.1 Maximum Difference in Cross-Sectional Diameters for Tanks of Double Curvature.
For tanks of double curvature, the meridian curvature of the plate surface shall not deviate from the design shape by more than \(\frac{1}{2}\)% of the radius, measured radially, and shall not show abrupt changes. Plate surfaces shall merge smoothly into the adjoining surfaces in all directions. Local inward deviations, such as flat spots, shall be limited by NC-NCD-4224.2.

NC-NCD-4224.2 Local Inward Deviations.
Local inward deviations, such as flat spots, if present on wall or bottom surfaces having double curvature, shall not be greater than the plate thickness, and shall not have a diameter \(d\) greater than \(\sqrt{8Rt}\), where \(R\) is the radius of the tank and \(t\) is the thickness of the plate involved. \(R\) shall be taken as \(R_1\), with \(d\) being the chord in a meridional direction, and as \(R_2\), with \(d\) being the chord in a latitudinal direction.

NC-NCD-4224.3 Tolerance Measurements.
The tolerance measurements are given for a tank while empty and shall be taken with a steel tape, making corrections for temperature, sag, and wind.
NC-NCD-4230 Fitting and Aligning

NC-NCD-4231 Fitting and Aligning Methods

Parts that are to be joined by welding may be fitted, aligned, and retained in position during the welding operation by the use of bars, jacks, clamps, tack welds, or temporary attachments.

NC-NCD-4231.1 Tack Welds.

Tack welds used to secure alignment shall either be removed completely when they have served their purpose, or their stopping and starting ends shall be properly prepared by grinding or other suitable means so that they may be satisfactorily incorporated into the final weld. Tack welds shall be made by qualified welders using qualified welding procedures. When tack welds are to become part of the finished weld, they shall be visually examined and defective tack welds removed.

NC-NCD-4232 Alignment Requirements When Components Are Welded From Two Sides

(a) Alignment of sections which are welded from two sides shall be such that the maximum offset of the finished weld will not be greater than the applicable amount listed in Table NC-D-4232(a)-1, where \( t \) is the nominal thickness of the thinner section at the joint.

(b) Joints in spherical vessels, joints within heads and joints between cylindrical shells and hemispherical heads shall meet the requirements in Table NC-D-4232(a)-1 for longitudinal joints.

**Table NC-D-4232(a)-1 — Maximum Allowable Offset in Final Welded Joints**

<table>
<thead>
<tr>
<th>Section Thickness, in. (mm)</th>
<th>Longitudinal</th>
<th>Circumferential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to ( \frac{1}{2} ) (13), incl.</td>
<td>( \frac{1}{4}t )</td>
<td>( \frac{1}{4}t )</td>
</tr>
<tr>
<td>Over ( \frac{1}{2} ) to ( \frac{3}{4} ) (13 to 19), incl.</td>
<td>( \frac{1}{8} ) in. (3 mm)</td>
<td>( \frac{1}{4}t )</td>
</tr>
<tr>
<td>Over ( \frac{3}{4} ) to 1 ( \frac{1}{2} ) (19 to 38), incl.</td>
<td>( \frac{1}{6} ) in. (3 mm)</td>
<td>( \frac{3}{16} ) in. (5 mm)</td>
</tr>
<tr>
<td>Over 1 ( \frac{1}{2} ) to 2 (38 to 50), incl.</td>
<td>( \frac{1}{8} ) in. (3 mm)</td>
<td>( \frac{1}{8}t )</td>
</tr>
<tr>
<td>Over 2 (50)</td>
<td>Lesser of ( \frac{1}{16}t ) or ( \frac{3}{8} ) in. (10 mm)</td>
<td>Lesser of ( \frac{1}{8}t ) or ( \frac{3}{4} ) in. (19 mm)</td>
</tr>
</tbody>
</table>

NC-NCD-4232.1 Fairing of Offsets.

Any offset within the allowable tolerance provided above shall be faired to at least 3:1 taper over the width of the finished weld or, if necessary, by adding additional weld metal beyond what would otherwise be the edge of the weld.

NC-NCD-4233 Alignment Requirements When Inside Surfaces Are Inaccessible

(a) When the inside surfaces of items are inaccessible for welding or fairing in accordance with NC-D-4232, alignment of sections shall meet the requirements of (1) and (2) below.

(1) See (-a) and (-b) below

(-a) For circumferential joints the inside diameters shall match each other within \( \frac{1}{16} \) in. (1.5 mm) When the items are aligned concentrically, a uniform mismatch of \( \frac{1}{32} \) in. (0.8 mm) all around the joint can result, as shown in Figure NC-D-4233-1 sketch.
(a). However, other variables not associated with the diameter of the item often result in alignments that are offset rather than concentric. In these cases, the maximum misalignment at any one point around the joint shall not exceed \(\frac{3}{32}\) in. (2.5 mm), as shown in Figure NCD-4233-1 sketch (b). Should tolerances on diameter, wall thickness, out-of-roundness, etc., result in inside diameter variation which does not meet these limits, the inside diameters shall be counterbored, sized, or ground to produce a bore within these limits, provided the requirements of NCD-4250 are met.

(-b) Offset of outside surfaces shall be faired to at least a 3:1 taper over the width of the finished weld or, if necessary, by adding additional weld metal.

(2) For longitudinal joints the misalignment of inside surfaces shall not exceed \(\frac{3}{32}\) in. (2.5 mm), and the offset of outside surfaces shall be faired to at least a 3:1 taper over the width of the finished weld or, if necessary, by adding additional weld metal.

(b) Single-welded joints may meet the alignment requirements of (a)(1) and (a)(2) above in lieu of the requirements of NCD-4232.

Figure NCD-4233-1 — Butt Weld Alignment and Mismatch Tolerances for Unequal I.D. and O.D. When Components Are Welded From One Side and Fairing Is Not Performed
GENERAL NOTE:
The weld end transitions are typical and are not intended as requirements. Refer to NC-4250 for weld end transition requirements.

**NC-NCD-4240 Requirements for Weld Joints in Components**

**NC-NCD-4241 Category A Weld Joints in Vessels and Longitudinal Weld Joints in Other Components**

### NCD-4241.1 Class 2 Only [Note to Editors: was NC-4241]

Category A weld joints in vessels and longitudinal weld joints in other components shall be full penetration butt joints. Joints that have been welded from one side with backing that has been removed, and those welded from one side without backing, are acceptable as full penetration welds provided the weld root side of the joints meet the requirements of NC-D-4424.

### NCD-4241.2 Class 3 Only [Note to Editors: was ND-4241]

All Category A weld joints in vessels and longitudinal weld joints in other components shall meet the requirements of (a), (b), and (c) below.

(a) When the design is based on a joint efficiency permitted by NC-D-3352.1(a) or NC-D-3352.1(b), all Category A welds in vessels and longitudinal joints in other components shall be Type 1 or Type 2 as described in NCD-4245.2.

(b) When the design is based on a joint efficiency permitted by NC-D-3352.1(c), any joint Type as described in NCD-4245 may be used, provided the limitations of the joint are followed.

(c) When the component is constructed of P-No. 11A, Group 1 material, Type 1 joints as described in NCD-4245.2 shall be used.

**NC-NCD-4242 Category B Weld Joints in Vessels and Circumferential Weld Joints in Other Components**

### NCD-4242.1 Class 2 Only [Note to Editors: was NC-4242]

Category B weld joints in vessels and circumferential weld joints in other components shall be full penetration butt joints, except that piping NPS 2 (DN 50) and smaller may be socket welded. Joints prepared with opposing lips to form an integral backing ring and joints with backing strips which are not later removed are acceptable, provided the requirements of NC-D-3352.2 are met.

### NCD-4242.2 Class 3 Only [Note to Editors: was ND-4242]

Category B weld joints in vessels and circumferential weld joints in other components shall meet the requirements of (a) and (b) below, except that piping NPS 2 (DN 50) and smaller may be socket welded.
(a) When the design is based on a joint efficiency permitted by NCD-3352.2(a) or NCD-3352.2(b), or when P-No. 11A, Group 1 materials are joined, all Category B welds in pressure vessels and circumferential joints in other components shall be Type 1 or Type 2 as described in NCD-4245.2.

(b) When the design is based on a joint efficiency permitted by NCD-3352.2(c), any joint Type as described in NCD-4245.2 may be used, provided the limitations of the joint are followed.

**NC-CD-4243 Category C Weld Joints in Vessels and Similar Weld Joints in Other Components**

NCD-4243.1 Class 2 Only [Note to Editors: was NC-4243]

Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints, as shown in Figures NCD-4243.1-1 and NCD-4243.1-2, except that socket welded flanges of NPS 2 (DN 50) and less and slip-on flanges may be used.

**Figure NCD-4243.1-1 — Acceptable Full Penetration Weld Details for Category C Joints (Class 2 Only)**

[Diagrams of weld joints are shown with labels and notes for Type 1 and Type 2 corner welds.]

GENERAL NOTE: For definitions of nomenclature, see NCD-3358.3(e)(1).
Figure NCD-4243.1-2 — Attachment of Pressure Parts to Plates to Form a Corner Joint (Class 2 Only)

**GENERAL NOTE:** For definitions of nomenclature, see NCD-3358.3(e)(2).

NCD-4243.2 Class 3 Only [Note to Editors: was ND-4243]

Category C weld joints in vessels and similar weld joints in other components shall meet the requirements of (a), (b), and (c) below, except that socket welded flanges NPS 2 (DN 50) and less and slip-on flanges may be used.

(a) Category C and similar weld joints shall be Type 1 or Type 2 as described in NCD-4245.2 when a butt weld detail is used and the provisions of NCD-3352.1(a) or NCD-3352.2(b) apply. These joints must be Type 1 or Type 2 butt welds when the joint is required to be radiographed.

(b) Typical Category C corner joints are shown in Figure NCD-4243.2-1 and Section III Appendices, Mandatory Appendix XI.
(c) All category C joints in P-No. 11A, Group 1 material shall be full penetration welds extending through the entire section of the joint.

Figure NCD-4243.2-1 (note to Editors: was Figure ND-4243-1) (Class 3 only)

Attachment of Pressure Parts to Plates to Form a Corner Joint

Typical Unstayed Flat Heads, Supported and Unsupported Tubesheets Without a Bolting Flange, and Rectangular Vessels (Sketches (a) Through (j))
NC-NCD-4243.1\footnote{Note to Editor: was NC-4243.1} Flat Heads and Tubesheets With Hubs. Hubs for butt welding to the adjacent shell, head, or other pressure part, as in Figure NC-4243.1-1, shall not be machined from rolled plate. The component having the hub shall be forged in such a manner as to provide in the hub the full minimum tensile strength and elongation specified for the material, in a direction parallel to the axis of the vessel. Proof of this shall be furnished by a tension test specimen, subsize if necessary, taken in this direction and as close to the hub as is practical. In no case shall the height of the hub be less than 1.5 times the thickness of the pressure part to which it is welded.
NC-NCD-4244 Category D Weld Joints in Vessels and Branch and Piping Connection Weld Joints in Other Components

NCD-4244.1 (Class 2 Only) Category D Weld Joints in Vessels and Branch and Piping Connection Weld Joints in Other Components (Note to Editors: was NC-4244)

Category D weld joints in vessels and similar weld joints in other components shall be welded using one of the details of (a) through (e) below.

(a) **Butt Welded Nozzles and Branch Piping Connections.** Nozzles and branch piping connections shall be attached by full penetration butt welds through the wall of the component, nozzle, or branch as shown in Figure NCD-4244(a)-1. Backing strips, if used, may be left in place.
(b) **Corner Welded Nozzles and Branch Piping Connections.** Nozzles and branch piping connections shall be joined to the component by full penetration welds through the wall of the component, nozzle, or branch similar to those shown in Figure NCD-4244(b)-1. When complete joint penetration cannot be verified by visual examination or other means permitted, backing strips or equivalent shall be used with full penetration welds deposited from only one side. Backing strips, if used, may be left in place.

(c) **Deposited Weld Metal of Opening for Nozzles and Branch Piping Connections.** Nozzles and branch piping connections shall be joined to the component by full penetration weld to built-up weld deposits applied to the component, nozzle, or branch as shown in Figure NCD-4244(c)-1. Backing strips, if used, may be left in place. Fillet welds shall be used only to provide a transition between the parts joined or to provide a seal. The fillet welds, when used, shall be finished by grinding to provide a smooth surface having a transition radius at its intersection with either part being joined.

(d) **Partial Penetration Welded Nozzles and Branch Piping Connections.** Partial penetration welds in components and branch piping connections, shall meet the weld design requirements of NC-NCD-3352.4(d) and NC-NCD-3359. Nozzles shall be attached as shown in Figure NCD-4244(d)-1. Reinforcing plates of nozzles attached to the outside of a vessel shall be provided with at least one telltale hole, maximum size 1/4 in. (6 mm) pipe tap, that may be tapped for a preliminary compressed air and soapsuds test for tightness of welds. These telltale holes may be left open or may be plugged when the vessel is in service. If the holes are plugged, the plugging material used shall not be capable of sustaining pressure between the reinforcing plate and the vessel wall.

(e) **Attachment of Fittings With Internal Threads.** Internally threaded fittings shall be attached by a full penetration groove weld or for NPS 3 (DN 80) and less, by two fillet or partial penetration welds, one on each face of the vessel wall, or by a fillet groove weld from the outside only as shown in Figure NCD-4244(e)-1 sketch (c-3). Internally threaded fitting and bolting pads not exceeding NPS 3 (DN 80), as shown in Figure NCD-4244(e)-2, may be attached to components having a wall thickness not greater than 3/8 in. (10 mm) by a fillet weld deposited from the outside only. The design requirements of NC-NCD-3352.4(e) shall be met for all components.

**NCD-4244.2 (Class 3 Only) Category D Weld Joints in Vessels and Branch Connection Weld Joints in Other Components (Note to Editors: was ND-4244)**

Category D weld joints in vessels and branch connection weld joints in other components shall be welded using one of the details of (a) through (g) below except that joints in P-No. 11A, Group 1 material shall be full penetration welds extending through the entire thickness of the component wall or nozzle wall as shown in Figures NCD-4244(a)-1, NCD-4244(b)-1, and NCD-4244(c)-1.

(a) **Butt-Welded Nozzles and Branch Piping Connections.**

Nozzles and branch piping connections shall be attached by full penetration butt welds through the wall of the component nozzle or branch as shown in Figure NCD-4244(a)-1. Backing strips, if used, may be left in place.

(b) **Corner-Welded Nozzles and Branch Piping Connections.**

Nozzles and branch piping connections shall be joined to the component by full penetration welds through the wall of the component, nozzle, or branch similar to those shown in Figure NCD-4244(b)-1. When complete joint penetration cannot be verified by visual examination or
other means permitted, backing strips or equivalent shall be used with full penetration welds deposited from only one side. Backing strips, if used, may be left in place.

(c) Deposited Weld Metal of Opening for Nozzles and Branch Piping Connections.

Nozzles and branch piping connections shall be joined to the component by full penetration weld to built-up weld deposits applied to the component, nozzle, or branch as shown in Figure NCD-4244(c)-1. Backing strips, if used, may be left in place. Fillet welds shall be used only to provide a transition between the parts joined or to provide a seal. The fillet welds, if used, shall be finished by grinding to provide a smooth surface having a transition radius at its intersection with either part being joined.

(d) Partial Penetration Welded Nozzle and Branch Piping Connections.

Partial penetration welds in components and branch piping connections shall meet the weld design requirements of NCD-3352.4(d) and NCD-3355. Nozzles shall be attached as shown in Figure NCD-4244(d)-1. Reinforcing plates of nozzles attached to the outside of a vessel shall be provided with at least one telltale hole, maximum size 1/4 in. (6 mm) pipe tap, that may be tapped for a preliminary compressed air and soapsuds test for tightness of welds that seal off the inside of the vessel. These telltale holes may be left open or may be plugged when the vessel is in service. If the holes are plugged, the plugging material used shall not be capable of sustaining pressure between the reinforcing plate and the vessel wall.

(e) Attachment of Fittings With Internal Threads.21

Internally threaded fittings shall be attached by a full penetration groove weld or, for NPS 3 (DN 80) and less, by two fillet or partial penetration welds, one on each face of the vessel wall, or by a fillet groove weld from the outside only as shown in Figure NCD-4244(e)-1, sketch (c-3). Internally threaded fitting and bolting pads not exceeding NPS 3 (DN 80), as shown in Figure NCD-4244(e)-2, may be attached to components having a wall thickness not greater than 3/8 in. (10 mm) by a fillet weld, deposited from the outside only. The design requirements of NCD-3352.4(e) shall be met for all components.

(f) Tubed Connections. Nozzles or tubes recessed into thick-walled components or parts may be welded from only one side, provided the requirements of NCD-3352.4(f) are met. Typical connections are shown in Figure NCD-4244(f)-1.

(g) Nozzles With Integral Reinforcing. Nozzles and other connections having integral reinforcing in the form of external necks or saddle type pads shall be attached by full penetration welds or by means of a fillet weld along the outer attachment having a wall, single bevel, or single J-weld along the inner attachment. Typical connections are shown in Figure NCD-4244(g)-1.
Figure NC-NCD-4244(a)-1 — Nozzles, Branch, and Piping Connections Joined by Full Penetration Butt Welds

(a) [Diagram showing a nozzles, branch, and piping connection with dimensions labeled.]

(b) [Diagram showing another configuration of nozzles, branch, and piping connection with dimensions labeled.]

(c) [Diagram showing a section perpendicular to the cylindrical vessel's axis.]

(d) [Diagram showing a section parallel to the cylindrical vessel's axis.]

(e) [Diagram showing a section with a backing ring.]

(f) [Diagram showing another section with a backing ring.]

GENERAL NOTE: For definition of symbols, see NC-NCD-3352.4(a).
Figure NC-NCD-4244(b)-1 — Nozzles, Branch, and Piping Connections Joined by Full Penetration Corner Welds

(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)

GENERAL NOTE: For definition of symbols, see NC-NCD-3352.4(b).
Figure NC-NCD-4244(c)-1 — Deposited Weld Metal Used as Reinforcement of Openings for Nozzles, Branch, and Piping Connections

GENERAL NOTE: For definition of symbols, see NC-NCD-3352.4(c).
Figure NC-NCD-4244(d)-1 — Some Acceptable Types of Welded Nozzles, Branch, and Piping Connections

GENERAL NOTE: For definition of symbols, see NC-NCD-3352.4(d).
**Figure NC-NCD-4244(e)-1 — Some Acceptable Types of Welded Nozzles**

Either method of attachment is satisfactory.

(a) (a-2)
(b) (b-2)
(c) (c-2)

GENERAL NOTE: For definition of symbols, see NC-NCD-3352.4(e).

**Figure NC-NCD-4244(e)-2 — Some Acceptable Types of Small Fittings**

GENERAL NOTES:
(a) For definitions of nomenclature, see NC-NCD-3352.4(e).
(b) Maximum shell thickness = \(\frac{3}{8}\) in. (10 mm).
(c) Maximum internal thread diameter = 3\(\frac{1}{2}\) in. (89 mm).
(d) Maximum dimension of opening in shell = no greater than 5 \(\frac{3}{8}\) in. (135 mm) or 0.5 \times shell diameter.
Figure ND-4244(f)-1
Tube Connections

(a) $t_c$ $t_n$ $t_w$
1/16 in. (1.5 mm) recess

(b) $t_c$ $t_n$

Typical Tube Connections

Section 1-1

GENERAL NOTES:
(a) For definitions of symbols, see ND-3352.4(f).
(b) When used for other than square, round, or oval headers, round off corners.
Figure NCD-4244(g)-1
Some Acceptable Types of Welded Nozzles, and Branch and Piping Connections

(a)  
(b)  
(c)  
(d)  
(e-1)  
(e-2)  
(f)  

GENERAL NOTE: For definition of symbols, see NCD-3352.4(g).

Note to Editor: change figure number above to Figure NCD-4244(g)-1 and change ND-3352.4(g) in note above to NCD-3352.4(g)

NCD-4245 Complete Joint Penetration Welds
NCD-4245.1 Class 2 Only [Note to Editors: was NC-4245]

Complete joint penetration is considered to be achieved when the acceptance criteria for the examinations specified by this Subsection have been met. No other examination is required to assess that complete penetration has been achieved.

NCD-4245.1 Class 3 Only [Note to Editors: was ND-4245]

Acceptable joint Types and limitations are listed in Table NCD-4245-1. Some typical configurations are shown in Figure NCD-4245-1.

### Table NCD-4245-1

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Butt joints as attained by double welded or by other means will obtain the same quality of deposit weld metal on the inside and outside surface to agree with the requirements of ND-4426. Welds using metal backing strips that remain in place are excluded.</td>
<td>The use of this joint Type is not limited</td>
</tr>
<tr>
<td>2</td>
<td>Single-welded butt joints with backing strips other than those included in Type 1</td>
<td>The use of this joint Type is not limited, except for butt welds with one plate offset, which can be used for circumferential joints only and are limited by the provisions of ND-3358.5 (Figure NCD-4245-1; sketch [8])</td>
</tr>
<tr>
<td>3</td>
<td>Single-welded butt joints without the use of a backing strip</td>
<td>This joint Type is limited to circumferential joints only, which are not over 7/8 in. (16 mm) thick and not over 24 in. (600 mm) outside diameter</td>
</tr>
<tr>
<td>4</td>
<td>Double full fillet lap joints</td>
<td>This joint Type is limited to longitudinal joints not over 7/8 in. (10 mm) thick and circumferential joints not over 7/8 in. (16 mm) thick</td>
</tr>
<tr>
<td>5</td>
<td>Single full fillet lap joints with plug welds conforming to ND-3356.2</td>
<td>This joint Type is limited to circumferential joints for attachments of heads (other than hemispherical) not over 24 in. (600 mm) outside diameter to shells not over 7/8 in. (13 mm) thick. This joint Type cannot be used for attaching hemispherical heads to shells.</td>
</tr>
<tr>
<td>6</td>
<td>Single full fillet lap joints without plug welds</td>
<td>This joint Type is limited to attachment of heads convex to pressure to shells not over 7/8 in. (16 mm) required thickness, using fillet welds on the inside of the shell or for the attachment of heads having pressure on either side, to shells not over 24 in. (600 mm) inside diameter and not over 7/8 in. (6 mm) required thickness with the fillet welds on the outside of the head flange only.</td>
</tr>
</tbody>
</table>
Figure ND-4245-1
Attachment Welds

(a) Single Fillet Lap Weld

For ellipsoidal heads: min. 2tₚ, but not less than 11/2 in. (13 mm)
For other heads: min. 2tₚ + 1/2 in. (13 mm)

Min. 3tₚ + 1/2 in. (13 mm), but not less than 1 in. (25 mm)

(b) Double Fillet Lap Weld

For ellipsoidal heads: min. 2tₚ, but not less than 11/2 in. (13 mm)
For other heads: min. 2tₚ + 1/2 in. (13 mm)

Min. tₚ or 4tₚ, whichever is less

(c) Single Fillet Lap Weld With Plug Welds

For ellipsoidal heads: min. 2tₚ, but not less than 11/2 in. (13 mm)
For other heads: min. 2tₚ + 1/2 in. (13 mm), but not less than 1 in. (25 mm)

Not less than d
Min. 3d

(d) Butt Weld

NCD-324.5(c)

When tₚ is equal to or less than 1.25tₚ

See NCD-324.5(c) for hemispherical heads

NCD-3361.1

When tₚ exceeds 1.25tₚ

See also NCD-3361.1
Requirements for special joints for atmospheric storage tanks are given below.
**NC-NCD-4246.1 Bottom Plates.**
Bottoms shall be built to either one of the alternative methods of construction given in (a) and (b) below.

(a) Lap-welded bottom plates shall be reasonably rectangular and square edged. Three plate laps in tank bottoms shall not be closer than 12 in. (300 mm) from each other and also from the tank shell. Bottom plates need be welded on the top side only with a continuous full fillet weld on all seams [Figure NC-D-4246.1(a)-1]. The plates under the bottom ring shell connection shall have the outer ends of the joints fitted and lap welded to form a smooth bearing for the shell plates as shown in Figure NC-D-4246.1(a)-1.

(b) Butt welded bottom plates shall have the parallel edges prepared for butt welding with either square or V-grooves. If square grooves are employed, the root opening shall be not less than 1/4 in. (6 mm). The butt welds shall be made by applying a backing strip 1/8 in. (3 mm) thick or heavier by tack welding to the underside of the plate [Figure NC-D-4246.1(a)-1]. A metal spacer shall be used, if necessary, to maintain the root opening between the adjoining plate edges. The Certificate Holder may submit other methods of butt welding the bottom for the Owner’s approval. Three plate joints in tank bottoms shall not be closer than 12 in. (300 mm) from each other and also from the tank shell.

**Figure NC-D-4246.1(a)-1 — Typical Bottom and Bottom-to-Shell Joints**

![Typical Bottom and Bottom-to-Shell Joints](image)

**NC-NCD-4246.2 Shell-to-Bottom Attachment.**
The attachment between the bottom edges of the lowest course shell plate and the bottom plate shall be a continuous full wall thickness weld with a cover fillet on each side of shell plate [Figure NC-D-4246.1(a)-1] or, for tanks not exceeding 35 ft (11 m) in diameter, the bottom plates may be flanged and butt welded to the bottom shell course. The flanged tank bottom plates shall be butt welded and have a thickness equal to the thickness of the bottom shell course. The inside radius of the bend shall be neither less than 1.75t nor more than 3t.
**NC-NCD-4246.3 Roof-to-Sidewall Attachment.**

Roof plates shall be attached to the top angle of the tank with a continuous fillet weld on the top side only (Figure NC-D-4246.3-1). Roof plates of supported cone roofs shall not be attached to the supporting members. For cone roofs the fillet weld shall be $\frac{3}{16}$ in. (5 mm) or smaller.

**NC-NCD-4246.4 Roof Plates.**

Roof plates shall be attached at least by a continuous full fillet lap joint on the top side (Figure NC-D-4246.4). The top angle sections for self supporting roofs shall be joined by full penetration butt welds.

**NC-NCD-4246.5 Nozzle, Manhole, and Bottom Outlet Joints.**

Nozzles, manholes, and outlets shall be attached by full fillet welds as shown in Figures NC-D-4246.5-1 through NC-D-4246.5-4.
GENERAL NOTES:
(a) Slip-on welding and welding neck flanges shall conform to the requirements for 150 lb forged carbon steel raised face flanges as given in ASME B16.5.
(b) Plate ring flanges shall conform to all dimensional requirements for slip-on welding flanges, except that the extended hub on the back of the flange may be omitted.

**Figure NCD-4246.5-3 — Screwed or Socket Weld Roof Nozzles**

![Figure NCD-4246.5-3](image)

**Figure NCD-4246.5-4 — Welded Bottom Outlet Elbow**

![Figure NCD-4246.5-4](image)

**NC-NCD-4246.6 Flanges to Roof Nozzles, Manholes, and Bottom Outlets. (Class 2 Only)**

Flanges to roof nozzles, manholes, and bottom outlets shall be attached by fillet welds as shown in Figures NCD-4246.5-1, NCD-4246.5-2, and NCD-4246.5-4.

**NCD-4246.7 Special Requirements.**

Special weld requirements for storage tanks are given in (a) through (d) below.

(a) The minimum size of fillet welds shall be as follows: plates \(\frac{3}{16}\) in. (5 mm) thick, full fillet welds; plates over \(\frac{3}{16}\) in. (5 mm) thick, not less than one-third the thickness of the thinner plate at the joint, with a minimum of \(\frac{3}{16}\) in. (5 mm).
(b) Lap-welded joints, as tack welded, shall be lapped not less than five times the nominal thickness of the thinner plate joined; but in the case of double welded lap joints the lap need not exceed 2 in. (50 mm), and in the case of single-welded lap joints the lap need not exceed 1 in. (25 mm).

(c) For plates over 1/2 in. (13 mm) thick in the sidewalls, roof, or bottom of the tank, if the thickness of two adjacent plates which are to be butt welded together differs more than 1/8 in. (3 mm), the thicker plate shall be trimmed to a smooth taper extending for a distance at least three times the offset between the abutting surfaces so that the adjoining edges will be approximately the same thickness (Figure NC-NCD-3361.1-1). The length of the required taper may include the width of the weld.

(d) Top angle sections for self-supporting roofs shall be joined by full penetration butt welds.

**NCD-4246.8 Other Weld Joints.**

The fabrication requirements for weld joints not specifically covered by NCD-4246, such as sidewall weld joints and nozzle-to-flange weld joints, are the same as given in NCD-4240 for Category A, B, and C weld joints for vessels.

**NCD-4247 Zero psi to 15 psi (0 kPa to 100 kPa) Storage Tank Special Joints**

Requirements for special joints for 0 psi to 15 psi (0 kPa to 100 kPa) storage tanks are given below.

**NCD-4247.1 Bottoms.**

All welds in flat bottoms supported directly on foundations shall be single full fillet lap joints as a minimum. For other bottoms, all welds shall be butt welds.

**NCD-4247.2 Bottom-to-Sidewall.**

All welds shall meet the design requirements of NCD-3933. Flat bottoms shall be attached to sidewalls by full penetration welds and fillet welds on each side as a minimum.

**NCD-4247.3 Roof-to-Sidewall.**

Roof-to-sidewall joints shall be in accordance with the design requirements of NCD-3933. The joints shall have continuous full fillet welds as a minimum.

**NCD-4247.4 Roofs.**

Roofs shall be in accordance with the design requirements of NCD-3933 and shall meet the requirements of NCD-4241.

**NCD-4247.5 Nozzles.**

Nozzle welds shall meet the requirements of NCD-4244.

**NCD-4247.6 Special Requirements.**

Special weld requirements for storage tanks are given in (a) through (d) below.

(a) The minimum size of fillet welds shall be as follows: plates 3/16 in. (5 mm) thick, full fillet welds; plates over 3/16 in. (5 mm) thick, not less than one-third the thickness of the thinner plate at the joint, with a minimum of 3/16 in. (5 mm).
(b) Lap-welded joints, as tack welded, shall be lapped not less than five times the nominal thickness of the thinner plate joined; but in the case of double welded lap joints the lap need not exceed 2 in. (50 mm), and in the case of single-welded lap joints the lap need not exceed 1 in. (25 mm).

(c) For plates over 1/2 in. (13 mm) thick in the sidewalls, roof, or bottom of the tank, if the thickness of two adjacent plates which are to be butt welded together differs more than 1/8 in. (3 mm), the thicker plate shall be trimmed to a smooth taper extending for a distance at least three times the offset between the abutting surfaces so that the adjoining edges will be approximately the same thickness (Figure NC-NCD-3361.1-1). The length of the required taper may include the width of the weld.

(d) The size of any weld along either edge of a compression ring shall not be less than the thickness of the thinner of the two parts joined or 1/4 in. (6 mm), whichever is less, nor shall the size of the corner welds between the shell and a girder bar, such as shown in Figure NC-NCD-3933.5(d)-1 sketches (d) and (e), or between the horizontal and vertical members of a compression ring assembly, such as shown in sketches (f) and (i), be less than the applicable value specified in Table NC-NCD-4247.6(d)-1.

Table NC-NCD-4247.6(d)-1 — Minimum Size for Fillet Welds

<table>
<thead>
<tr>
<th>Thickness of the Thicker of the Two Parts Joined, in. (mm)</th>
<th>Minimum Size of Fillet Weld, in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not over 1/4 (6)</td>
<td>3/16 (5)</td>
</tr>
<tr>
<td>Over 1/4 through 3/4 (6 through 19)</td>
<td>3/16 (5)</td>
</tr>
<tr>
<td>Over 3/4 through 1 1/4 (19 through 32)</td>
<td>5/16 (8)</td>
</tr>
<tr>
<td>Over 1 1/4 (32)</td>
<td>3/8 (10)</td>
</tr>
</tbody>
</table>

NC-NCD-4247.7 Other Weld Joints.

The fabrication requirements for weld joints not specifically covered by NC-NCD-4247, such as sidewall weld joints and nozzle-to-flange weld joints, are the same as given in NC-NCD-4240 for Category A, B, and C weld joints for vessels.

NC-NCD-4250 Welding End Transitions — Maximum Envelope

The welding ends of items or fittings shall provide a gradual change in thickness from the item or fitting to the adjoining item. Any welding end transition which lies entirely within the envelope shown in Figure NC-NCD-4250-1 is acceptable, provided that:

(a) the wall thickness in the transition region is not less than the min. wall thickness of the adjoining pipe; and

(b) sharp reentrant angles and abrupt changes in slope in the transition region are avoided. When the included angle between any two adjoining surfaces of a taper transition is less than 150 deg, the intersection or corner (except for the weld reinforcement) shall be provided with a radius of at least 0.05\(t_{\text{min}}\).
GENERAL NOTES:
(a) Weld bevel is shown for illustration only.
(b) The weld reinforcement permitted by NCD-4426 may lie outside the maximum envelope.

NOTES:
(1) The maximum thickness at the end of the component is:
   (a) the greater of $t_{\text{min}} + 0.15$ in. (3.8 mm) or $1.15t_{\text{min}}$ when ordered on a minimum wall basis;
   (b) the greater of $t_{\text{min}} + 0.15$ in. (3.8 mm) or $1.0t_{\text{nom}}$ when ordered on a nominal wall basis.

(2) The value of $t_{\text{min}}$ is whichever of the following is applicable:
   (a) the minimum ordered wall thickness of the pipe;
   (b) 0.875 times the nominal wall thickness of pipe ordered to a pipe schedule wall thickness that has an under tolerance of 12.5%;
   (c) the minimum ordered wall thickness of the cylindrical welding end of a component or fitting (or the thinner of the two) when the joint is between two components.
NC-NCD-4260 Special Requirements for Weld Joints in Vessels Designed to NC-NCD-3200 (Class 2 Only)

NC-NCD-4261 General

Except for NC-NCD-4240, all other requirements of Article NC-NCD-4000 apply. The requirements of NC-NCD-4260 are to be used instead of those in NC-NCD-4240.

NC-NCD-4262 Description and Limitations of Joint Types

The description of the joint types are as follows.

(a) Type No. 1 Butt Joints. Type No. 1 butt joints are those produced by double welding or by other means which produce the same quality of deposited weld metal on both inside and outside weld surfaces. Welds using backing strips which remain in place do not qualify as Type No. 1 butt joints. Type No. 1 butt joints shall have complete joint penetration and full fusion and shall meet the requirements of NC-NCD-4424 and NC-NCD-4426.

(b) Type No. 2 Butt Joints. Type No. 2 butt joints are single-welded butt joints having backing strips which remain in place. NC-3252.2 gives stress concentration factors to be applied to Type No. 2 joints when a fatigue analysis is required. When Type No. 2 butt joints are used, care shall be taken on aligning and separating the components to be joined so that there will be complete penetration and fusion at the bottom of the joints for their full length. However, weld reinforcement need be supplied only on the side opposite the backing strip. The requirements of NC-NCD-4424 and NC-NCD-4426 shall be met.

(c) Full Penetration Corner Joints. Corner joints are those connecting two members approximately at right angles to each other in the form of an L or T and shall be made with full penetration welds.

(d) Fillet Welded Joints. Fillet welded joints, permitted by the rules of this subarticle, are those of approximately triangular cross section, joining two surfaces at approximately right angles to each other and having a throat dimension at least 70% of the smaller thickness of the parts being joined but not less than \(\frac{1}{4}\) in. (6 mm).

NC-NCD-4263 Category A Weld Joints

Category A weld joints shall be Type No. 1 butt joints.

NC-NCD-4264 Category B Weld Joints

Category B weld joints shall be Type No. 1 or Type No. 2 butt joints. Backing strips shall be removed from Type No. 2 joints unless access conditions prevent their removal. Backing strips shall be continuous, and any splices shall be butt welded. Circumferential single-welded butt joints with one plate offset to form a backing strip are prohibited.

NC-NCD-4265 Category C Weld Joints

Category C weld joints shall be Type No. 1 butt joints or full penetration corner joints. Welds in full penetration corner joints shall be groove welds extending completely through at least one of the parts
being joined and shall be fully fused to each part. Typical details are shown in Figures NCD-4265-1 and NCD-4265-2.

**Figure NCD-4265-1 — Acceptable Full Penetration Details to Form a Corner Joint**

GENERAL NOTES:

(a) For definitions of nomenclature for illustrations (a) through (c), see NCD-3358.3(e)(2).

(b) For definitions of nomenclature for illustrations (d) through (g), see NCD-3358.3(e)(1).

references changed from unverified to verified
NC-NCD-4265.1 Flat Heads and Tubesheets With Hubs.

(a) Hubs for butt welding to the adjacent shell, head, or other pressure parts, as shown in Figure NC-NCD-4243.1-1 for flat heads, shall not be machined from flat plate. The hubs shall be forged in such a manner as to provide in the hub the full minimum tensile strength and elongation specified for the material in the direction parallel to the axis of the vessel. Proof of this shall be furnished by a tension test specimen (subsize, if necessary) taken in this direction and as close to the hub as is practical. The minimum height of the hub shall be the lesser of 1 1/2 times the thickness of the pressure part to which it is welded or 3/4 in. (19 mm), but need not be greater than 2 in. (50 mm).

(b) Hubbed flanges, as shown in Section III Appendices, Mandatory Appendix XI, Figure XI-3120-1 sketches (6), (6a), and (6b), shall not be machined from flat plate.

NC-NCD-4266 Category D Weld Joints

Category D and similar weld joints shall be welded using one of the details of (a) through (d) below.

(a) Butt Welded Attachments. Nozzles shall be attached by Type No. 1 butt welds through either the vessel or the nozzle wall as shown in Figure NC-NCD-4266(a)-1.

(b) Full Penetration Corner Welded Attachment. Nozzles shall be attached by full penetration welds through the wall of the vessel or nozzle as shown in Figure NC-NCD-4266(b)-1. The welds shall be groove welds extending completely through at least one of the parts being joined and shall be fully fused to each part. Backing strips shall be used with welds deposited from only one side or when complete joint penetration cannot be verified by visual inspection. Backing strips, when used, shall be removed after welding.
Figure NCD-4266(a)-1 — Nozzles Attached by Full Penetration Butt Welds

Sections perpendicular and parallel to the vessel's cylindrical axis.
(c) Pad and Screwed Fitting Types of Welded Nozzles

(1) Inserted Nozzle Necks With Added Reinforcement. Inserted type necks having added reinforcement in the form of one or more separate reinforcing plates shall be attached by welds at the outer edge of the reinforcement plate and at the nozzle neck periphery. The weld at the outer edge of the reinforcement shall be a fillet weld with a minimum throat dimension of the smaller of 0.7t or 0.7t. The welds attaching the neck to the vessel wall and to the reinforcement shall be full penetration groove welds. Permissible types of weld attachments are shown in Figure NCD-4266(c)-1 sketches (a), (b), and (c).
(2) **Studded Connections**

(a) Studded connections, which may have externally imposed loads, shall have tapped holes complying with the requirements of NC-D-3262. The vessel or integral weld buildup shall have a flat surface machined on the shell to receive the connection. Drilled holes to be tapped shall not penetrate within one-fourth of the wall thickness from the inside surface of the vessel after deducting corrosion allowance unless at least the minimum thickness required as above is maintained by adding metal to the inside surface of the vessel.

(b) Studded pad-type connections may be used for connections on which there are essentially no external mechanical loads, such as manways and handholes used only as inspection openings or thermowell connections, provided the requirements of NC-D-3262 are met.
NCD-3237 are met. The pad shall be attached by a fillet weld along the outer edge and a single bevel weld along the inner edge. Permissible type of weld attachment is shown in Figure NC-D-4266(c)-1 sketch (d). The tapped holes for stud threads shall comply with NCD-NCD-3262.4.

(3) **Fittings With Internal Threads.** Internally threaded fittings shall be limited to NPS 2 (DN 50). They shall be attached by means of full penetration groove welds as illustrated in Figure NC-D-4266(c)-1 sketches (e), (f), and (g), except pad type fittings, such as shown in sketch (h), which may be used if attached by means of fillet welds having a minimum throat dimension of the smaller of 0.7\(t_e\) or 0.7\(t_t\), as shown in sketch (h).

(d) **Attachment of Nozzles Using Partial Penetration Welds.** Partial penetration welds are limited by the restrictions of NCD-NCD-3252.4(d). The weld size shall be such that the depth of penetration \(t_w\) will be at least \(1/4t_n\). Typical details are shown in Figure NC-D-4266(d)-1.

**NC-NCD-4267 Types of Attachment Welds**

Lugs, brackets, stiffeners, and other attachments shall be attached to the pressure-retaining parts by continuous welds. Fillet or partial penetration welds shall be continuous on all sides. Attachments are shown in Figure NC-D-4267/1.
Figure NCD-4266(d)-1 — Partial Penetration Weld Connections

(a) Not less than $1\frac{1}{2}d_{n}$ recess

(b) $1/66$ in. (1.5 mm) recess

(c)
Figure NCD-4267-1 — Attachments

Bracket and Lug Attachments

Stiffener Attachments

Weld buildup

Section A - A

Section B - B

Bracket, Lug, and Stiffener Attachments

Support Skirts

GENERAL NOTES:
(a) \( a \geq t/4; \ b \geq t/2; \ c \geq t \)

\( c = \) minimum thickness of weld metal from the root to the face of the weld
\( t = \) thickness of attached member

(b) All welds continuous.