CC-2122.3 **Authorized Inspector.** Reports of all required examinations, tests, and treatments shall be made available to the Authorized Inspector of the applicable Fabricator or Constructor and provisions made for inspections as required by the Authorized Inspector.

**CC-2123 Size Ranges of Metallic Material**

Metallic material outside the limits of size or thickness given in any specification allowed by this Division may be used if the material is in compliance with the other requirements of the specification and no size limitation is given in the rules for construction. In those specifications in which chemical composition and mechanical properties are indicated to vary with size or thickness, any material outside the specification range shall be required to conform to the composition and mechanical properties shown for the nearest specified range.

**CC-2130 CERTIFICATION OF MATERIAL**

**CC-2131 Introduction**

Such laboratory inspections can be provided by the Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology, with accreditation programs provided by the National Voluntary Laboratory Accreditation Program (NVLAP), American Association for Laboratory Accreditation (AALAA), and Construction Materials Engineering Council (CMEC).

**CC-2131.3 Concrete Constituents.**

**CC-2131.3.1 Laboratory Accreditation.** The tests required by CC-2200 shall be performed by an accredited laboratory that complies with ASTM C1077.1 and CC-2222.

**CC-2131.3.2 Certified Material Test Reports.** The Certified Material Test Reports (CMTR) for concrete constituents shall meet the following requirements:

(a) The CMTR for aggregate shall certify that the aggregates are from the same source (natural deposit) as the aggregate qualified in accordance with CC-2222.

(b) The CMTR for Portland cement shall include the standard chemical and physical test results in accordance with ASTM C150/C150M. Sampling and testing frequencies shall meet the requirements of ASTM C183.

(c) The CMTR for blended hydraulic cement shall include the standard chemical and physical test results in accordance with ASTM C595/C595M and any optional requirements in the Construction Specification. Sampling and testing frequencies shall meet the requirements of ASTM C183.

(d) The CMTR for fly ash and natural pozzolan shall include the standard chemical and physical test results in accordance with ASTM C618 and any requirements in the Construction Specification. Sampling and testing frequencies shall meet the requirements in the Construction Specification. Sampling and testing frequencies shall meet the requirements of ASTM C311.

(e) The CMTR for ground-granulated, blast-furnace slag (GGBS) test results in accordance with ASTM C989 and any requirements of the Construction Specification. Sampling and testing frequencies shall meet the requirements of ASTM C989.

(f) The CMTR for air-entraining admixtures shall include infrared spectrophotometry traces, percent solids, and percent chlorides of each manufacturing lot. A statement shall be included to certify that these tests or other included tests have established equivalence with ASTM C260.

(g) The CMTR for silica fume shall include the standard chemical and physical test results in accordance with ASTM C183. A statement shall be included to certify that these tests or other included tests have established equivalence with ASTM C1240.

(h) The CMTR for chemical admixtures shall include infrared spectrophotometry traces, percent solids, and percent chlorides of each manufacturing lot. A statement shall be included to certify that these tests or other included tests have established equivalence with admixtures tested in accordance with ASTM C494/C494M or ASTM C1017/C1017M.

(i) A CMTR for water and ice is not required.

**CC-2131.4 Personnel Qualification.** Laboratory testing personnel performing tests required by Article CC-2000 shall be qualified using appropriate industry or laboratory standards such as ACI Laboratory Technician Certification Programs, Technician Levels 1 and 2. The
CC-2332 Chemical Analysis

A ladle analysis of each heat of reinforcing bar shall be made and reported in accordance with ASTM A615 or ASTM A706, as applicable.

CC-2332.1 Reinforcing Bar Intended for Welding.
(a) ASTM A706 and ASTM A615 may be welded by any of the welding processes listed in D2-VIII-1400.
(b) The ladle analysis of ASTM A615 reinforcing bar heats intended for welding shall be as follows:
1. carbon, 0.30% maximum
2. manganese, 1.50% maximum
3. sulfur, 0.045% maximum
4. phosphorus, 0.035% maximum
5. silicon, 0.50% maximum

An analysis for the following residual elements shall also be performed and reported: copper, nickel, chromium, molybdenum, vanadium. The carbon equivalent of such bars shall be computed per D2-VIII-1430 for application in Table D2-VIII-1430-1.
(c) The results of the product verification analysis for ASTM A706 reinforcing bar shall not exceed that specified in ASTM A706. Product verification analysis for ASTM A615 reinforcing bar shall not exceed the following:
1. carbon, 0.33%
2. manganese, 1.55%
3. sulfur, 0.053%
4. phosphorus, 0.043%
5. silicon, 0.55%

CC-2400 MATERIAL FOR PRESTRESSING SYSTEMS

CC-2410 INTRODUCTION

This subarticle establishes the requirements for the material to be used for bonded and unbonded containment prestressing systems.

CC-2420 PRESTRESSING STEEL

CC-2421 Permitted Material

Prestressing elements are limited to those listed in Table D2-I-1.2. The materials shall conform to their respective material specifications and to the additional requirements described in the following subparagraphs.

CC-2422 Test Specimen Sizes

All mechanical tests on prestressing elements shall be performed on full-diameter test pieces.

CC-2423 Tensile Tests

Material produced to an ASTM specification shall be sampled and tested as required by that specification. The tensile strength, yield strength, elongation, and other pertinent data shall be reported on the Certified Material Test Report.

CC-2424 Stress Relaxation Properties

The stress relaxation properties of the prestressing elements tested in accordance with ASTM E328 shall be provided by the Material Organization. Reports relating thereto shall be based upon tests performed on material previously manufactured to the same ASTM or other applicable specification, and produced in the same plant utilizing the same procedures that will be employed to produce the prestressing elements for the production tendons.

CC-2424.1 Data to Be Furnished. The following data shall be furnished:
(a) deviations from ASTM E328 recommended testing
(b) specimen identification
(c) initial and final stress
(d) loss of stress at intervals during test
(e) temperature control limits
(f) predicted stress relaxation design life and basis for extrapolation

CC-2424.2 Number of Tests. A minimum of three relaxation tests of 1,000 hr duration shall be performed and reported to document adequately that the relaxation losses are in compliance with the Construction Specification.

CC-2430 COMPONENT STANDARDS

CC-2431 General

Ensure all connectors, connections, and components of post-tensioning system hardware are completely sealed against leakage of concrete past. All hardware, components, and connections shall be airtight and watertight and pass the pressure test requirements herein.

CC-2432 Anchorage Components

CC-2432.1 Bearing Plates. Materials for bearing plates shall conform to their respective material specifications. The dimensions, finish, alignment, and tolerances of the bearing plates shall be within the limits set forth in the Construction Specification.

Bearing plates and associated concrete test block shall be tested in accordance with CC-2441.

For items requiring heat treatment to develop mechanical properties, the alloy and heat treatment shall be selected to preclude embrittlement.

CC-2432.2 Wedge Plates and Wedges. Wedge plates and wedges shall meet the requirements of CC-2442.

CC-2432.3 Trumpets. Trumpets associated with bearing plates shall be made of ferrous metal. The thickness of the trumpet at the duct end shall not be less than the thickness of the duct. Connections from the trumpet to the duct and the trumpet to the bearing plate shall have the same leak tightness requirements as duct-to-duct couplers.
CC-2511 and any metallic cladding material of weldable quality that in the judgment of the user is suitable for the intended service.

(c) Integrally clad steel plate, in which any part of the cladding is included in the design calculations, shall show a minimum strength of 20,000 psi (140 MPa) when tested in the manner described in the plate specification. One shear test shall be made on each such clad plate as rolled, and the results shall be reported on the CMTR.

(d) When any part of the cladding thickness is specified as an allowance for corrosion, such added thickness shall be removed before mill tension tests are made. When no part of the cladding thickness is specified as an allowance for corrosion, the cladding material need not be removed before testing.

CC-2514 Permanent Structural Attachment Material

Materials to be used for attachments to liners are listed in Table D2-I-2.2. In addition to Table D2-I-2.2, any material permitted to be attached to the pressure-containing shell under NE-2190(a) of Class MC containment vessel may be welded to the Class CC liner. In which case, the rules of NF-2000 shall be used for the material, and the attachment weld shall meet the requirements of Subsection CC for welding and nondestructive examination.

Structural steel rolled shapes, which are permitted by CC-2121 to be furnished with a certificate of compliance, may be repaired by welding using the welders, documentation, and examination requirements specified in SA-6.

CC-2520 FRACTURE TOUGHNESS REQUIREMENTS FOR MATERIALS

CC-2521 Materials to be Impact Tested

CC-2521.1 Materials for Which Impact Testing Is Required. Carbon steel and low alloy steel for liners shall be tested either by drop weight tests or the Charpy V-notch impact test. Such tests are not required for

(a) materials with a nominal section thickness of 5/8 in. (16 mm) or less where the thickness shall be taken as defined in (1) through (4)
(1) for liners, use the nominal thickness of the shell or head as applicable
(2) for nozzles or parts welded to liners, use the lesser of the liner thickness to which the item is welded, or the maximum radial thickness of the item exclusive of integral shell buttwelding projections
(3) for flat heads or flanges, use the maximum shell thickness as defined in CC-2524.2.1 or CC-2524.2.2.

(b) austenitic stainless steels
(c) all thicknesses of material for pipe, tube, and fittings with a nominal pipe size of 6 in. (150 mm) and smaller
(d) material for fittings with pipe connections of 5/8 in. (16 mm) nominal wall thickness and less
(e) bolting, including studs, nuts, and bolts with a nominal size of 1 in. (25 mm) or less
(f) materials listed in Table CC-2521.1-1 for which the listed value of T<sub>NDT</sub> was established from data on heavy section steel (thickness greater than 2 in. (51 mm) or more)
(g) rolled structural shapes, when the thickness of a flange is 5/8 in. (16 mm) or less
(h) materials listed in Table CC-2521.1-1 for which the listed value of T<sub>NDT</sub> exceeded the equation, T<sub>NDT</sub> = A, where A is a temperature increment determined from Figure CC-2521.1-1. This exemption does not apply to either the weld impact tests required by CC-2612 or the welding procedure qualification impact tests required by CC-4533.

(i) material for which the lowest service metal temperature exceeds 150°F (66°C)

(j) material for embedment anchors when the maximum stress does not exceed 6,000 psi (40 MPa) tension or is in compression

(k) rolled structural shapes, when the thickness of a flange is 5/8 in. (16 mm) or less

CC-2522 Impact Test Procedures

CC-2522.1 Types of Tests. CC-2522.1.1 Drop Weight Tests.

(a) The drop weight test, when required, shall be performed in accordance with ASTM E208.

### Table CC-2521.1-1

<table>
<thead>
<tr>
<th>Material [Note (1)]</th>
<th>Material Condition [Note (2)]</th>
<th>T&lt;sub&gt;NDT&lt;/sub&gt;, °F (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-537 Class 1</td>
<td>N</td>
<td>-30 (-34)</td>
</tr>
<tr>
<td>SA-516 Grade 70</td>
<td>Q &amp; T</td>
<td>-10 (-23)</td>
</tr>
<tr>
<td>SA-516 Grade 70</td>
<td>N</td>
<td>0 (-18)</td>
</tr>
<tr>
<td>SA-508 Class</td>
<td>Q &amp; T</td>
<td>+10 (+12)</td>
</tr>
<tr>
<td>SA-299 [Note (4)]</td>
<td>N</td>
<td>+20 (+7)</td>
</tr>
<tr>
<td>SA-216 Grades WCB, WCC</td>
<td>Q &amp; T</td>
<td>+30 (+10)</td>
</tr>
<tr>
<td>SA-36 Plate</td>
<td>HR</td>
<td>+40 (4)</td>
</tr>
</tbody>
</table>

NOTES:

(1) These materials are exempt from toughness testing when A or LSMT – T<sub>NDT</sub> is above the curve in Figure CC-2521.1-1 for the thickness as defined in CC-2524.2.1 or CC-2524.2.2.

T<sub>NDT</sub> is the temperature at or above the nil-ductility transition temperature NDT (ASTM E208) and T<sub>NDT</sub> is 10°F (6°C) below the temperature at which at least two specimens show no-break performance. The LSMT shall be the lowest temperature that the metal may experience in service while the plant is in operation and shall be established by appropriate calculations based on atmospheric ambient conditions, the insulation or enclosure provided, and the minimum temperature that will be maintained inside the containment during the plant operation.
CC-2524.2 Specific Test Methods and Acceptance Standards for Liner Material for Tests Based on Lowest Service Metal Temperature.

CC-2524.2.1 Liner Material With 2½ in. (64 mm) Maximum Thickness.

(a) Except as limited in CC-4533.5, apply one of the methods of CC-2524.1(a) to test the following:

1. The base material
2. The base material, the heat-affected zone, and the weld metal for the weld procedure qualification tests of CC-4533.5
3. The weld metal for CC-2612.1

(b) The impact test results shall meet one of the acceptance standards applicable to the specified test method.

1. Charpy V-Notch Testing for Lateral Expansion Values. The test results of the three specimens collectively and singly shall meet the respective requirements of Table CC-2524.2-1.
2. Charpy V-Notch Testing for Absorbed Energy Values. The test results of the three specimens collectively and singly shall meet the respective requirements of Table CC-2524.2-2.
3. Drop Weight Testing. An acceptance test shall consist of at least two no-break specimens as described in ASTM E208.

CC-2524.2.2 Liner Material With Thickness Ex-


termination strain shall be at least as far from the material surface as that specified for tensile test specimens in the material specification. For bolting, the CV impact test specimens shall be taken with the longitudinal axis of the specimen located at least one-half radius or 1 in. (25 mm) below the surface plus the machining allowance per side, whichever is less. The fracture plane of the specimen shall be at least one diameter or thickness from the heat-treated end.

CC-2523 Orientation of Test Specimens.

(a) Impact test specimens for Charpy V-notch tests shall be oriented in accordance with the requirements given for tensile test specimens in SA-370.

(b) Specimens for drop weight tests may have their axes oriented in any direction.

CC-2523.2 Structural Shapes. Orientation of impact test specimens shall be as specified in ASTM A673.

CC-2524 Test Requirements Standards

CC-2524.1 Liner Material Test Method and Temperature.

(a) Liner material shall be impact tested in accordance with one of the following test methods:

1. Charpy V-notch testing at or below the lowest service metal temperature.
2. Drop weight testing to establish a \( T_{NDT} \) and demonstrate that \( T_{NDT} \leq (LSMT - A) \)

(b) In addition, when the Construction Specification requires that the pneumatic pressure test (Article CC-6000) be performed at a temperature that is lower than the LSMT, the impact tests for liner material shall be performed in accordance with (a) above, at or below the lowest specified test temperature.

As an alternative, a lowest overpressure test metal temperature shall be specified. In this case, Charpy V-notch testing, in addition to the tests required by (a), shall be performed as specified in CC-2522.1.2 at a temperature 30°F (17°C) or more below the lowest overpressure test metal temperature in accordance with either of the base materials being joined.

The lowest overpressure test metal temperature shall be the lowest temperature that the metal may experience during the overpressure test and shall be established by appropriate calculations based on atmospheric conditions, the insulation or enclosure provided, and the temperature that will be maintained inside the vessel during the test.
CC-2526 Test Coupon Heat Treatment, Ferritic Material

Where ferritic steel material is subjected during fabrication or installation of material used for the tensile and impact test coupons, the test material shall be heat treated in the same manner as the material used for the tensile and impact test coupons and specimens for P-No. 1 materials with a nominal thickness of 2 in. (50 mm) or less are not required to be so heat treated. The Fabricator shall provide the Material Organization with the temperature and heating and cooling rates to be used. In the case of postweld heat treatment, the total time at temperature or temperatures for the test material shall be at least 80% of the total time at temperature or temperatures during actual postweld heat treatment of the material, and the total time at temperature or temperatures for the test material may be performed in a single cycle.

CC-2527 Retests

CC-2527.1 Retests for Material Other Than Bolting.
(a) For Charpy V-notch tests required by CC-2524, one retest at the same temperature may be conducted provided

(1) the average value of the test results meets the average of three requirements specified in Table CC-2524.2-1, Table CC-2524.2-2, or Table CC-2524.4-1, as applicable
(2) not more than one specimen per test is below the lowest one of three requirements specified in Table CC-2524.2-1, Table CC-2524.2-2, or Table CC-2524.4-1, as applicable
(3) the specimen not meeting the requirements is not lower than 5 ft-lb (7 J) or 5 mils (0.13 mm) below the lowest one of three requirements specified in Table CC-2524.2-1, Table CC-2524.2-2, or Table CC-2524.4-1, as applicable

(b) A retest consists of two additional specimens taken as near as practicable to the failed specimens. For acceptance of the retests, both specimens shall be equal to or greater than the average of three requirements specified in Table CC-2524.2-1, Table CC-2524.2-2, or Table CC-2524.4-1, as applicable.

CC-2527.2 Retests for Bolting Material.
(a) For Charpy V-notch tests required by CC-2524, one retest at the same temperature may be conducted provided

(1) not more than one specimen per test is below the acceptance requirements
(2) the specimen not meeting the requirements is not lower than 5 ft-lb (7 J) or 5 mils (0.13 mm) below the acceptance requirements

(b) A retest consists of two additional specimens taken as near as practicable to the failed specimens. For acceptance of the retests, both specimens shall meet the specified acceptance requirements.

Any postweld heat treatment time that is anticipated to be applied to the ferritic material during fabrication or construction after completion of manufacture shall be specified in the Construction Specification. The Material Organization shall include this time in the total time at temperature specified to be applied to the test specimens.

recorded to meet the requirements of NCA-4258.2 at least once in each 3-month interval.

(b) Charpy V-notch impact test machines shall be calibrated and the results recorded to meet the requirements of NCA-4258.2. The calibrations shall be performed using the frequency and methods outlined in ASTM E23 and employing standard specimens obtained from the National Institute of Standards and Technology, or any supplier of subcontracted calibration services accredited in accordance with the requirements of NCA-3126 and NCA-4255.3(c).

CC-2530 EXAMINATION AND REPAIR OF LINER MATERIAL

CC-2531 Liner Material

Liner material shall be examined and repaired in accordance with the material specification and as otherwise required by this Article.

CC-2532 Examination After Quenching and Tempering

Ferritic steel products that are used in the quenched and tempered condition shall be examined by the methods specified in this Article for each product form after the quenching and tempering phase of the heat treatment.

CC-2533 Examination and Repair of Plate

CC-2533.1 Required Examination. Plates shall be examined in accordance with the requirements of the material specification.

CC-2533.2 Time of Examination. Acceptance examinations shall be performed at the following times:

(a) Examinations shall be performed as required by the material specification.

(b) Radiographic examination of repair welds, when performed, may be performed prior to or after any required postweld heat treatment.

(c) Ultrasonic examination shall be performed after heat treatment.

(d) Magnetic particle or liquid penetrant examination of repair welds shall be performed after any required postweld heat treatment except for P-No. 1 material, which may be examined before or after any required postweld heat treatment.

CC-2533.3 Elimination of Surface Defects. Unacceptable surface defects may be removed by grinding or machining provided
(a) the depression, after defect elimination, is blended uniformly into the surrounding surface.

(b) The remaining thickness of the plate is not less than that required by Article CC-3000.

(c) elimination of the defect does not reduce the required section thickness by more than $\frac{1}{16}$ in. (1.5 mm)

(d) if the elimination of the defect reduces the required thickness of the section by more than $\frac{1}{16}$ in. (1.5 mm), the product shall be repaired by welding in accordance with CC-2533.4 or rejected

**CC-2533.4 Repair by Welding.** The Material Organization may repair by welding materials from which defects have been removed, provided the requirements of the following subparagraphs are met. Prior approval of the Certificate of Authorization Holder shall be obtained.

**CC-2533.4.1 Defect Removal.** The defect shall be removed or reduced to an acceptable size by suitable mechanical or thermal cutting or gouging methods, and the cavity prepared for welding. The area shall be examined by magnetic particle or liquid penetrant testing before repair by welding. When thermal cutting and gouging methods are used, preheating in accordance with CC-4521.1.1 shall be used.

**CC-2533.4.2 Qualification of Welding Procedures and Welders.** The welding procedures and welders or welding operators shall be qualified in accordance with CC-4500 and Section IX.

**CC-2533.4.3 Blending of Repaired Areas.** After repair, the surface shall be blended uniformly into the surrounding surface.

**CC-2533.4.4 Examination of Repair Welds.** Each repair weld shall be examined by the magnetic particle method or by the liquid penetrant method. In addition, when the depth of the repair cavity exceeds the lesser of $\frac{3}{8}$ in. (10 mm) in depth or 50% of the section thickness, the weld repair shall be radiographed and evaluated to the acceptance standards for radiographic examination in accordance with CC-4554. The weld repair shall be radiographed and evaluated to the acceptance standards of CC-5542. The penetrameter and weld repair shall be radiographed and evaluated to the acceptance standards of CC-5542. The penetrometer and weld repair shall be radiographed and evaluated to the acceptance standards of CC-5542.

**CC-2533.4.5 Heat Treatment After Repairs.** The product shall be heat treated after repair in accordance with the heat treatment requirements of CC-4554.

**CC-2533.4.6 Material Report Describing Defects and Repairs.** Each defect repair exceeding $\frac{3}{8}$ in. (10 mm) in depth or 50% of the section thickness shall be described in the CMTR when the repair is made by the Material Organization. The CMTR for each piece shall include a chart that shows the location and size of the prepared cavity, the welding material identification, the welding procedure, the heat treatment, and a report of the results of the examinations, including radiographic film.

**CC-2534 Examination and Repair of Forgings and Bars**

**CC-2534.1 Required Examinations.** Forgings and bars shall be examined visually for the presence of chip marks, blemishes, or other surface irregularities.

**CC-2534.2 Time of Examination.** Acceptance examinations shall be performed at the time of manufacture and in accordance with CC-2533.1.

**CC-2534.3 Elimination of Surface Defects.** Elimination of surface defects shall be made in accordance with CC-2533.3.

**CC-2534.4 Repair by Welding.** Repair by welding shall be made in accordance with CC-2533.4.

**CC-2535 Examination and Repair of Seamless and Welded (Without Filler Metal) Tubular Products and Fittings**

**CC-2535.1 Required Examination.**

(a) Wrought seamless tubular products and fittings shall comply with the requirements of CC-2535.1.4, CC-2535.1.5, and CC-2535.1.6; in addition, the welds shall be examined by one of the following methods:

1. ultrasonic examination in accordance with CC-2535.1.1

2. eddy current examination in accordance with CC-2535.1.3

3. radiographic examination in accordance with CC-2535.1.2

**CC-2535.1.1 Ultrasonic Examination.**

**CC-2535.1.1.1 Examination Procedure for Welds in Pipe and Tubing.**

(a) Circumferential Direction $\frac{3}{4}$ in. (171 mm) O.D. and Smaller. The welds in pipe and tubing shall be examined in two circumferential directions. The procedure for ultrasonic examination of pipe and tubing in the circumferential directions shall be in accordance with SE-213 and the requirements of this paragraph. The procedure shall provide a sensitivity that will consistently detect defects that produce indications equal to or greater than the indications produced by standard defects included in the reference specimens specified in CC-2535.1.1.3.

(b) Pipe and Tubing Larger Than $\frac{3}{4}$ in. (171 mm) O.D. The welds in pipe and tubing shall be examined in two circumferential directions. The procedure for ultrasonic examination of pipe and tubing larger than $\frac{3}{4}$ in. (171 mm) O.D. shall be in accordance with the requirements of SA-388 for angle beam scanning in the circumferential direction or with the requirements of SE-213. The reference standard shall be in accordance with CC-2535.1.1.3.
(b) The test assembly required by SFA-5.1 or SFA-5.5, as applicable, shall be used for test coupon preparation, except that it shall be increased in size to obtain the number of Charpy V-notch specimens or the drop weight test specimens required by CC-2524 or CC-2525, where applicable.

(c) The welding of the test coupon shall conform to the requirements of the SFA specification for the classification of electrode being tested. Coupons shall be tested in the as-welded condition and also in the postweld heat-treated condition. The postweld heat treatment temperature shall be in accordance with Table CC-4552-1 for the applicable P-Number equivalent. The time at postweld heat treatment temperature shall be 8 hr, which qualifies postweld heat treatments of 10 hr or less. Where the postweld heat treatment (PWHT) of the production weld exceeds 10 hr, or the PWHT temperature is other than that required above, the general test of CC-2612.1.1 shall be used.

(d) The tensile and Charpy V-notch specimens shall be located and prepared in accordance with the requirements of SFA-5.1 or SFA-5.5, as applicable. Drop weight impact test specimens, where required, shall be located and prepared in accordance with the requirements of CC-2612.1.1(d).

(e) One all-weld-metal tensile specimen shall be tested and shall meet the specified minimum tensile strength requirement of the SFA specification for the applicable electrode classification.

(f) The requirements of CC-2612.1.1(f) shall be applicable to the impact testing of the standard test.

CC-2613 Chemical Analysis Test

Chemical analysis of filler metal or weld deposits shall be made in accordance with CC-2611 and as required by the following subparagraphs.

CC-2613.1 Test Method. The chemical analysis test shall be performed in accordance with this subparagraph and Table CC-2613.1-1, and the results shall conform to CC-2613.2.

(a) A-No. 8 welding material to be used with gas tungsten-arc welding (GTAW) and plasma-arc welding (PAW) processes and any other welding material to be used with any GTAW, PAW, or GMAW process shall have chemical analysis performed on either the filler metal or on a weld deposit made with the filler metal in accordance with (c) or (d) below.

(b) See (1) and (2) below.

(1) A-No. 8 welding material to be used with other than the GTAW and PAW processes and other welding materials to be used with other than the GTAW, PAW, or GMAW process shall have chemical analysis performed on a weld deposit of the material or combination of materials being certified in accordance with (c) and (d) below. The removal of chemical analysis samples shall be from an undiluted weld deposit made in accordance with (c) below.

(2) As an alternative, the deposit shall be made in accordance with (d) for material that will be used for corrosion resistant overlay cladding. Where the Welding Procedure Specification or the welding material specification specifies percentage composition limits for analysis, it shall state that the specified limits apply for the filler metal analysis, the undiluted weld deposit analysis, or for in situ cladding deposit analysis in conformance with the above required certification testing.

(c) The preparation of samples for chemical analysis of undiluted weld deposits shall comply with the method given in the applicable SFA specification. Where a weld deposit method is not provided by the SFA specification, the sample shall be removed from a weld pad, groove, or other test weld made using the welding process that will be followed when the welding material or combination of welding materials being certified is consumed. The weld for A-No. 8 material to be used with the GMAW or EGW process shall be made using the shielding gas composition specified in the Welding Procedure Specification that will be followed when the material is consumed.

The test sample for ESW shall be removed from the weld metal of the mechanical properties test coupon. Where a chemical analysis is required for a welding material which does not have a mechanical properties test requirement, a chemical analysis test coupon shall be prepared as required by CC-2612.1.1(c), except that heat treatment of the coupon is not required and the weld coupon thickness requirements of CC-2612.1.1(c) do not apply.

The alternative method provided in (b)(2) above for preparation of samples for chemical analysis of material to be used for corrosion resistant overlay welding shall require a test weld made in accordance with the essential variables of the Welding Procedure Specification that will be followed when the welding material is consumed. The test weld shall be made in conformance with the requirements of Section IX, QW-214.1.

Removal of chemical analysis sample shall conform to V-462 for the minimum thickness for which the Welding Procedure Specifications are qualified.

The methods given in the Appendix of SFA-5.9, Specification for Corrosion Resisting Cr and Cr-Ni Steel Welding Rods and Bare Electrodes, shall be used to establish a welding and sampling method for the pad, groove, or other test weld to ensure that the weld deposit being sampled will be substantially free of base metal dilution.
CC-2613.2 Requirements for Chemical Analysis. The chemical elements to be determined, the composition requirements of the weld metal, and the recording of results of the chemical analysis shall be in accordance with the following:

(a) Welding material of ferrous alloy A-No. 8 (Section IX, Table QW-442) shall be analyzed for the elements listed in Table CC-2613.2-1 and for any other elements specified either in the welding material specification referenced by the Welding Procedure Specification or in the Welding Procedure Specification.

(b) The chemical composition of the weld metal or filler metal shall conform to the welding material specification for elements having specified percentage composition limits. Where the Welding Procedure Specification contains a modification of the composition limits of SFA or other referenced welding material specifications, or provides limits for additional elements, these composition limits of the Welding Procedure Specification shall apply for acceptability.

(c) The results of the chemical analysis shall be reported in the Certified Material Test Report. Elements listed in Table CC-2613.2-1, but not specified in the welding material specification or Welding Procedure Specification shall be reported for information only.

CC-2613.3 Delta Ferrite Determination. A determination of delta ferrite shall be performed on A-No. 8 weld material (Section IX, Table QW-442), backing filler metal (consumable inserts), bare electrode, rod, or wire filler metal, or weld metal, except that delta ferrite determinations are not required for SFA-5.4, Type 16-8-2, or A-No. 8 weld filler metal to be used for weld metal cladding.

CC-2613.3.1 Method. Delta ferrite determinations of welding material, including consumable insert material, shall be made using a magnetic measuring instrument and weld deposits made in accordance with (b) below. Alternatively, the delta ferrite determinations for welding materials may be performed by the use of chemical analysis of CC-2613 in conjunction with Figure CC-2613.3.1-1.

(a) Calibration of magnetic instruments shall conform to AWS-A4.2.

(b) The weld deposit for magnetic delta ferrite determination shall be made in accordance with CC-2613.1(c).

CC-2613.3.2 Acceptance Standards. The minimum acceptable delta ferrite shall be 5FN (Ferrite Number). The results of the delta ferrite determination shall be included in the Certified Material Test Report of CC-2130 or CC-4120.

CC-2614 Storage and Handling of Welding Material

Suitable storage and handling of electrodes, flux, and other welding material shall be maintained. Precautions shall be taken to minimize absorption of moisture by fluxes and cored, fabricated, and coated electrodes.

CC-2620 STUD WELDING MATERIAL

CC-2621 General Requirements

CC-2621.1 Material Specifications. Stud material shall conform to ASTM A108, Grades 1010, 1015, 1016, 1018, or 1020, and to the additional requirements described in this paragraph.

CC-2621.2 Definitions.

(a) Stud base as used herein shall be considered as the stud tip at the welding end, including flux and container, and ⅛ in. (3 mm) of the body of the stud adjacent to the tip.

(b) Angle of bend in testing studs as used herein shall be measured between the original axis of the base material and a line passing through the centers of the two ends of the bent stud.

CC-2621.3 Stud Design. Studs shall be of a design suitable for arc welding to steel members with automatically timed stud welding equipment. The type, size or diameter, and length of stud shall be as specified by the Construction Specification. Dimensions and tolerances of standard type studs are given in Figure CC-2620-1.

CC-2621.4 Surface Condition. Finished studs shall be of uniform quality and condition, free of injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. A stud with cracks or bursts deeper than one-half the distance from the periphery of the head to the shank shall be cause for rejection.

CC-2622 Stud Base Requirements

CC-2622.1 Arc Shield. An arc shield (ferrule) of heat resistant ceramic or other suitable material shall be furnished with each stud.

CC-2622.2 Flux. A suitable deoxidizing and arc stabilizing flux for welding shall be furnished with each stud of ⅛ in. (8 mm) diameter or larger. Studs less than ⅛ in. (3 mm) diameter may be furnished with or without flux.

CC-2622.3 Base. The stud base shall not be painted, galvanized, or plated.

It is noted heads of studs are subject to cracks or bursts, which are terms that designate an abrupt interruption of the periphery of the head of the stud by radial separation of the metal. Such interruptions do not adversely affect the structural strength, corrosion resistance, or other functional requirements of studs. However, studs
CC-2630 IDENTIFICATION OF WELDING MATERIAL

(a) The identification of welding material (including stud welding material) shall meet the requirements of NCA-4256.4.

(b) Welding material shall be controlled during the repair of material and the manufacture and installation of components so that they are identifiable as accepted material until the material is actually consumed in the process (CC-4122).

CC-2700 MATERIAL FOR EMBEDMENT ANCHORS

CC-2710 INTRODUCTION

This subarticle establishes the requirements for load-bearing steel materials that are embedded in the concrete containment to perform a containment function. These requirements do not apply to liner, liner attachments or anchor components of prestressing systems.

CC-2711 Permitted Material Specifications

The material to be used for the construction of embedment anchors are listed in Table D2-I-2.3. Material listed in Table D2-I-2.2 may also be used.

CC-2712 Requirements for Nuts and Washers

(a) Material for nuts shall conform to ASTM A563 or to the requirements for nuts in the specification for the bolting material which is to be used.

(b) Nuts shall be threaded to Class 2B or finer tolerances according to ANSI B1.1. Materials for nuts and washers shall be selected as follows:

(1) Carbon steel nuts and carbon steel washers may be used with carbon steel bolts or studs.

(2) Carbon or alloy steel nuts and carbon or alloy steel washers of approximately the same hardness as the nuts may be used with alloy steel bolts or studs.

(c) Nuts shall be semifinished, extra heavy, chamfered, and trimmed.

Table CC-2623.2-1
Strength Requirements for Studs

<table>
<thead>
<tr>
<th></th>
<th>Type A [Note (1)]</th>
<th>Type B</th>
<th>Type C [Note (1)]</th>
<th>Type D [Note (1)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield strength, psi (MPa) (minimum)</td>
<td>...</td>
<td>...</td>
<td>50,000 (345)</td>
<td>55,000 (380)</td>
</tr>
<tr>
<td>Tensile strength, psi (MPa) (minimum)</td>
<td>55,000 (380)</td>
<td>60,000 (410)</td>
<td>65,000 (450)</td>
<td>75,000 (520)</td>
</tr>
<tr>
<td>Elongation in 2 in. (50 mm), % (minimum)</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Reduction of area, % (minimum)</td>
<td>...</td>
<td>50</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

NOTE:
(1) Not to be used as shear connector studs.

CC-2720 FRACTURE TOUGHNESS REQUIREMENTS FOR EMBEDMENT ANCHOR MATERIALS

Fracture toughness requirements for embedment anchor materials shall be in accordance with CC-2520.

CC-2730 EXAMINATION AND REPAIR OF EMBEDMENT ANCHOR MATERIAL

CC-2731 Examination and Repair of Embedment Anchor Material Other Than Bolting

(a) Material for embedment anchors shall be examined in accordance with the material specification. Unacceptable defects may be repaired as permitted by the material specification.

(b) Structural steel rolled shapes, which are permitted by the section to be furnished with a certificate of compliance, may be repaired by welding using welders, documentation, and examination requirements specified in SA-6.

CC-2732 Examination of Bolting Material and Rods

Bolts, studs, and nuts shall be examined in accordance with the requirements of the material specification and CC-2733.

CC-2733 Visual Examination

The final surfaces of threads, shanks, and heads of bolts, studs, and nuts shall be visually examined for workmanship, finish, and appearance in accordance with the requirements of ASTM F788 for bolting material and ASTM F812 for nuts. The visual examination personnel shall be trained and qualified in accordance with the Material Organization’s Quality System Program or the Certificate Holder’s Quality Assurance Program. These examinations are not required to be performed either in accordance with procedures qualified to CC-5112 or by personnel qualified in accordance with CC-5120.

CC-2734 Repair by Welding

Weld repairs of bolting material and rods are not permitted.
CC-3133  **Serviceability**
Serviceability defines behavior for service or factored load conditions that are not defined by strength or stress limitations. It includes those items where distortion, concrete crack size, or strain are limited. Examples are weathering of concrete, mechanism distortion at hatches and penetrations, liner leakage, and containment interaction with adjacent structures.

CC-3134  **Reinforced Concrete**
Reinforced concrete is concrete containing reinforcement and designed on the assumption that the two materials act together in resisting forces.

CC-3135  **Prestressed Concrete**
Prestressed concrete is reinforced concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from loads are counteracted to a desired degree.

CC-3136  **Stresses and Forces**
CC-3136.1  **Membrane Stress.** Membrane stress is the component of normal stress, hoop or meridional, which is uniformly distributed and equal to the average of stress across the thickness of the section under consideration.

CC-3136.2  **Bending Stress.** Bending stress is the variable component of normal stress. The variation may or may not be linear across the thickness.

CC-3136.3  **Shear Stress.** Shear stress may be radial, tangential, peripheral (punching), or torsional.

(a) Radial shear stress is a flexural shear stress which acts perpendicular to the plane of the wall or other element of the containment structure.

(b) Tangential shear stress is a membrane shear stress which acts in the plane of the wall or other element of the containment structure.

(c) Peripheral shear stress is a shear stress around a punching type shear surface, produced by local externally applied forces acting perpendicular to the plane of the wall or other element.

(d) Torsional shear stress is a stress in the plane of the wall or other element of the containment structure produced by components of local externally applied moments about an axis perpendicular to the wall or other element.

CC-3136.4  **Primary Force.** Primary force is a local, internal force (kip/ft) (N/m) or moment (kip-ft/ft) (N·m/m) which is required to equilibrate applied loads. Thus, a secondary force may be either:

(a) a local, internal force, or moment that results from applied loads, but is not required to equilibrate such loads; or

(b) a local, internal force, or moment that results from nonload, volume change effects, such as shrinkage strain and thermal strain.

CC-3136.5  **Secondary Force.** Secondary force is a local, internal force (kip/ft) (N/m) or moment (kip-ft/ft) (N·m/m) that is not required for equilibrating the applied loads. Thus, a secondary force may be either:

(a) a local, internal, force or moment that results from applied loads, but is not required to equilibrate such loads; or

CC-3136.6  **Classification of Forces.** Forces shall be classified in accordance with Table CC-3136.6-1.

CC-3140  **TOLERANCES**
The Construction Specification shall delineate the tolerance requirements for fabrication and construction. The Designer shall ensure that the tolerances specified in the Construction Specification are compatible with the design assumptions.

CC-3200  **LOAD CRITERIA**
CC-3210  **GENERAL**
The containment shall be designed to resist the loads and load combinations given in this Article and as specified in the Design Specification (NCA-3250). The design shall not be limited to the loads specified herein if any other loads are applicable to the particular site conditions.

CC-3220  **LOAD CATEGORIES**
CC-3221  **Service Loads**
CC-3221.1  **Normal Loads.** Normal loads are loads which are encountered during normal plant operation and shutdown.

\[
\begin{align*}
D &= \text{dead loads, including hydrostatic and permanent equipment loads} \\
F &= \text{loads resulting from the application of prestress} \\
G &= \text{loads resulting from relief valve or other high energy device actuation} \\
L &= \text{live loads, including any movable equipment loads and other loads which vary with intensity and occurrence, such as soil pressures} \\
P_v &= \text{external pressure loads resulting from pressure variation either inside or outside the containment} \\
R_o &= \text{pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition} \\
T_o &= \text{thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition}
\end{align*}
\]
(b) The stress may exceed that given in (a) above for compatibility with the concrete but this stress may not be used for load resistance.

(c) The values given in (a) above may be increased by $33\frac{1}{3}\%$ when the following loads are combined with other loads in the load combination:

1. the temporary loads from prestressing which will be reduced at completion of prestressing
2. the temporary pressure loads during the test condition
3. when secondary forces, defined in Table CC-3136.6-1, are combined with other forces, provided the section thus required is not less than that required for the combination of other loads in the loading combination.

**CC-3433 Tendon System Stresses**

Tensile stress in prestressing steel shall not exceed the following:

(a) Due to prestressing steel jacking force, the tendon tensile stress shall not exceed $0.94f_y$ but not greater than the lesser of $0.80f_{pu}$, and the maximum value recommended by the manufacturer of prestressing steel or anchorage devices.

(b) Immediately after anchoring, the tension stress at the anchor point shall not exceed $0.81f_y$ or $0.73f_{pu}$, and the average tension stress at the anchorage point of the tendon group 13 after anchoring shall not exceed $0.70f_{pu}$. 

(c) For the purpose of design, the effective prestress shall be based on tendon stresses not exceeding those calculated to occur immediately after anchoring minus all applicable losses defined in CC-3420.

**CC-3440 CONCRETE TEMPERATURES**

(a) The following temperature limitations are for normal operation or any other short-term period. The temperatures shall not exceed $150^\circ\text{F}$ ($65^\circ\text{C}$) except for local areas, such as around a penetration, which are allowed to have increased temperatures not to exceed $200^\circ\text{F}$ ($95^\circ\text{C}$).

(b) The following temperature limitations are for accident or any other short-term period. The temperatures shall not exceed $350^\circ\text{F}$ ($175^\circ\text{C}$) for the interior surface. However, local areas are allowed to reach $650^\circ\text{F}$ ($345^\circ\text{C}$) from steam or water jets in the event of a pipe failure.

(c) Higher temperatures than given in (a) and (b) above may be allowed in the concrete if tests are provided to evaluate the reduction in strength and this reduction is applied to the design allowables. Also, evidence shall be provided which verifies that the increased temperatures do not cause deterioration of the concrete either with or without load.

**CC-3500 CONTAINMENT DESIGN DETAILS**

**CC-3510 DESIGN FOR FLEXURE AND AXIAL LOADS**

**CC-3511 Assumptions**

**CC-3511.1 Factored Load Design.**

(a) The design of sections for flexure and membrane loads shall be based on the assumptions given in this paragraph and on satisfaction of the applicable conditions of equilibrium and compatibility of strains.

(b) Strain in the reinforcing steel and concrete shall be assumed directly proportional to the distance from the neutral axis.

(c) Stress in reinforcement below $0.9$ of the specified yield strength for the grade of steel used shall be taken as $E_y$ times the steel strain. For strains greater than that corresponding to $0.9f_y$, the stress in the reinforcement shall be considered independent of strain and equal to $0.9f_y$.

(d) Tensile strength of the concrete shall be neglected in flexural calculations of reinforced concrete.

(e) The relationship between the concrete compressive stress distribution and the concrete strain used in the analysis of sections may be assumed to be a triangle, parabola, or any other shape that results in prediction of stress and strains in substantial agreement with the results of comprehensive tests. The stresses determined shall be compared to the stress limits of CC-3420 to ensure design adequacy.

**CC-3511.2 Service Load Design.** The straight line theory of stress and strain shall be used and the following assumptions shall be made:

(a) A section plane before bending remains plane after bending; strains vary as the distance from the neutral axis.

(b) The stress–strain relation for concrete is a straight line under service loads within the allowable stresses; stresses vary as the distance from the neutral axis.

(c) Tensile stress of the concrete shall be neglected in flexural calculations of reinforced concrete.

(d) The modular ratio, $n = E_s/E_c$, may be taken as the nearest whole number but not less than 6. In doubly reinforced members, an effective modular ratio of $2E_s/E_c$ may be used to transform the compression reinforcement for stress computations.

**CC-3520 DESIGN OF SHEAR REINFORCEMENT**

**CC-3521 Factored Load Design**

**CC-3521.1 Tangential Shear and Membrane Forces.**

**CC-3521.1.1 Reinforced Concrete.**

(a) Required area of orthogonal (hoop and meridional) reinforcement, with or without inclined reinforcement, provided for combined tangential shear and membrane strength shall be computed by

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Tendon group is defined by its geometry and position in the containment, e.g., vertical, hoop, dome, inverted “U.”
\( t = \text{nominal thickness of liner} \)
\( t_a = \text{nominal thickness of attachments to liner} \)
\( t_c = 0.7t_n, 0.7t_1, 0.7t_a, \text{or } \frac{1}{4} \text{ in. (6 mm)}, \text{whichever is less} \)
\( t_{\text{min}} = \text{the smaller of } \frac{3}{4} \text{ in. (19 mm) or the thickness} \)
\( t_n = \text{nominal thickness of penetrating part} \)
\( t_w = 0.7t_{\text{min}} \)
\( t_1 \text{ or } t_2 = \text{not less than the smaller of } \frac{1}{4} \text{ in. (6 mm) or } 0.7t_{\text{min}} \)
\( t_1 + t_2 \geq 1\frac{1}{4}t_{\text{min}} \)

**CC-3843 Unequal Thickness Transitions**

A tapered transition section having a length not less than three times the offset between the adjacent section surfaces as shown in Figure CC-3840-1 shall be provided at joints of Categories A and B between sections that differ in thickness by more than one-fourth of the thickness of the thinner section. The transition section may be formed by any process that will provide a uniform taper.

**CC-3900 DESIGN CRITERIA FOR IMPULSE LOADINGS AND MISSILE IMPACT**

**CC-3910 GENERAL**

Containment and liner shall be designed to resist the effects of impulse loadings from pipe rupture and the impact of missiles resulting from pipe rupture, tornadoes, or any other missile specified in the Design Specification in accordance with CC-3200. Load classifications are given in CC-3240.

**CC-3920 DESIGN ALLOWABLES**

**CC-3921 General**

**CC-3921.1 Normal and Severe Environmental Load Categories.** Structural members designed to resist loads in the normal and severe environmental load categories are not allowed to exceed yield.

**CC-3921.2 Abnormal, Extreme Environmental, Abnormal and Extreme Environmental Load Categories.** Structural members designed to resist impulse loads and dynamic effects in the abnormal, extreme environmental, and abnormal and extreme environmental categories are allowed to exceed yield strain and displacement values. Design adequacy is controlled by limiting the ductility assumed in evaluating the energy absorption capability or resistance function of the structure.

**CC-3922 Stress Allowables**

The allowable stresses applicable to the determination of section strength are given in CC-3400 and CC-3700. In determining \( f_y \) values, the dynamic effect of the loading may be considered.

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**Figure CC-3840-1**

**Tapered Transition Sections**

NOTE:

(1) Length of taper may include the width of the weld.
ARTICLE CC-5000
CONSTRUCTION TESTING AND EXAMINATION

CC-5100 GENERAL REQUIREMENTS FOR EXAMINATION

CC-5110 PROCEDURES, QUALIFICATION, AND EVALUATIONS

CC-5111 General Requirements

Nondestructive examination, except leak testing by the vacuum box technique, shall be in accordance with the examination procedures of Section V. Leak testing by the vacuum box technique shall be in accordance with Mandatory Appendix D2-VI. For radiography, geometric unsharpness shall not exceed the limits of Section V, Article 2, T-274.2. The examinations shall be performed by personnel who have been qualified as required in this Article. The results of the examinations shall be evaluated in accordance with the acceptance standards of this Article. The examination of parts and appurtenances meeting the requirements for Class MC and which are not backed up by concrete for load carrying purposes shall meet the requirements of Article NE-5000 and Subsection NCA. Examination of embedded attachments to parts examined to the requirements of Division 1 shall meet the requirements of this Article.

CC-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. Section V Special configurations and materials may require modified methods and techniques. In these cases, special procedures which are at least equivalent to the methods and techniques recommended by Section V shall be developed. Written procedures and records of demonstration of procedure capability and personnel qualification shall be available to the Inspector upon request. At least one copy of each procedure shall be readily available to all appropriate nondestructive examination personnel for reference and use.

CC-5120 QUALIFICATION AND CERTIFICATION OF NONDESTRUCTIVE EXAMINATION PERSONNEL

CC-5121 General Requirements

Organizations performing Code required nondestructive examinations shall use personnel competent and knowledgeable to the degree specified by CC-5122. 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 CC-5122. All nondestructive examinations required by this Subsection shall be performed by and the results evaluated by qualified nondestructive examination personnel.

CC-5122 Qualification, Certification, and Verification

CC-5122.1 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 para. 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. The basic examination, paragraph 8.8.3 of SNT-TC-1A, may be prepared and administered by the Employer or 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%.

SNT-TC-1A is a Recommended Practice for Nondestructive Testing. Personnel Qualification and Certification published by the American Society for Nondestructive Testing. Personnel qualified by examination and certified to the previous editions of SNT-TC-1A are considered to be qualified to the edition referenced in Table NCA-7100-3 when the recertification is based on continuing satisfactory performance. All reexaminations and new examinations shall be in accordance with the edition referenced in Table NCA-7100-3.
disqualify the lot of concrete constituents represented. The examinations and tests required by this subarticle shall be performed by the Constructor, Fabricator, or Manufacturer of Nonmetallic Materials and monitored by the Authorized Inspector in accordance with Article NCA-5000. If the examinations and tests are performed by the Manufacturer of Nonmetallic Materials, provisions shall be made for the Authorized Inspector of the Constructor or Fabricator, as applicable, to make the necessary inspections to ensure compliance with this subarticle. The results shall be verified by the Fabricator or Constructor.

CC-5211 Laboratory Qualification

The tests required by CC-5200 shall be performed by an accredited laboratory that complies with ASTM C1077, except that testing personnel shall be qualified in accordance with CC-5132.

CC-5220 CONCRETE CONSTITUENTS

CC-5221 Cementitious Materials

CC-5221.1 Requirements. Quality control testing shall be performed by the Constructor to ascertain conformance of cementitious materials to applicable requirements of ASTM C150/C150M, ASTM C595/C595M, ASTM C618, ASTM C989, and ASTM C1240, as shown in Table CC-5200-1.

CC-5221.2 Testing Frequency. The frequency of testing shall be as shown in Table CC-5200-1.

CC-5221.3 Uniformity Requirements. The quality control testing for fly ash and pozzolan shall be evaluated to ascertain conformance with ASTM C618 uniformity requirements for
(a) specific gravity (density)
(b) fineness

CC-5222 Admixtures

CC-5222.1 Air-Entraining Admixtures. The quality control testing for fly ash and pozzolan shall be performed using procedures recommended by the Manufacturer: infrared analysis, pH, and solids content. Additionally, the optional uniformity requirements of ASTM C260 shall apply — pH, specific gravity, and air content.

CC-5222.2 Testing Frequency. Quality control tests shall be conducted on the admixture prior to use in accordance with Table CC-5200-1.

CC-5222.3 Grout Fluidifier. Requirements. Quality control testing shall be performed to ascertain conformance to ASTM C937.

CC-5222.4 Chemical Admixtures

CC-5222.4.1 Requirements. Quality control testing shall be performed to ascertain conformance to ASTM C937.

CC-5222.4.2 Testing Frequency. Quality control tests shall be conducted on the fluidifier in accordance with Table CC-5200-1.

CC-5223 Aggregates

CC-5223.1 Requirements. Quality control tests shall be as shown in Table CC-5200-1. Aggregate samples for gradation, moisture content, and material finer than #200 sieve tests shall be obtained from conveyors, bins, or chutes at the batch plant. Aggregate samples for other quality control tests may be obtained from these same locations, at the point of delivery, or from stockpiles.

If the aggregate sampled for gradation and materials finer than #200 sieve tests are not within the specification limits, two additional samples shall be obtained from the same location and tested. If both of the retest samples are within specification limits, the aggregate is acceptable. If either or both of the retest samples are outside of the specification limits, the three test results shall be averaged. This test result shall be averaged with the previous five aggregate test results. If the average of the six tests is within specification limits, the remaining aggregate is acceptable. If the average of the six tests is outside specification limits, the remaining aggregate shall be adjusted to bring the aggregate within limits or the aggregate shall be rejected.

If the aggregate sampled for the other quality control tests is outside the specification limits, two additional aggregate samples shall be obtained from the same location and tested. If both samples are within the specification limits, the aggregate is acceptable.

CC-5223.2 Testing Frequency. The frequency of testing shall be as shown in Table CC-5200-1.

CC-5224 Mixing Water

CC-5224.1 Requirements. Quality control testing shall be performed to ensure conformity with the requirements of CC-2223.

CC-5224.2 Testing Frequency. The frequency of testing shall be as shown in Table CC-5200-1.

Such laboratory inspections can be provided by the Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology, with accreditation programs provided by the National Voluntary Laboratory Accreditation Program (NVLAP), American Association for Laboratory Accreditation (AALA), and Construction Materials Engineering Council (CMEC).
penetrate the thermal barrier or at other locations within the bulk concrete due to radiation heating or other causes. It also includes liner areas subjected to high temperature jet impingement.

membrane stress: the component of normal stress, hoop or meridional, that is uniformly distributed and equal to the average of stress across the thickness of the section under consideration.

microindentation hardness test: a hardness test using a calibrated machine to force a diamond indenter of specific geometry into the surface of the test material being evaluated.

mineral admixture (fly ash and pozzolans): a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

operating basis earthquake: for a site, that which produces the vibratory ground motion for which those features of the power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.

operating basis wind: wind velocities and forces required for the design of a structure in accordance with the uniform building code.

peak stress: total stress due to local discontinuities or local thermal stress including the effects of stress concentrations. Its basic characteristic is that it does not cause any noticeable distortion and is objectionable only as a possible source of a fatigue crack or brittle fracture or a localized concrete crack. A stress that is not highly localized falls into this category if it is of a type that cannot cause noticeable distortion. Examples are stresses at a local discontinuity and thermal stresses produced by a local hot spot.

point stress: the maximum apparent stress calculated by adding the membrane stress and the maximum bending stress calculated by elemental beam equations. When advanced analytical methods (e.g., finite element analysis) are used for design, the point stress is defined as the maximum stress across the section under consideration.

primary stress: any normal stress or a shear stress developed by an imposed loading that is necessary to satisfy the laws of equilibrium of external and internal forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses that considerably exceed the yield strength in a steel member or gross cracking in concrete will result in failure or in gross distortion. A thermal stress is not classified as a primary stress. Examples are stresses due to internal pressure or to distributed live loads and bending stress in the central portion of a flat slab due to pressure.

safe shutdown earthquake: for a site, that which produces the vibratory ground motion for which those features of the power plant necessary to shut down the reactor and maintain the plant in a safe condition without undue risk to the health and safety of the public are designed to remain functional.

secondary stress: a normal stress or shear stress developed by the constraint of adjacent material or by self-constraint of the structure. Its basic characteristic is that it is self-limiting. Local yielding, minor distortions, and concrete cracking can satisfy the conditions that cause the stress to occur, and failure is not to be expected. Examples are general thermal stresses, bending stress at a gross structural discontinuity, and stresses induced by concrete shrinkage and creep.

shear connectors: general term for steel members attached to the liner and embedded in the concrete to provide general compatibility of strains between liner and concrete.

structural integrity: the ability of a structure or component to withstand prescribed loads.

tendon: the complete assembly consisting of pre-stressing steel and anchorages, and couplings. The tendons impart prestressing forces to the concrete.

prestressing element: an individual wire, strand, or bar, whether in a multiple or single wire, strand, or bar system.

As applied in this Division, membrane stress is not to be substituted for principal stress or stress intensity.
\( P_c = \) pressurized crack pressure load
\( p_c = \) pressurized crack pressure
\( P_d = \) differential flow pressure load
\( p_d = \) differential flow pressure
\( P_l = \) local pressure buildup load
\( p_l = \) local pressure buildup
\( p_m = \) maximum cavity pressure
\( P_m = \) maximum cavity pressure load
\( p_o = \) operational maximum
\( P_o = \) operational maximum
\( P_s = \) steel force at jacking
\( p_t = \) test pressure
\( P_t = \) test pressure load
\( p_v = \) subatmospheric minimum
\( P_v = \) subatmospheric minimum pressure load
\( P_x = \) steel force at any point \( x \)
\( Q = \) plant movable equipment loads
\( R_a = \) piping loads due to increased temperature resulting from the design accident
\( R_o = \) piping loads during operating conditions
\( R_r = \) local effects on the containment due to the design basis accident. The local effects shall include the following:

\[ R_{rj} = \] load on the containment generated by the design basis accident (for example, jet impingement from a ruptured high energy pipe during the postulated event). The time-dependent nature of the load and the ability of the structure to deform beyond yield shall be considered in establishing the structural capacity necessary to resist the effects of \( R_{rj} \).

\[ R_{rm} = \] effects resulting from the impact of a ruptured high energy pipe on the containment during the design basis accident. The type of impact (e.g., plastic, elastic) together with the ability of the structure to deform beyond yield shall be considered in establishing the structural capacity necessary to resist the impact.

\[ R_{rr} = \] load on the containment generated by the design basis accident (for example, reaction of a ruptured high energy pipe during the postulated event). The time-dependent nature of the load and the ability of the structure to deform beyond yield shall be considered in establishing the structural capacity necessary to resist the effects of \( R_{rr} \).

\( s = \) spacing of shear reinforcement in a direction parallel to the longitudinal reinforcement
\( S = \) standard deviation
\( T_a = \) accident/incident temperature effects
\( T_o = \) operating temperature effects
\( T_p = \) preoperational heatup temperature effects
\( T_t = \) test temperature effects
\( v_c = \) nominal permissible shear stress carried by concrete
\( V_s = \) membrane shear force
\( v_u = \) nominal total design shear stress
\( V_u = \) total applied design shear force at section
\( W = \) wind loads
\( W_t = \) tornado load
\( W_{tm} = \) tornado-generated missile impact effects. The type of impact (for example, plastic, elastic) together with the ability of the structure to deform beyond yield shall be considered in establishing the structural capacity necessary to resist the impact.

\( W_{tp} = \) differential pressure loads due to rapid atmospheric pressure
\( W_{tq} = \) loads due to tornado wind pressure
\( x = \) distance from extreme compression fiber to neutral axis
\( Y = \) dynamic force loads
\( Y_j = \) jet impingement due to fluid discharge
\( Y_m = \) missile impingement load
\( Y_r = \) reaction load due to fluid discharge
\( Y_w = \) water force dynamic load
\( \alpha = \) angle between inclined shear reinforcement and longitudinal axis of member
\( \alpha_x = \) total angular deviation of prestressing steel profile in radians from jacking end to any point \( x \)
\( \delta_a = \) allowable displacement for liner anchors
\( \delta_u = \) ultimate displacement capacity for liner anchors
\( \mu = \) coefficient of friction
\( \mu_p = \) curvature friction coefficient
\( \rho = A_s/bd \)
\( \epsilon_{sc} = \) allowable liner plate compressive strain
\( \epsilon_{st} = \) allowable liner plate tensile strain

As defined in U.S. NRC Regulatory Guide 1.70
NONMANDATORY APPENDIX D2-B
NONMANDATORY PREHEAT PROCEDURES

ARTICLE D2-B-1000
NONMANDATORY PREHEAT PROCEDURES

D2-B-1100 INTRODUCTION

D2-B-1110 SCOPE

The preheat temperatures given herein are a general guide for the materials listed in P-Numbers of Section IX, Specific rules for preheating are not given, and the minimum preheating temperatures suggested are not mandatory. The Welding Procedure Specification for the material being welded shall specify the minimum preheating requirements under the welding procedure qualification requirements of Section IX.

D2-B-1120 TEMPERATURE MAINTENANCE

(a) Difficulty may be experienced with certain materials if the temperature is allowed to fall below the preheat temperature between passes. It may be desirable to maintain the preheat temperature or to heat the joint to the postweld treatment temperature before allowing it to cool to ambient temperature.

(b) The preheat temperature may be checked by suitable methods, such as temperature-indicating crayons or thermocouple pyrometers, to ensure that the required preheat temperature is maintained during the welding operation. The Fabricator or Constructor should be cautious in the use of temperature-indicating crayons and pellets because some metals may be severely attacked by the chemicals in crayons or pellets at elevated temperatures.

D2-B-1200 FERROUS MATERIAL

D2-B-1210 PREHEAT TEMPERATURES

D2-B-1211 Group P-No. 1

A temperature of 175°F (80°C) is suggested for material that has both a specified maximum carbon content in excess of 0.30% and a thickness in excess of 1 in. (25 mm) This does not apply to fillet welds 1/2 in. (13 mm) and under in size that are used to attach parts not carrying loadings due to internal pressure. For all other material in this group, 50°F (10°C) is suggested. It is suggested that stud welding be performed at not less than 0°F (−18°C). When the ambient temperature is less than 32°F (0°C), it is suggested that the stud welding procedure be tested at the start of each day’s production welding period. Testing shall be done by bend testing of two studs to an angle of 15 deg and returning to their original position.

D2-B-1212 Group P-No. 8

No preheat temperatures are suggested.

These requirements do not apply to the arc welding of reinforcing bar, the requirements for which are given in D2-VIII-1550.

The temperature 0°F (−18°C) does not mean the ambient environmental temperature but the temperature in the immediate vicinity of the weld. The ambient environmental temperature may be below 0°F (−18°C), but a heated structure or shelter around the area being welded could maintain the temperature adjacent to the weldment at 0°F (−18°C) or higher.
1 Such laboratory inspections can be provided by the Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology, with accreditation programs provided by the National Voluntary Laboratory Accreditation Program (NVLAP), American Association for Laboratory Accreditation (AALA), and American Materials Engineering Council (CEMC).

2 The term **prestressing element** is defined as an individual wire, strand, or bar, whether in a multiple or single wire, strand, or bar system.

3 \( T_{\text{NDT}} \): temperature at or above the nil-ductility transition temperature NDT (ASTM E208); \( T_{\text{NDT}} \) is 10°F (6°C) below the temperature at which at least two specimens show no-break performance.

4 The **lowest service metal temperature** shall be the lowest temperature that the metal may experience in service while the plant is in operation and shall be established by appropriate calculations based on atmospheric ambient conditions, the insulation or enclosure provided, and the minimum temperature that will be maintained inside the containment during the plant operation.

5 The requirements for impact testing of the heat-affected zone (CC-4533.5) may result in reduced impact test temperatures for the base material.

6 The **lowest overpressure test metal temperature** shall be the lowest temperature that the metal may experience during the overpressure test and shall be established by appropriate calculations based on atmospheric conditions, the insulation or enclosure provided, and the temperature that will be maintained inside the vessel during the test.

7 Any postweld heat treatment time that is anticipated to be applied to the material during fabrication or construction after completion of manufacture shall be specified in the Construction Specification. The Material Organization shall include this time in the total time at temperature specified to be applied to the test specimens.

8 The volumetric examinations required by this paragraph need only be conducted from one surface.

9 The methods given in the Appendix of SFA-5.9, Specification for Corrosion-Resisting Cr and Cr–Ni Steel Welding Rods and Bare Electrodes, shall be used to establish a welding and sampling method for the pad, groove, or other test weld to ensure that the weld deposit being sampled will be substantially free of base metal dilution.

10 Heads of studs are subject to cracks or bursts, which are terms that designate an abrupt interruption of the periphery of the head of the stud by radial separation of the metal. Such interruptions do not adversely affect the structural strength, corrosion resistance, or other functional requirements of studs.

11 The word *rods* as used in this subarticle is intended to cover rods that are threaded. It also includes forged piston rods if they are threaded for a portion of their length. It does not apply to unthreaded bar stock.

12 As applied in this Division, not to be substituted for principal stress or stress intensity.

13 Tendon group is defined by its geometry and position in the containment, e.g., vertical, hoop, dome, inverted “U.”

14 **Ductility** is defined as the ratio of maximum deformation or strain of the member at the point of collapse to the maximum elastic deformation or strain.

15 SNT-TC-1A is a Recommended Practice for Nondestructive Testing Personnel Qualification and Certification published by the American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228-0518.

16 Personnel qualified by examination and certified to the previous editions of SNT-TC-1A are considered to be qualified to the editions referenced in Table NCA-7100-3 when the recertification is based on continuing satisfactory performance. All reexaminations and new examinations shall be in accordance with the applicable edition referenced in Table NCA-7100-3.
17 Employer as used in this Article shall include N, NPT, or NA Certificate Holders; Quality System Certificate Holders; Material Organizations who are qualified in accordance with NCA-3842; and organizations who provide subcontracted nondestructive examination services to organizations described above.

18 Such laboratory inspections can be provided by the Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology, with accreditation programs provided by the National Voluntary Laboratory Accreditation Program (NVLAP), American Association for Laboratory Accreditation (AALA), and American Materials Engineering Council (CEMC).

19 As applied in this Division, membrane stress is not to be substituted for principal stress or stress intensity.

20 As defined in U.S. NRC Regulatory Guide 1.70.

21 These requirements do not apply to the arc welding of reinforcing bar, the requirements for which are given in D2-VIII-1550.

22 The temperature 0°F (−18°C) does not mean the ambient environmental temperature but the temperature in the immediate vicinity of the weld. The ambient environmental temperature may be below 0°F (−18°C), but a heated structure or shelter around the area being welded could maintain the temperature adjacent to the weldment at 0°F (−18°C) or higher.