

2010 SECTION III, DIVISION 2

CC-2300 MATERIAL FOR REINFORCING SYSTEMS**CC-2310 INTRODUCTION**

(a) The material to be used for reinforcing bars for containments shall conform to ASTM A 615 or A 706 and the special requirements described in CC-2330.

(b) The material to be used for bar-to-bar splice sleeves in reinforcing bars shall conform to ASTM A 513, A 519, or A 576.

(c) The material to be used for reinforcing bar splice sleeves attached to liner plates or structural steel shapes shall be carbon steel conforming to ASTM A 513, A 519, or A 576 Grades 1008 through 1030.

(d) Only material listed in Table I-2.1 may be used for joining reinforcing bar to liner plate or structural steel shapes by welding.

CC-2320 MATERIAL IDENTIFICATION

Reinforcing systems material shall be tagged or marked to ensure traceability to the Certified Material Test Report during production and while in transit and storage.

CC-2330 SPECIAL MATERIAL TESTING**CC-2331 Tensile Tests**

CC-2331.1 Number of Tests Required. One full-diameter tensile bar of each bar size shall be tensile tested for each 50 tons (45 Mg), or fraction thereof, of reinforcing bars produced from each heat of steel. The tensile test procedures shall be in accordance with SA-370.

CC-2331.2 Acceptance Standards. The acceptance standards shall be in conformance with the tensile requirements of ASTM A 615 or ASTM A 706, as applicable. If a test specimen fails to meet the tensile requirements, two additional specimens from the same heat and of the same bar size shall be tested. If either of the two additional specimens fails to meet the tensile requirements, the material represented by the tests shall not be accepted.

CC-2333 Chemical Analysis

A ladle analysis of each heat of reinforcing bar shall be made and reported in accordance with A 615 or A 706, as applicable.

CC-2333.1 Reinforcing Bar Intended for Welding

(a) ASTM A 706 and ASTM A 615 may be welded by any of the welding processes listed in VIII-1400.

(b) The ladle analysis of ASTM A 615 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 comply with the 0.55% maximum carbon equivalent as computed in VIII-1430.

(c) The results of the product verification analysis for ASTM A 706 reinforcing bar shall not exceed that specified in ASTM A 706. Product verification analysis for ASTM A 615 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 elements² are limited to those listed in Appendix I, Table I-1.1. 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 E 328, Standard

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.

TABLE CC-3421-1
ALLOWABLE COMPRESSION STRESSES FOR FACTORED LOADS

| Primary | | Primary Plus Secondary [Note (1)] | |
|-------------|-------------------------------------|--------------------------------------|-------------------------------------|
| Membrane | Membrane Plus Bending [Note (2)] | Membrane | Membrane Plus Bending [Note (2)] |
| $0.60 f'_c$ | $0.75 f'_c$ | $0.75 f'_c$ | $0.85 f'_c$ [Note (3)] |
| | | | |

NOTES:

- (1) The primary portion of this calculated stress shall not exceed the allowable stress applicable when primary stress acts alone.
 (2) The membrane portion of this calculated stress shall not exceed the allowable stress applicable when membrane stress acts alone.
 (3) The maximum allowable primary-plus-secondary membrane and bending compressive stress of $0.85 f'_c$ corresponds to a limiting strain of 0.002 in./in. (0.051 mm/mm).

(U.S. Customary Units)

$$v_c = 3.5 \sqrt{f'_c} \sqrt{1 + 0.002 N_u / A_g} \quad (6)$$

(SI Units)

$$v_c = 0.29 \sqrt{f'_c} \sqrt{1 + 0.29 \left(\frac{N_u}{A_g} \right)}$$

The units for N_u / A_g are psi (MPa), and N_u is positive for compression.

(c) For sections subjected to membrane tension, eq. (7) shall be used with N_u negative for tension:

(U.S. Customary Units)

$$v_c = 2.0 \sqrt{f'_c} (1 + 0.002 N_u / A_g) \quad (7)$$

When $v_u \leq 0.5 \sqrt{f'_c}$, v_c may be taken to equal v_u .

(SI Units)

$$v_c = 0.17 \sqrt{f'_c} \left[1 + 0.3 \left(\frac{N_u}{A_g} \right) \right]$$

When $v_u \leq 0.042 \sqrt{f'_c}$, v_c may be taken to equal v_u .

CC-3421.4.2 Prestressed Concrete. The allowable shear stress v_c shall be the lesser of v_{ci} or v_{cw} , as calculated by eqs. (8) and (9):

(U.S. Customary Units)

$$v_{cw} = 3.5 \sqrt{f'_c} \sqrt{1 + \frac{f_{pc}}{3.5 \sqrt{f'_c}}} \quad (8)$$

(SI Units)

$$v_{cw} = 0.3 \sqrt{f'_c} \sqrt{1 + \frac{f_{pc}}{0.3 \sqrt{f'_c}}}$$

(U.S. Customary Units)

$$v_{ci} = K \sqrt{f'_c} + \frac{(M_{cr} - M_i) \frac{V}{M} + V_i}{b' d} \quad (9)$$

(SI Units)

$$v_{ci} = 0.083 K \sqrt{f'_c} + \frac{(M_{cr} - M_i) \frac{V}{M} + V_i}{b' d}$$

For $\rho \geq 0.003$, $K = 1.75 - (0.036 / n\rho) + 4.0 n\rho$, but not less than 0.6.

- (1) bar end preparation
- (2) cleanliness requirements
- (3) bar end location tolerances
- (4) bar and sleeve centering tolerances
- (5) permissible gap between reinforcing bar ends
- (6) allowable voidage in the grout
- (7) procedures for storing, mixing, placing, and curing the grout
- (8) maximum and minimum temperature of the splice system during placement and curing of grout
- (9) restriction to prevent relative bar movement during setting and strength development of the grout
- (f) for cold roll formed parallel threaded splices
 - (1) type of equipment and methods used to verify bar thread acceptability
 - (2) cleanliness requirements
 - (3) type of equipment and methods used for torquing
 - (4) required torque, tolerance on required torque, and method of measurement
 - (5) method used to lock the coupling in position to prevent loosening of the splice
 - (6) method used to verify the final alignment and engagement of the coupler on both bars

CC-4333.4 Initial Qualification Tests. Each splicer shall prepare two qualification splices on the largest bar size to be used. In addition, for ferrous filler metal splices, cementitious grouted splices, and swaged splices only, each of the splice positions to be used (e.g., horizontal, vertical, diagonal) shall be qualified. The qualification splices shall be made using reinforcing bar identical to that to be used in the structure. The completed qualification splices shall be tensile tested using the loading rates set forth in SA-370 and the tensile results shall meet those specified in Table CC-4333-1.

CC-4333.5 Continuing Splice Performance Tests

CC-4333.5.1 Introduction. A continuing series of tests shall be made to ensure that production splices meet the tensile requirements. Nondestructive examination requirements are specified in CC-5320.

CC-4333.5.2 Splice Samples. Splice samples may be production splices (cut directly from in-place reinforcement) or straight sister splices (removable splices made in place next to production splices and under the same conditions), in accordance with the schedule established in CC-4333.5.3.

CC-4333.5.3 Testing Frequency. Splice samples shall be tensile tested in accordance with the following schedule for the appropriate splice system.

- (a) Separate test cycles shall be established for sleeve with ferrous filler metal splices, sleeve with cementitious grout splices, and swaged splices in horizontal, vertical, and diagonal bars. Straight sister splices may be substituted

for production test samples on radius bent bars and for splicing sleeves arc welded to structural steel elements or the liner.

- (1) For sleeve with ferrous filler metal splices, one splice shall be tested for each unit of 100 production splices.

- (2) For swaged splices and sleeve with cementitious grout splices, test cycles shall be established as follows:

- (a) If only production splices are tested, the sample frequency shall be as follows:

- (1) 1 of the first 10 production splices
- (2) 1 of the next 90 production splices
- (3) 2 of the next units and each subsequent unit of 100 production splices

- (b) If production and sister splices are tested, the sample frequency shall be as follows:

- (1) 1 production splice of the first 10 production splices

- (2) 1 production and 3 sister splices for the next 90 production splices

- (3) 3 splices, either production or sister splices, for the next and each subsequent unit of 100 production splices. At least one-fourth of the total number of splices tested shall be production splices

- (b) Taper threaded splices, cold roll formed parallel threaded splices, and threaded splices in thread deformed reinforcing bar. Separate test cycles shall be established for each bar size and grade, using straight sister splices as follows:

- (1) 1 of the first 10 splices
- (2) 1 of the next 90 splices
- (3) 2 of the next and subsequent units of 100 splices

In addition, for taper threaded splices and cold roll formed parallel threaded splices, a minimum of three tests shall be made for each bar heat.

CC-4333.5.4 Tensile Testing Requirements. Splice samples shall be tensile tested using the loading rates set forth in SA-370. All taper threaded and cold roll formed parallel threaded sample splices shall be tensile tested at 20°F (−7°C) or less. The following shall constitute the acceptance standards:

- (a) The tensile strength of each sample shall equal or exceed 125% of the specified yield strength as shown in Table ~~CC-4334-1~~ **CC-4333-1**

- (b) The average tensile strength of each group of 15 consecutive samples shall equal or exceed the specified minimum tensile strength as shown in Table ~~CC-4334-1~~ **CC-4333-1**

If any sample tested fails to meet the provisions of (a) or (b) above, the requirements of CC-4333.5.5 shall be followed.

CC-4333.5.5 Substandard Tensile Test Results

- (a) If any splice used for testing fails to meet the strength requirement of Table CC-4333-1 and failure occurs in the

MANDATORY APPENDIX III

APPROVAL OF NEW MATERIAL

ARTICLE III-1000 PROCEDURE FOR OBTAINING APPROVAL FOR NEW MATERIAL

III-1100 CODE POLICY

III-1110 MATERIAL THAT WILL BE CONSIDERED

It is the policy of the Code to adopt for inclusion in this Division only such specifications that have been adopted by the American Society for Testing and Materials or those others that have been shown by the necessary testing to be suitable for CRV or containment construction.

III-1200 DATA REQUIRED TO BE SUBMITTED WITH REQUESTS FOR APPROVAL

III-1210 CONCRETE MATERIAL

III-1211 Mechanical Properties

The inquirer shall furnish the specification for the concrete material, including any characteristics that deviate from the accepted ASTM standard. In addition, the inquirer shall furnish data on the properties of the proposed concrete mix using this new material inasmuch as the properties deviate from those specified herein. Special attention shall be given to the influence of the new material on concrete compressive and flexural strength, shrinkage, creep, thermal conductivity, coefficient of expansion, and modulus of elasticity. If the properties are dependent upon revised proportions, mixing, placing, or curing procedures, these shall be enumerated.

III-1212 Additional Considerations

It is important to recognize that the continued durability of the concrete is an essential element in the service life of the structure. Data representing previous experience with the new material showing its influence on concrete durability will be useful to the Code. Also, if the new material results in the limits on chemical contaminants being exceeded, data shall be furnished on the corrosion potential

of embedded metals. Service experience or test data are the type of data to be furnished.

III-1220 REINFORCING SYSTEM MATERIAL

III-1221 Mechanical, Physical, and Chemical Properties

Request for acceptance of new reinforcing system material shall include specifications for the material and system characteristics. Any deviation from this Division or accepted standards shall be specifically noted.

Data shall be furnished to demonstrate that the mechanical, physical, and chemical properties of the proposed material meet the specifications. These shall include, but not be limited to, the following:

(a) *Mechanical and Physical Properties*

- (1) ultimate tensile strength
- (2) yield strength
- (3) elongation at rupture
- (4) specific weight
- (5) coefficient of thermal expansion
- (6) modulus of elasticity
- (7) deformation geometry

(b) *Chemical Properties.* Complete chemical analysis of material.

III-1222 System Performance

Documentation shall be furnished to demonstrate that the new material will be physically and chemically compatible when assembled into a reinforced concrete system. The reinforcing system material shall meet the requirements set forth in ~~CB-2300, CB-4300, CB-5300 or~~ CC-2300, CC-4300, and CC-5300.

III-1230 PRESTRESSING SYSTEM MATERIAL

III-1231 Mechanical, Physical, and Chemical Properties

Request for acceptance of new prestressing system material shall include specifications for the material and system characteristics. Any deviation from this Division or accepted standards shall be specifically noted.

VIII-1522 Gas Metal-Arc Welding (GMAW) and Flux-Cored Arc Welding (FCAW)

(a) A change in electrode or method of shielding not covered by AWS A5.18 (GMAW), AWS A5.20 (FCAW), or AWS A5.28 (FCAW).

(b) A change increasing filler metal strength level, e.g., a change from E70S to E80S, but not vice versa.

(c) A change in electrode diameter for GMAW, or an increase in the diameter of electrode used over that called for in the procedure specification for FCAW.

(d) A change from a single gas to any other single gas or to a mixture of gases, or a change in specified composition of gas mixture not covered by AWS A5.18, AWS A5.20, or AWS A5.28.

(e) A change of more than 10% above or below the specified mean amperage for each size electrode used.

(f) A change of more than 7% above or below the specified mean arc voltage for each size electrode used.

(g) A change of more than 10% above or below the specified mean travel speed.

(h) An increase of 25% or more or a decrease of 10% or more in the rate of flow of shielding gas or mixture of shielding gas.

(i) A change in the position in which welding is done as defined in Fig. VIII-1520-1.

(j) A change in the type of groove, e.g., a change from a single-Vee groove to a double-Vee groove.

(k) A change in the shape of any one type groove involving the following:

(1) a decrease in the included angle of the groove exceeding 5 deg (0.09 rad)

(2) a decrease in the root opening of a groove exceeding $\frac{1}{16}$ in. (1.5 mm)

(3) an increase in the root face of a groove exceeding $\frac{1}{16}$ in. (1.5 mm)

(4) the omission, but not inclusion, of backing material

(l) A decrease of more than 10% in the preheat or interpass temperature specified in the welding procedure, provided the resulting preheat or interpass temperature is not less than that specified in Table VIII-1430-1.

(m) A change in the type of welding current (ac or dc), polarity, or mode of metal transfer across the arc.

(n) A change from uncoated to galvanized reinforcing bar.

(o) An increase of more than one bar size.

(p) An increase in the carbon equivalent number calculated by VIII-1430.

VIII-1530 WELD SPECIMEN TESTING**VIII-1531 Purpose of Test**

The tests listed below are to determine the tensile strength and degree of soundness of welded joints made under a given procedure specification:

(a) full-section tension test (for tensile strength)

(b) macroetch test (for soundness)

VIII-1532 Base Metal

The base metal and its preparation for welding shall comply with the Welding Procedure Specification.

VIII-1533 Direct Butt Splices

All direct butt splices shall be classified in accordance with definitions of welding positions for groove welds and shall be welded in the position for which the procedure is to be qualified (see Fig. VIII-1420-1).

VIII-1534 Test Welds

Three test welds shall be made for each procedure specification to be qualified. Unless a greater length is required by the testing agency, the test weld specimens for direct butt splices shall have a minimum length of at least 16 times the diameter of the bar with the weld centrally located (see Fig. VIII-1530-1). Two of the three test welds shall be subject to a full-section tensile test. The remaining test weld shall be subjected to the macroetch test.

VIII-1535 Method of Testing Specimens

(a) *Full-Section Tensile Test.* The test joints shall be tensile tested in the as-welded condition, i.e., full-size welded joints without machining. The minimum distance between jaws of the testing machine shall be equal to at least eight times the diameter of the bar for direct butt splices. The test specimens shall be ruptured under tensile load. The maximum load, lb (N), shall be determined. The tensile strength, psi (kPa), shall be obtained by dividing the maximum load by the nominal cross-sectional area of the bar.

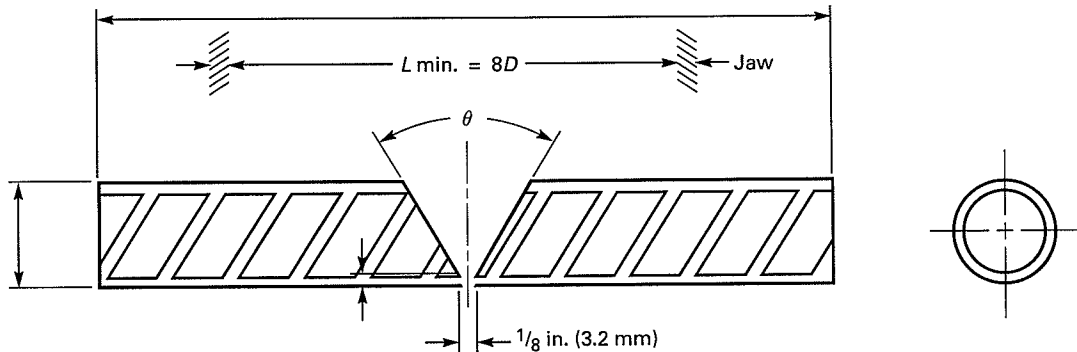
(b) *Macroetch Test.* The test specimens shall be mechanically cut perpendicular to the direction of welding. The section so obtained shall be polished and show the full longitudinal cross section of the weldment, the root of the weld, and any reinforcement. Etching shall be done by a suitable solution to give a clear definition of the weld.

VIII-1536 Test Results Required

(a) *Full-Section Tension Test.* The tensile test results shall comply with the strength requirements of Table CC-4334-1 for the appropriate grade of reinforcing bar. CC-4333-1

(b) *Macroetch Test.* The specimens shall be examined for imperfections and shall comply with the acceptance standards of VIII-1622. The etched cross section shall show complete penetration and complete fusion with the base metal.

FIG. VIII-1530-1 COMPLETE JOINT PENETRATION GROOVE



GENERAL NOTES:

- (a) For bars No. 9 or larger, use single Vee- or bevel groove weld ($\theta = 45$ deg).
 (b) For bars No. 8 or smaller, use single Vee-groove with split pipe backing ($\theta = 60$ deg).

VIII-1540 WELDER AND WELDING OPERATOR PERFORMANCE QUALIFICATION

The requirements for the initial qualification test for welders and welding operators shall be in accordance with VIII-1541. Welders and welding operators shall qualify for each type of weld to be performed by that individual during the course of the work. The completed qualification welds that are tension tested shall satisfy the tensile requirements specified in Table CC-4334-1.

CC-4333-1

VIII-1541 Limitation of Variables

Qualifications established with any of the reinforcing steels shall be considered as qualification to weld any of the other reinforcing steels within the essential variables. Separate qualifications, without reciprocal validity, shall be required for galvanized and uncoated steels. A welder or welding operator shall be qualified for each process to be used in production. A welder or welding operator qualified with an approved electrode and shielding medium combination shall be considered qualified to weld with any other approved electrode and shielding medium combination (see Table VIII-1410-1) for the process used in the qualification test. A change in the position of welding to a position for which the welder is not already qualified shall require requalification of the welder or welding operator.

VIII-1542 Qualification Tests Required

The qualification test joint shall be a full penetration groove weld made by the SMAW, GMAW, or FCAW process with a single-Vee groove or bevel groove (see Fig. VIII-1530-1). Welding on No. 9 (29) bar shall qualify a welder or welding operator for welding all bars greater than No. 9 (29) within the essential variables. If bars

smaller than No. 9 (29) are to be welded, the welder or welding operator shall qualify on the smallest bar size to be welded. For bars smaller than No. 9 (29), split pipe backing shall be used (see Fig. VIII-1420-1).

VIII-1543 Position of Test Welds and Validity of Qualification for Direct Butt Splice Groove Weld Tests (See Fig. VIII-1520-1)

- (a) Qualification in the 1G (flat) position qualifies for welding in the 1G position only.
 (b) Qualification in the 2G (horizontal) position qualifies for welding in the 1G and 2G positions.
 (c) Qualification in the 3G (vertical) position qualifies for welding in the 1G, 2G, and 3G positions.
 (d) Qualification in the 4G (overhead) position qualifies for direct butt welding in the 1G and 4G positions.
 (e) Qualification in the 1G and 2G positions qualifies for welding in the 1G position for diagonal bars.
 (f) Qualification in the 2G and 3G positions qualifies for welding in the 3G position for diagonal bars.

VIII-1544 Base Metal

The base metal used shall comply with CC-2310.

VIII-1545 Welding Procedure

The welder or the welding operator shall follow the Welding Procedure Specification.

VIII-1546 Test Specimens — Number, Type, and Preparation

For each test there shall be two test assemblies welded in accordance with VIII-1540 to qualify each welder or welding operator.

Test assemblies welded by GMAW (except short circuiting transfer), SMAW, or FCAW shall be tested by radiography, or one test assembly shall be subjected to the full-section tensile test and the other test assembly to the macroetch test. Direct butt splice test assemblies welded by GMAW short-circuiting transfer methods shall have one test assembly subjected to the full-section tension test and the other to the macroetch test.

Unless a greater length is required by the testing agency, the full-section tension test specimens shall have a minimum length of at least 16 times the diameter of the bar with the weld centrally located (see Fig. VIII-1530-1).

VIII-1547 Method of Testing Specimens

(a) *Full-Section Tension Test.* The test joints shall be tensile tested in the as-welded condition, i.e., full-size welded joints without machining. The minimum distance between jaws of the testing machine shall be equal to at least eight times the diameter of the bar for direct butt splices. The test specimens shall be ruptured under tensile load. The maximum load, lb (N), shall be determined. The tensile strength, psi (kPa), shall be obtained by dividing the maximum load by the nominal cross-sectional area of the bar.

(b) *Macroetch Test.* The test specimens shall be mechanically cut perpendicular to the direction of welding. The section so obtained shall be polished and show the full longitudinal cross section of the weldment, the root of the weld, and any reinforcement. Etching shall be done by a suitable solution to give a clear definition of the weld.

VIII-1548 Test Results Required

(a) *Radiographic Examination.* For acceptable qualification, the weld shall meet the acceptance standards of VIII-1622.

(b) *Full-Section Tension Test.* The tension test results shall comply with the strength requirements of ~~Table CB-4334-1 or Table CC-4334-1~~ as applicable, for the appropriate grade of reinforcing bar. *CC-4333-1*

(c) *Macroetch Test.* The specimens shall be examined for imperfections and shall meet the acceptance standards of VIII-1622. The etched cross section shall show complete penetration and complete fusion with the base metal.

VIII-1549 Retests

If a welder or welding operator fails to meet the qualification requirements of one or more test welds, a retest may be allowed under the following conditions:

(a) An immediate retest may be made consisting of two test welds of each type on which the welder or welding operator failed. All test specimens shall meet all requirements for all such welds.

(b) A retest may be made provided there is evidence that the welder or welding operator has had further training or practice. A complete retest shall be made in this case.

(c) If the Inspector has reason to doubt the qualifications of a welder or welding operator, he may require retest.

VIII-1550 PERIOD OF EFFECTIVENESS

The welder's or welding operator's qualifications specified in this Code shall remain in effect indefinitely unless

(a) the welder or welding operator is not engaged in a given process of welding for which he is qualified for a period exceeding 6 months;

(b) there is some specific reason to question a welder's or welding operator's ability.

VIII-1551 Records

Records of the test results shall be kept by the Constructor or Fabricator and shall be available to those authorized to examine them.

VIII-1560 CONTINUING JOINT PERFORMANCE TESTS

VIII-1561 Introduction

A continuing series of tests shall be made to ensure joints meet the tensile requirements. Nondestructive examination requirements are specified in VIII-1600.

VIII-1562 Joint Samples

Joint samples may be production joints (i.e., cut directly from in-place reinforcement) or sister joints (i.e., removable joints made in place next to production joints and under the same conditions).

VIII-1563 Testing Frequency

Separate test cycles shall be established for joints in horizontal, vertical, and diagonal bars as follows.

VIII-1563.1 Production Joints. If only production joints are tested, the sample frequency shall be as follows:

- (a) 1 of the first 10
- (b) 1 of the next 90
- (c) 2 of the next and each subsequent unit of 100

VIII-1563.2 Production and Sister Joints. If production and sister joints are tested, the sample frequency shall be as follows:

- (a) 1 production joint of the first 10 production joints
- (b) 1 production and 3 sister joints for the next 90 production joints

(c) 1 joint, either production or sister joint, for all subsequent units of 33 joints

At least one-fourth of the total number of joints tested shall be production joints.

VIII-1563.3 Sister Joints. Straight sister joints shall be substituted for production samples or radius bent bars and for bars arc welded to structural steel elements or the liner.

VIII-1564 Tensile Testing Requirements

Joint samples shall be tensile tested using the loading rates set forth in SA-370. The following shall constitute the acceptance standards.

(a) The tensile strength of each sample shall equal or exceed 125% of the specified yield strength as shown in Table CC-4334-1

(b) The average tensile strength of each group of 15 consecutive samples shall equal or exceed the specified minimum tensile strength as shown in Table CC-4334-1

(c) If any sample joint tested fails to meet the provisions of (a) or (b) above, requirements of VIII-1565 shall be followed.

VIII-1565 Substandard Tensile Test Results

(a) If any production or sister joint used for testing fails to meet the strength requirement of Table CC-4334-1 and failure occurs in the bar, the cause of the bar break shall be investigated by the Constructor or Fabricator. Any necessary corrective action affecting joint samples shall be implemented prior to continuing the testing frequency of VIII-1563.

(b) If any production joint used for testing fails to meet the strength requirement of Table CC-4334-1 and failure does not occur in the bar, the adjacent production joints on each side of the failed joint shall be tested. If any sister joint used for testing fails to meet the strength requirement of Table CC-4334-1 and failure does not occur in the bar, two additional sister joints shall be tested. If either of these joints fails to meet the strength requirement of Table CC-4334-1, welding shall be halted. Welding shall not be resumed until the cause of failures has been corrected.

(c) If the running average tensile strength of 15 consecutive joints fails to meet the strength requirement of Table CC-4334-1, welding shall be halted. The Constructor or Fabricator shall investigate the cause and make the necessary corrective action.

(d) When welding is resumed, the testing frequency shall be started anew.

TABLE VIII-1620-1
RADIOGRAPH ACCEPTANCE CRITERIA

| Customary Unit Bar Size | Sum of Discontinuity Dimensions, in. (mm) | Single Discontinuity Dimension, in. (mm) |
|-------------------------|-------------------------------------------|------------------------------------------|
| 8 (25) | $\frac{3}{16}$ (5) | $\frac{1}{8}$ (3) |
| 9 (29) | $\frac{3}{16}$ (5) | $\frac{1}{8}$ (3) |
| 10 (32) | $\frac{1}{4}$ (6) | $\frac{1}{8}$ (3) |
| 11 (36) | $\frac{1}{4}$ (6) | $\frac{3}{16}$ (5) |
| 14 (43) | $\frac{5}{16}$ (8) | $\frac{3}{16}$ (5) |
| 18 (57) | $\frac{7}{16}$ (11) | $\frac{1}{4}$ (6) |

VIII-1570 RECORDING OF TENSILE TEST RESULTS

The results of all tensile tests obtained from the tests prescribed by VIII-1530, VIII-1540, and VIII-1560, along with all other pertinent data, shall be recorded.

VIII-1600 EXAMINATION OF WELDED JOINTS OF REINFORCING BAR

VIII-1610 VISUAL EXAMINATION

All completed arc welded joints shall be visually examined for the presence of cracks, undercut, inadequate size, and other visible defects. Welds exhibiting such defects shall be repaired.

VIII-1620 RADIOGRAPHIC EXAMINATION

VIII-1621 Extent and Procedure Requirements

One joint selected at random from each 25 direct butt production joints made by each welder shall be radiographed from two mutually perpendicular directions. The radiographic examination procedure shall be in accordance with Article 2 of Section V. Ultrasonic examination and inspection may be performed where radiographic examinations are not practical. If ultrasonic examination is used, the examination shall be in accordance with Article 5 of Section V.

VIII-1622 Acceptance Standards

Welds shall be free of any type of crack or zone of incomplete fusion or penetration. All craters shall be filled to the full cross section of the weld.

Direct butt splices inspected by radiography shall have a maximum dimension of any single porosity or fusion type discontinuity or the sum of the maximum dimensions of all porosity or fusion type discontinuities not exceeding the limits given in Table VIII-1620-1.

Undercutting deeper than $\frac{1}{32}$ in. (0.8 mm) shall not be allowed, regardless of the direction of stress, except that

NONMANDATORY APPENDIX D

LINER DIMENSIONAL TOLERANCES

ARTICLE D-1000

LINER DIMENSIONAL TOLERANCES

D-1100 SCOPE

The dimensional tolerances as given herein are a general guide for constructed liners. These tolerances were established as typical for a liner with a diameter of 150 ft (45.7 m), a hemispherical dome, and a 150 ft (45.7 m) high cylindrical shell. Further consideration should be given to liners with different configurations or that vary significantly from these dimensions. Areas of the liner that visually appear to have significant deviations and do not fall on the check points suggested in this Appendix should also be examined.

D-1200 CYLINDRICAL LINERS

D-1210 GENERAL

The measurements are to be taken at the completion of the work on the circumferential seams above and below the point being measured and prior to supporting reinforcing bar or formwork on this section of the liner. Dimensional tolerances for right circular cylindrical liner shells are established in D-1220 and D-1230.

D-1220 OVERALL DIMENSIONS

(a) At the specified increments of elevation, the difference between the actual radius of the shell and the theoretical radius should not exceed the larger of 3 in. (75 mm) or $\frac{1}{3}$ of 1% of the radius. The radius shall be measured from the theoretical true vertical center line of the cylinder or some offset point. This requirement may be satisfied by measuring radii spaced approximately 30 deg (0.82 rad) apart on each shell course. The vertical distance between these measurements should not exceed 12 ft (3.6 m). This requirement may be met by taking measurements within the center $\frac{1}{3}$ of the shell course height.

(b) The average elevation of points on the spring line of the cylinder measured at approximately 30 deg (0.82 rad) apart should not deviate from the theoretical elevation of the spring line of the cylinder by more than the larger

of 3 in. (75 mm) or $\frac{1}{6}$ of 1% of the height. Also, these points should be enveloped by two horizontal planes which are no more than 1 in. (25 mm) apart.

(c) An individual liner plate should not deviate from vertical by more than 2 in. (50 mm) in 10 ft (3.0 m). This requirement may be satisfied by taking measurements approximately 30 deg (0.82 rad) apart on each shell course. The vertical distance between these measurements should not exceed 12 ft (3.6 m).

D-1230 LOCAL DIMENSIONS

(a) The gap should be measured between the shell and a 15 ft (4.8 m) template curved to the theoretical radius when placed horizontally against the surface of the shell. Measurements may be made on the complete circumference at no greater than 12 ft (3.6 m) increments vertically. These requirements may be met by taking a set of measurements on each shell course. The gap should not exceed 1 in. (25 mm) with a single plate section when the template is not closer than 12 in. (300 mm) to a weld seam. When the template is closer than 12 in. (300 mm) to a weld seam or crosses a weld seam, the gap should not exceed $1\frac{1}{2}$ in. (48 mm). Measurements should be taken and recorded per Fig. D-1230-1.

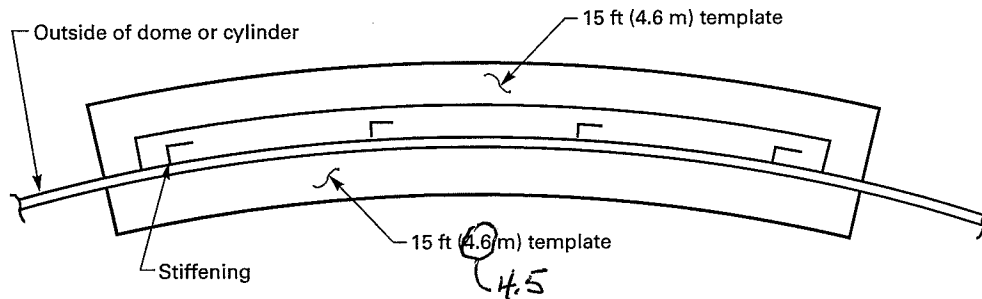
(b) The gap between the liner shell and a straight edge placed vertically against the liner should not exceed 1 in. (25 mm). The length of the straight edge should be the height of the liner shell course minus 2 ft (0.6 m), and the measurement should not be taken across the weld seam. This requirement may be satisfied by taking measurements approximately 30 deg (0.82 rad) apart on each shell course. Measurements should be taken and recorded per Fig. D-1230-1.

D-1300 DOME LINERS

D-1310 GENERAL

The dimensional tolerances in this Subarticle are for the final dome configuration prior to supporting reinforcing bar or formwork. It is recommended that the elevation and radial location of circumferential seams be checked

FIG. D-1230-1 MEASUREMENTS OF LOCAL DIMENSIONS PER F-1230



GENERAL NOTE:

Record measurements outside of tolerance or, if none are out of tolerance, record the maximum deviation per template placement.

during the erection so as to ensure that the final dome is within these tolerances.

D-1320 OVERALL DIMENSIONS

The difference between the actual location of the dome and the theoretical location should not exceed 6 in. (150 mm). The horizontal location of the dome should be measured relative to the center line of the top of the as-constructed cylindrical liner, and the vertical location of the dome should be measured relative to the average elevation of the top of the as-constructed cylindrical liner.

This requirement should be satisfied by taking measurements at 15 deg (0.26 rad) intervals as shown in Fig. D-1320-1, Section. Measurement shall be taken at approximately 15 deg (0.26 rad) in plan (see Fig. D-1320-1, Plan View) along these circles, except that the spacing need not be less than 15 ft (4.8 m).

4.5

D-1330 LOCAL DIMENSIONS

The gap should be measured between the shell and a 15 ft (4.8 m) template curved to the theoretical radius when placed normal to the shell (see Fig. D-1230-1). The gap should not exceed 1 in. (25 mm) within a single plate section when the template is not closer than 12 in. (300 mm) to a weld seam. When the template is closer than 12 in. (300 mm) to a weld seam or crosses a weld seam, the gap should not exceed 1½ in. (48 mm). A minimum of one meridional and one horizontal template placement check should be made in each 225 ft² (21 m²) of surface area. A suggested method of template placement is shown in Fig. D-1330-1. Measurements should be taken and recorded per Fig. D-1230-1.

When ground assemblies are used in construction, consideration may be given to taking these measurements on the ground after completion of the assembly, provided measurements are taken on the welds joining assemblies.

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