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NE E 15-2NC-T

Supersedes NE E 15-2NC-T

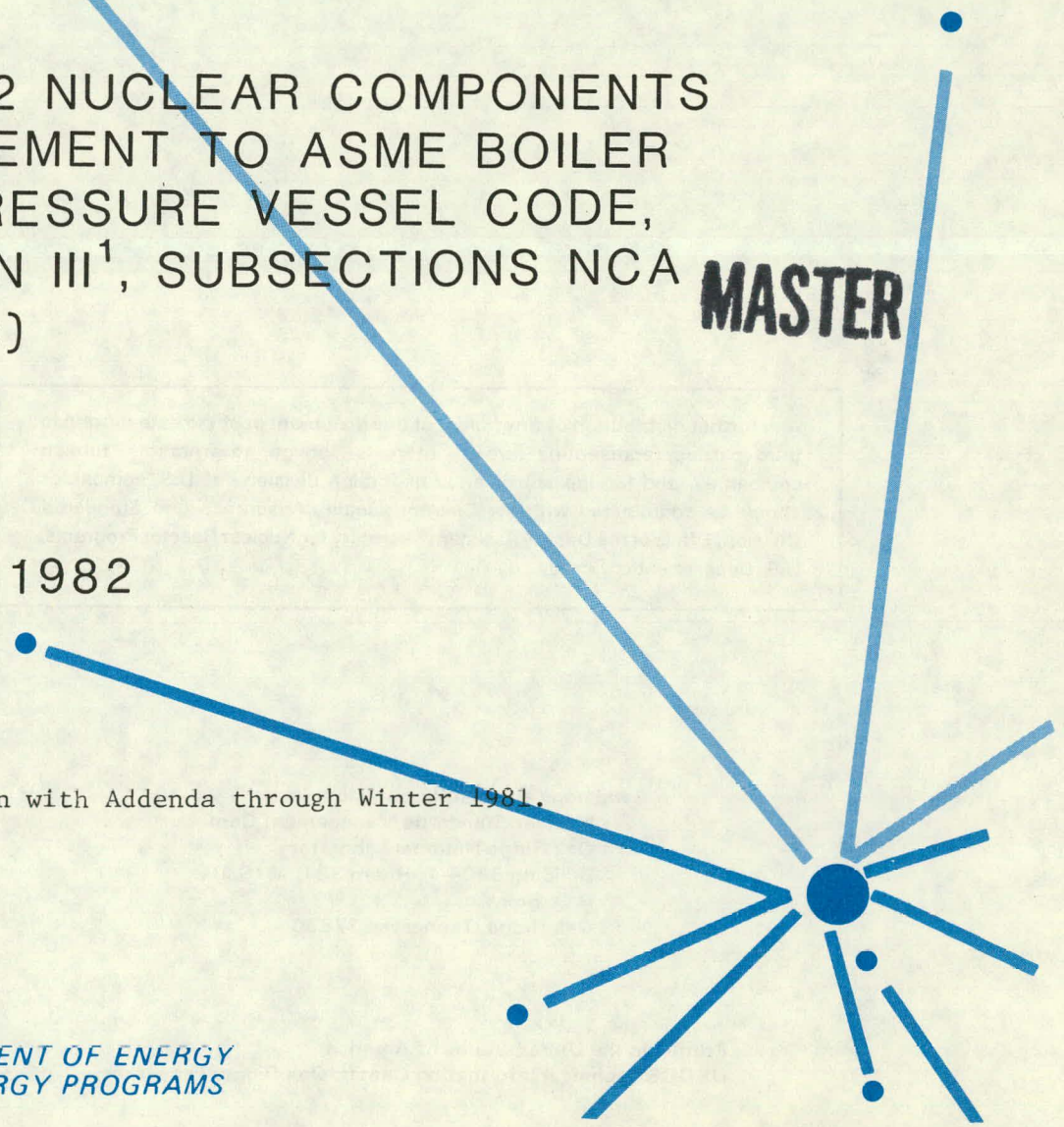
July 1981

nuclear STANDARD

CLASS 2 NUCLEAR COMPONENTS (SUPPLEMENT TO ASME BOILER AND PRESSURE VESSEL CODE, SECTION III[1], SUBSECTIONS NCA AND NC)

MARCH 1982

[1] 1980 Edition with Addenda through Winter 1981.



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NE E 15-2NC-T, "Class 2 Nuclear Components (Supplement to ASME Boiler and Pressure Vessel Code, Section III [1], Subsections NCA and NC)"

Justification for Revision

Page 10, paragraph ANC-4424d	Revised paragraph to include phrase "and less than 1/16 in. (1.6 mm) for material thickness in excess of 3/16 in. (4.7 mm)" which was inadvertently dropped in typing Amendment 4, June 1980.
Page 24, paragraph NNC-5390, Item 3	Deleted requirement on "degree of undercutting." Code acceptance criteria applies. Renumbered item paragraphs.

FOREWORD

This standard supersedes the July 1981 issue of NE E 15-2NC-T.

Changes are identified by the following marginal notation:

C Change

CLASS 2 NUCLEAR COMPONENTS (SUPPLEMENT TO ASME BOILER AND PRESSURE VESSEL CODE, SECTION III, SUBSECTIONS NCA AND NC)

TABLE OF CONTENTS

CLASS 2 NUCLEAR COMPONENTS (SUPPLEMENT TO ASME BOILER AND PRESSURE VESSEL CODE, SECTION III, SUBSECTIONS NCA AND NC)

0. INTRODUCTION

0.1 Scope. This standard supplements the rules for the construction of nuclear components that are covered by Subsections NCA and NC of the 1980 Edition of the ASME Boiler and Pressure Vessel Code (the Code), Section III. When this standard is invoked or referenced, the applicable subsections of Section III of the Code are also invoked or referenced. The user is responsible for obtaining and applying the edition and revisions of this standard that supplement the edition and Addenda of the Code that are in legal effect at the time of use.

0.2 Organization of the Standard. Section 0 contains requirements for using this standard as a supplement to the Code, and succeeding sections contain the supplemental Code requirements. The following paragraph designations are used in this standard.

0.2.1 Additions to Existing Code Paragraphs. Requirements which supplement an existing Code paragraph are designated by the Code paragraph number prefixed with an "A." For example, the addition to paragraph "NCA-4100" is designated "ANCA-4100."

0.2.2 New Paragraph Numbers. The requirements that are not added to existing Code paragraphs are designated as new Code paragraphs at the location of similar Code rules. These paragraphs are numbered using the next sequential Code paragraph number and prefixing it with an "N." For example, the new paragraph of this standard that is to be added to NCA-1140(e) is designated as "NNCA-1140(e)(1)." In the event Code Addenda are published that cause duplication of numbers, such as Code paragraph NCA-3280, the "N" prefix used in this standard indicates that no reference to the thus created Code paragraph is intended since such reference would be designated with the prefix "A."

0.2.3 Introductory Phrase. To clarify that the requirements of this standard are additional to and not replacements for the requirements of the applicable subsection of Section III, and that they are mandatory for NE standard applications only, each entry in this standard shall be understood to be preceded by the phrase: "For NE E 15-2NC applications."

0.3 Conflicts. Class 2 components shall be constructed in accordance with the rules of the Code, Section III, Subsection NC, including Addenda as specified in 0.1; applicable Code Cases as specified in NNCA-1140(e); and the supplemental requirements of NE E 15-2NC. The requirements of this standard shall in no way be construed as relieving any Code-designated party of his responsibility for meeting the requirements set forth by the Code.

Any requirement of this standard that conflicts with the rules of the Code shall be brought to the attention of the purchaser prior to any implementing action by the manufacturer.

0.4 Definitions. The definitions of terms found in this standard are consistent with those employed by the Code. Terms not now defined by the Code are defined when first used in this standard, except that as used herein "Owner" is defined as the Owner or his designee.

0.5 Applicable Documents. The following documents are referenced in whole or in part by this standard and are necessary to the extent herein specified in meeting the requirements of this standard.

0.5.1 NE Standards.

NE F 2-2	Quality Assurance Program Requirements
NE F 2-4	Quality Verification Program Requirements
NE F 3-6T	Nondestructive Examination (Supplement to ASME Boiler and Pressure Vessel Code, Section V)
NE F 6-5T	Welding and Brazing Qualifications (Supplement to ASME Boiler and Pressure Vessel Code, Section IX)

0.5.2 American Society of Mechanical Engineers (ASME) Code.

ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components

ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications

0.5.3 American Society for Testing and Materials (ASTM) Publications.

ASTM A 262	Recommended Practices for Detecting Susceptibility to Intergranular Attack in Stainless Steels
ASTM E 45	Recommended Practice for Determining the Inclusion Content of Steel

SUBSECTION NCA
GENERAL REQUIREMENTS

NCA-1000 SCOPE OF SECTION III

NCA-1140 Use of Code Editions, Addenda, and Cases. Add:

NNCA-1140(e)(1) Code Cases. Only those Code Cases permitted by this standard, by NE standards which invoke or are invoked by this standard, or by the Design Specification shall be used in the construction of components in accordance with NE E 15-2NC.

NCA-3000 RESPONSIBILITIES AND DUTIES

NCA-3250 Provision of Design Specifications. Add:

ANCA-3252 Contents of Design Specifications. The design requirements to permit periodic inservice examinations, testing, and maintenance shall be stated in the Design Specification.

ANCA-3255 Certification of the Design Specifications. A revised Design Specification shall be prepared by the Owner and certified by a Registered Professional Engineer when any change in the design conditions is made.

NCA-4000 QUALITY ASSURANCE

NCA-4100 Introduction. Add:

ANCA-4100 The quality assurance requirements of NE F 2-2 shall be met in addition to those specified in NCA-4100. When duplicate quality assurance activities are specified, only one activity is required provided the minimum requirements of all applicable documents are met.

SUBSECTION NC
REQUIREMENTS FOR CLASS 2 COMPONENTS

NC-1000 INTRODUCTION

NC-1100 Scope. Add:

NNC-1100(d) The requirements of NE E 15-2NC do not apply to atmospheric storage tanks or 0 to 15 psi storage tanks as described in NC-3800 and NC-3900. All other items to which the rules of Subsection NC apply shall also conform to the requirements of NE E 15-2NC. Whenever the requirements of NE E 15-2NC differ from the requirements of Section III, a single operation may be performed provided the requirements of both NE E 15-2NC and Section III are satisfied.

NC-2000 MATERIALS

NC-2120 Pressure Retaining Material. Add:

NNC-2128 Material Grain Flow Requirements. Whenever practicable, pressure boundary materials shall be fabricated such that the direction of grain flow is generally parallel to the pressure boundary surface. When this is not practicable, one of the following shall apply.

(a) The Component Manufacturer shall, subject to Owner approval, specify a limit on nonmetallic inclusion content of the steel as determined by ASTM E 45.

(b) The material area which has grain flow in a direction intersecting the pressure boundary, which could allow a path for leakage through the pressure boundary, shall be weld overlaid by the Component Manufacturer in accordance with NC-4000 as supplemented by NE E 15-2NC to a minimum depth of 20% of the base material thickness or 1/4 in. (6.35 mm) whichever is less.

(c) The question of acceptable and unacceptable character of grain flow shall be a subject of agreement between the Component Manufacturer and the Owner.

NC-2500 Examination and Repair of Pressure Retaining Material. Add:

ANC-2500 In addition to the requirements of NC-2500, pressure retaining material shall be examined by the methods and acceptance standards of NB-2500. Elimination of surface defects and repair by welding shall be in accordance with NC-2500.

NC-2610 Documentation and Maintenance of Quality System Programs. Add:

ANC-2610(a) Material manufacturers and suppliers shall have a Quality System Program or Identification and Verification Program, as applicable, which meets the requirements of NCA-3800 of the ASME Code. Alternatively, for materials which NC-2610(b) exempts from these requirements a quality verification program which meets the requirements of NE F 2-4 is acceptable.

NC-3000 DESIGN

NC-3100 General Design.

NNC-3140 Permissible Types of Welded Joints. Add:

(a) Fillet welds shall not be used in vessels for joints of Category A, B, C, or D or similar joints in other components.

(b) Unless permitted by the Design Specification, added reinforcement at opening in the form of separate plates or rings, such as shown in Fig. NC-3335(b)-1(a), (b), or (c) shall not be used.

(c) Permanent structural attachments shall be attached by full penetration continuous welds. Welds such as shown in Fig. NC-4433-1 are permitted only for temporary or nonstructural permanent attachments.

(d) Welded joints shall be designed to permit required physical and visual accessibility for welding and nondestructive examination personnel and equipment. The weld joint designs shall make allowance for welder's environment, position, and comfort due to the potential necessity to weld in close quarters while the part is under the high degree of preheat and due to location and orientation of the weld joint.

(e) For joints of Categories B and D, backing strips which are not to be removed shall not be used without prior approval of the Owner.

(f) Joints of Category C for which ultrasonic examination in addition to radiographic examination is required (see ANC-5230) shall be permitted only if the Manufacturer demonstrates that meaningful ultrasonic examination can be performed.

(g) Joints of Category D for which ultrasonic examination in addition to radiographic examination is required [see NNC-5240(a) and NNC-5241(c)] shall be permitted only if the Manufacturer demonstrates that meaningful ultrasonic examination can be performed.

(h) Welded tube-to-tubesheet joints shall be of either the face joint or the butt joint type and shall meet the requirements of NC-4350 and the following.

(1) Face joints may be welded with either fillet welds or fillet reinforced "J" groove welds. Unless otherwise specified in the Design Specification, the Manufacturer shall establish required average and minimum dimensions of welds based on ability of the weld joint to withstand all imposed forces. In determining weld joint strength, no credit shall be taken for tube rolling or for any increase in the strength of the weld material above that of the base material. When fatigue analysis is required, a fatigue strength reduction factor of not less than four shall be used. Calculations supporting the selection of weld dimensions shall be submitted to the Owner prior to the start of fabrication.

(2) Butt joints shall meet the requirements of NC-3352.4(a) or NC-3352.4(c)(1), except that the dimensional requirements shall not apply. Weld reinforcement shall be in accordance with NC-4426, ANC-4426.1, and ANC-4426.2 and as further restricted by design requirements that limit the amount of flow restriction in a tube.

(i) A weld joint which is provided for a fluid containment function only where strength is provided by a separate device, where the joint is designed for cutting when removal of one of the joined components is required, and where welding is normally performed from one side is defined as a seal welded joint. Seal welded joints include, but are not limited to, specially designed welded seals (NC-4361).

(1) The minimum weld thickness of any seal weld shall not be less than the membrane thickness for welds made between parts of the same nominal thickness nor less than the thickness of the thinner member for welds made between parts of different thickness. Total seal weld reinforcement (root plus face) shall not exceed 60% of the membrane thickness for automatic welds nor 80% of the membrane thickness for manual welds made between parts of the same nominal thickness. Local areas along the length of the weld, whose accumulated length does not exceed 10% of the length of the seal weld, may exhibit reinforcements up to 80% and 100% of the material thickness, respectively, for the above welds. In no location shall the face or root reinforcement exceed 1/16 in. (1.6 mm) for automatic welds nor 3/32 in. (2.4 mm) for manual welds. Maximum concavity at the face or root shall not exceed 10% of the membrane thickness for welds made between parts of the same nominal thickness or 10% of the thickness of the thinner member for welds made between parts of different thickness.

(2) For seal welds made between parts of different thickness, the maximum reinforcement of the face of the seal weld shall not exceed one-half the thickness of the thinner member. The reinforcement of the root of such seal welds shall not exceed 3/32 in. (2.4 mm).

(j) Socket welded joints shall be limited to 1 in. (25 mm) nominal pipe size and smaller.

(k) The use of flanged joints in piping shall be limited to those locations in the system where they are necessary for component removal.

(l) The use of sleeve-coupled (see NC-3671.7) and other patented joints shall be subject to Owner approval.

NC-3673.2 Basic Assumptions and Requirements. Add:

ANC-3673.2(b) For pipe having a ratio of nominal outside diameter of nominal wall thickness greater than 20, the stress

intensification factors[1] given in Fig. NC-3673.2(b)-1 for butt welds shall be increased to account for radial shrinkage at the weld joint as follows:

Description, Butt Weld	Stress Intensification Factor, i
$t_n > 3/16$ and $\delta/t_n \leq 0.1$	$1.0 + 2.6\ \Delta/t_n$
$t_n \leq 3/16$ or $\delta/t_n > 0.1$	$1.0 + 1.1\ \Delta/t_n$ for flush weld[2]
$t_n \leq 3/16$ or $\delta/t_n > 0.1$	$1.8 + 3.6\ \Delta/t_n$ for as-welded[3]

where Δ is the radial shrinkage as measured in accordance with NNC-5290.1(b)(6). The radial shrinkage, Δ, shall not exceed 2% of the original outside radius.

NC-4000 FABRICATION AND INSTALLATION REQUIREMENTS

NC-4200 Forming, Cutting and Aligning. Add:

ANC-4211 Cutting. After cutting or gouging, the affected surfaces shall be mechanically cleaned and prepared for nondestructive examinations required. Following thermal cutting or gouging, at least 1/8 in. (3.2 mm) (measured from the deepest irregularity) shall be removed mechanically from the cut surface of P-8 group materials and all nonferrous materials. For P-3, P-5, and P-11A group materials, one of the following shall be done.

(a) At least 1/8 in. (3.2 mm) of material shall be mechanically removed from the cut edge.

(b) The cut edge shall be flame softened (P-3 materials only).

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[1]The stress intensification factors for butt welds in Fig. NC-3673.2(b)-1 are derived from Table NB-3681(a)-1 and are equal to $C_2K_2/2$. The rules herein provide for adjustment of the C_2 values.

[2]Flush welds are defined as those welds which have been ground on both interior and exterior surfaces to remove weld irregularities and abrupt changes in contour due to misalignment. Thickness of weld reinforcement (total inside and outside) shall not exceed 0.1T. No concavity on the root side is permitted. The finished contour shall not have a slope (angle measured from tangent to surface of pipe or, on a tapered transition of weld, to the nominal transition surface) greater than 7 degrees.

[3]As-welded is defined as welds not meeting the special requirements for flush welds.

(c) The materials shall be given a stress relieving treatment in accordance with a procedure which shall be developed by the Manufacturer and submitted to the Owner for approval.

Thermal cutting or gouging of P-6 group materials is prohibited.

ANC-4211.1 Preheating Before Thermal Cutting. Material shall be preheated to the temperature required by ANC-4611 prior to thermal cutting or gouging.

NC-4300 Welding Qualifications.

NC-4311 Types of Processes Permitted. Add:

NNC-4311.2 Wash-Pass Welding. Gas-tungsten-arc welding without the addition of filler metal (sometimes called wash-pass welding) shall not be used for the purpose of surface finishing.

NNC-4311.3 Single Welded Joints. Weld joints which do not permit access for examination of the back surfaces shall have the root pass applied by the gas-tungsten-arc or plasma arc process.

NC-4321 Required Qualifications. Add:

ANC-4321(a) In addition to the requirements of NC-4300, procedure and performance qualifications for the following shall be in accordance with NE F 6-5:

1. All new qualifications.
2. All requalifications.
3. Tube-to-tubesheet welding.
4. Seal welding.
5. Hard surfacing.
6. Welds without the addition of filler metal.

NNC-4322.2 Welding Records. The welding records shall include a weld map of the component which shows for each weld joint, or portion thereof, the number of the welding procedure used. A copy of each weld map shall be furnished to the Owner.

Add: NNC-4325 Welding Conditions. When environmental or accessibility conditions are such as to indicate potential welding difficulties beyond those anticipated during welding qualification, mockups shall be made with simulated expected welding conditions to demonstrate that satisfactory production welds can be produced.

NC-4331 Conformance to Section IX Requirements. Add:

ANC-4331 Welding procedure qualification tests shall be in accordance with ANC-4321(a).

NC-4350 Special Qualification Requirements for Tube-to-Tubesheet Welds. Add:

ANC-4351 General Requirements. The additional qualification requirements contained in NE F 6-5 shall apply to tube-to-tubesheet welds.

NC-4360 Qualification Requirements for Welding Specially Designed Welded Seals. Add:

ANC-4361(b) The additional qualification requirements contained in NE F 6-5 for seal welds shall apply to welds for specially designed seals.

NC-4410 Precautions to be Taken Before Welding. Add:

ANC-4411 Identification, Storage and Handling of Welding Materials. The control of welding materials shall include procedures for segregating by lot, reclaiming, and reusing submerged-arc or other welding fluxes.

NC-4420 Rules for Making Welded Joints. Add:

ANC-4420 All pressure boundary welds shall have two or more layers of weld metal, except that one layer is acceptable for:

1. Automatic seal welds and automatic tube-to-tubesheet welds.

2. Manual seal welds in materials less than 0.090 in. (2.4 mm) thick when welded by the gas-tungsten-arc process.

3. Welds which are radiographed in production.

A layer of weld metal need not always involve the deposition of filler metal. For example, fusion of the abutting base metals at the root of a butt weld would constitute a layer, but no more than one such layer could be involved in a weld. The remainder would require filler metal deposits.

NC-4423 Double Welded Joints, Single Welded Joints and Peening. Add:

ANC-4423 Thermal gouging shall be in accordance with ANC-4211 and ANC-4211.1.

NC-4424 Surfaces of Welds. Add:

ANC-4424(d) Continuous root surface concavity shall not exceed 1/32 in. (0.8 mm) for material thicknesses 3/16 in. (4.7 mm) and less, and 1/16 in. (1.5 mm) for material thickness in excess of 3/16 in. | C

(4.7 mm), provided the concavity does not reduce the thickness of the weld below the minimum thickness of the adjacent base metal, and the concavity has a uniform radium and blends smoothly with the adjacent base metal. Concavity up to 1/16 in. (1.6 mm) for material 3/16 in. (4.7 mm) thick is acceptable, provided the foregoing conditions for radius, blending with the base metal, and weld thickness are met and the total length of the weld characterized by the greater concavity does not exceed 25% of the pipe inside circumference. Concavity shall be determined from the lower of the inside abutting surfaces.

NC-4426 Reinforcement of Welds. Add:

ANC-4426.1 Thickness of Weld Reinforcement for Vessels, Pumps, and Valves. The requirements of ANC-4426.2 shall also apply to vessels, pumps, and valves.

ANC-4426.2 Thickness of Weld Reinforcement for Piping. The requirements for weld reinforcement shall be as shown in the following tabulation:

Material Nominal Thickness, in. (mm)	Weld Reinforcement Thickness, in. (mm) Vessels, Pumps and Valves (each face)	Piping OD Col. 1	Piping ID[a] Col. 2
Up to 3/16 (4.7), inclusive	1/16 (1.6)	1/16	1/16
Over 3/16 to 1/2 (13), inclusive	1/16	3/32	3/32
Over 1/2 to 1 (25), inclusive	3/32 (2.4)	1/8	3/32
Over 1 to 2 (51), inclusive	1/8 (3.2)	5/32	1/8
Over 2 to 3 (76), inclusive	5/32 (4)	3/16	1/8
Over 3 inclusive	3/16 (4.7)	3/16	1/8

[a]See ANC-4424(d) for weld concavity requirements for inside diameter for piping.

NC-4453 Requirements for Making Repairs of Welds. Add:

ANC-4453.4 Examination of Repair Welds. Examination of welds repaired by welding shall be in accordance with the requirements for the original weld regardless of the depth of the repair cavity. The requirements of NC-4211.1, ANC-4211, and ANC-4211.1 shall apply for such repairs when preheating or cutting is performed.

NC-4500 Brazing. Add:

ANC-4521 Brazing Procedure and Performance Qualifications. Brazing procedures and performance qualifications shall also meet the requirements of NE F 6-5.

NC-4600 Heat Treatment. Add:

NNC-4600.1 Procedure Approval. Owner's approval shall be required for heat treating procedures to be used for components, or parts thereof, constructed of austenitic stainless steel or nonferrous materials.

ANC-4611 When Preheat is Necessary. The requirements of Subsubarticle D-1200 of Appendix D shall be mandatory for components constructed in accordance with the requirements of NE E 15-2NC, and the following additional requirements shall apply.

(a) For welds joining materials of the same P-number:

(1) The minimum preheat temperature shall be maintained during welding.

(2) The maximum interpass temperature for P-8 material shall not exceed 350°F (177°C).

(3) The maximum interpass temperature for P-6 material shall not exceed 600°F (316°C).

(4) The maximum interpass temperature for all other materials shall not exceed 500°F (260°C).

(5) For P-3, P-5, and P-11A group materials, the minimum preheat temperature shall be maintained until a postweld heat treatment is performed. Alternatively and subject to Owner approval, procedures for P-5 material which do not involve maintaining preheat until postweld heat treatment may be used provided that justification for such procedures is submitted by the Manufacturer. This requirement does not apply to welds that are exempted from postweld heat treatment by the rules of NC-4620.

(b) For weld joining materials of different P-numbers, the maximum interpass temperature shall be that of the material having the higher assigned interpass temperature [see (a)(1) through (a)(4)].

(c) For hard surfacing involving welding or brazing, no maximum interpass temperature is assigned.

ANC-4622.2 Time-Temperature Recordings. The heat treatment procedure and all recorded data, including measurement locations and the furnace charts or data from furnace charts, shall be furnished to the Owner. The charts or data based thereon shall as a minimum show time versus temperature for heating, holding, and cooling. Temperature measurements shall be made at a sufficient number of locations on the component to ensure that the temperature gradients do not exceed the limits specified.

NNC-4623.1 Temperature Variation During Holding Time. During the holding time, the temperature of welds throughout the component

shall not differ from the temperatures used for weld procedure qualification by more than minus 25°F (-4°C) or plus 50°F (10°C).

ANC-4624.2 Furnace Heating--More Than One Heat. Temperature measurements shall be made on that part outside the furnace to define the gradient. Any calculations required to establish the allowable temperature gradient and shielding requirements shall be submitted with the heat treating procedure. The temperatures measured during heat treatments shall be evaluated to determine that the allowable gradient was not exceeded, and a report of this evaluation shall be furnished to the Owner in accordance with ANC-4622.2.

ANC-4624.3 Local Heating. Temperature measurements shall be made on part outside the heating device to define the gradient. Any calculations required to establish the allowable temperature gradient and shielding requirements shall be submitted with the heat treatment procedure. The heat treatment procedure, all recorded data, and a report of each heat treatment shall be furnished to the Owner in accordance with ANC-4622.2.

NNC-4660 Solution Heat Treatment of Austenitic Stainless Steel. When required by the Design Specification, austenitic stainless steel which has been heated to temperatures above 750°F (400°C) for forming shall be heated to a minimum temperature of 1900°F (1038°C) and then quenched in water or rapidly cooled by other means. Where cooling is by means other than water quenching, the heat treatment procedure used for solution treatment shall be acceptable upon demonstration that specimens of the component material given the same heat treatment, including hold time at temperature and cooling rates, are free of intergranular attack when tested in accordance with ASTM A 262 Practice E. The corrosion test practice and the frequency of test shall be as specified in the Design Specification (see NCA-3250).

NC-5000 EXAMINATION

NC-5100 General Requirements for Examination. Add:

ANC-5111(a) The performance of examinations required by NC-5000 as supplemented herein shall also meet the requirements of NE F 3-6.

NC-5120 Time of Examination of Welds. Add:

NNC-5120(a)(1) Radiographic Examination. Radiographic examination of welds in all components constructed of austenitic steels or high nickel alloys, regardless of thickness, shall be performed on welds

in the final surface[1] and final heat treated[2] conditions. Radiographic examination of welds in all components constructed of ferritic steels, regardless of thickness, shall be performed on welds in the final surface condition and after an intermediate or final post-weld heat treatment. Such examination of ferritic steel welds may be performed after an intermediate postweld heat treatment only if that heat treatment meets the holding time requirements of Table NC-4622.1-1 and the holding temperature is as high as or higher than any subsequent temperature to which the weld will be subjected. Ferritic steel welds which are to be covered with weld overlay cladding shall be examined by radiography prior to weld overlay cladding.

NNC-5120(b)(1) Magnetic Particle and Liquid Penetrant Examination. Magnetic particle or liquid penetrant examination shall be performed on all welds, regardless of material type, in the final surface and final heat treated conditions.

NNC-5120(c)(1) Dissimilar Metal Weld Joints. All dissimilar metal weld joints shall be examined in the final surface and final heat treated conditions.

NNC-5120(d)(1) Double Welded Joints. Before applying weld metal to the second side of double-welded joints to be welded, the weld preparation surface shall be examined by a magnetic particle or liquid penetrant method. This examination need not be performed on ferritic welds when the welding procedure requires that preheat be maintained until completion of the weld.

ANC-5130 Examination of Weld Edge Preparation Surfaces. All weld edge preparation surfaces for joint Categories A, B, C, and D and similar joints in materials greater than 3/8 in. (9.5 mm) in nominal thickness shall be subject to the requirements of NC-5130 except that laminar type linear indications shall not exceed the lesser of 1/2T or 1 in. (25 mm). Regardless of material thickness, weld edge preparation surfaces for joint Categories A, B, C, and D, and similar joints, and for the special joints of NNC-3140, shall be examined visually in accordance with NNC-5290.

NC-5200 Examination of Welds.

NC-5210 Category A Vessel Weld Joints and Longitudinal Weld Joints in Other Components. Add:

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[1]The condition of the weld after all surface finishing operations, excluding surface coating, have been performed prior to placing the weld in service.

[2]The condition of the weld after all heat treatments have been performed prior to placing the weld in service.

ANC-5210 Category A weld joints in vessels and longitudinal weld joints in other components shall be radiographed. The external and accessible internal weld surfaces and adjacent base material for at least 1/2 in. (13 mm) on each side of the weld shall be examined by either a magnetic particle or liquid penetrant method.

NC-5220 Category B Vessel Weld Joints and Circumferential Weld Joints in Other Components. Add:

ANC-5220 Category B weld joints in vessels and circumferential weld joints in other components shall be radiographed. The external and accessible internal weld surfaces and adjacent base material for at least 1/2 in. (13 mm) on each side of the weld shall be examined by either a magnetic particle or liquid penetrant method.

NC-5230 Category C Vessel Weld Joints and Similar Weld Joints in Other Components. Add:

ANC-5230 Category C weld joints in vessels and similar weld joints in other components shall be radiographed. The external and accessible weld surfaces and adjacent base material for at least 1/2 in. (13 mm) on each side of the weld shall be examined by either a magnetic particle or liquid penetrant method. Type 1 and 2 full penetration corner weld joints similar to those shown in Fig. NC-4243-1 required special radiographic techniques which may include the use of multiple exposures. In addition, for Type 2 full penetration corner weld joints similar to Fig. NC-4243-1(d), (e), and (f), the fusion zone and the parent metal beneath the attachment surface shall be ultrasonically examined after welding to verify freedom from lack of fusion and laminar defects.

NC-5240 Category D Vessel Weld Joints and Similar Weld Joints in Other Components. Add:

NNC-5240(a) Weld Buildup Deposits. The weld fusion zone and the parent metal beneath the weld metal buildup deposits for connections described in NC-4244(c) shall be ultrasonically examined after welding to ensure freedom from lack of fusion and laminar defects. Additionally, the completed weld surfaces and adjacent base material for at least 1/2 in. (13 mm) from any weld edge shall be examined by either a magnetic particle or liquid penetrant method.

NNC-5240(b) Partial Penetration Welds. Partial penetration welds shall be examined progressively using either a magnetic particle or liquid penetrant method. The increments of examination shall be the root layer, the lesser of each one-third of the maximum weld dimension measured parallel to the center line of the connection or 1/2 in. (13 mm), and the surface of the finished weld.

NNC-5241(a)(1) Butt Welded Nozzles in Vessels. Butt welded nozzles in vessels attached by full penetration welds through either

the wall of the vessel or the nozzle shall be radiographed. The weld surfaces and adjacent base material for at least 1/2 in. (13 mm) on each side of the weld shall also be examined by either a magnetic particle or liquid penetrant method.

NNC-5241(c) Corner Welded Nozzles in Vessels. Corner welded nozzles in vessels shall be radiographed. The weld surfaces and adjacent base material for at least 1/2 in. (13 mm) on each side of the weld shall also be examined by either a magnetic particle or liquid penetrant method. In addition to radiography, the weld, the fusion zone, and the parent metal beneath the attachment surface for details shown in sketches (a), (b), (c), (d), (e), and (g) of Fig. NC-4244(b)-1 and Fig. NC-4256(b)-1 shall be ultrasonically examined after welding to ensure freedom from lack of fusion and laminar defects.

NNC-5242(a)(1) Branch Connections and Nozzles in Piping, Pumps, and Valves. The external and accessible internal weld surfaces and adjacent base metal for at least 1/2 in. (13 mm) on each side of the weld of branch connections and nozzles with nominal pipe size exceeding 4 in. (102 mm) shall be examined by either a magnetic particle or liquid penetrant method in addition to radiographic examination.

ANC-5242(b) Butt Welded Connections. Butt welded branch connections and nozzles in piping, pumps, and valves with nominal pipe size 4 in. (102 mm) and smaller shall be examined by radiography in addition to magnetic particle or liquid penetrant examination.

NNC-5242(c) Corner Welded Connections. The examination requirements of ANC-5242(a) shall apply to full penetration corner welded branch connections and nozzles of all sizes in piping, pumps, and valves, except as follows.

(1) For connections 4 in. (102 mm) nominal pipe size (I.P.S.) and less in diameter, where the ratio of diameters of the branch and the cylinder to which it is welded (d_i/D_i) is 0.25 or less, a progressive magnetic particle or liquid penetrant examination may be substituted for radiographic examination if a meaningful radiographic examination is not feasible. In such case, the magnetic particle or liquid penetrant examination shall consist of a progressive examination of the root layer at the lesser of each one-third of the thickness of the joint or each 1/2 in. (13 mm) and at the root of the weld from the inside surface in the final surface condition.

(2) For connections 2 in. (51 mm) nominal size and less in diameter, where inside surface examination may not be feasible because of inaccessibility, a progressive examination of the outside surface only [as specified in (1)] is acceptable, provided that the weld joint is of a form in which the root of the weld is drilled out or machined out to sound metal as shown in Fig. NNC-5242. In such case, the

minimum thickness of metal to be removed from the root of the weld shall be as follows:

Nominal Size of Connection	Minimum Thickness to be Removed
1 in. (25 mm) I.P.S. and smaller	1/16 in. (1.6 mm)
Over 1 in. to 2 in. (51 mm) I.P.S.	1/8 in. (3.2 mm)

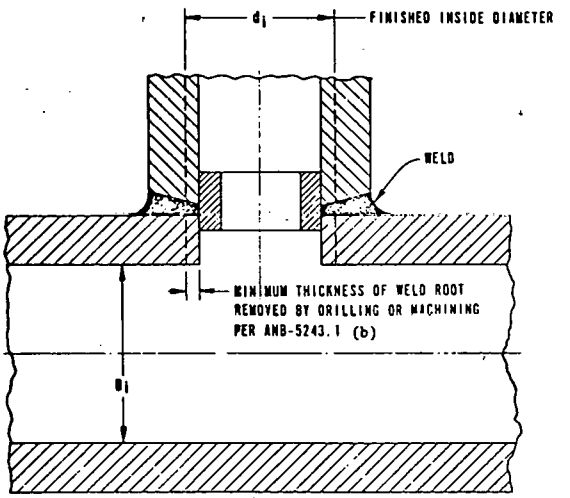

Fig. NNC-5242. Corner Welded Nozzles

NC-5250 Examination of Welds for Vessels Designed to NC-3200. Add:

ANC-5250 The requirements of NC-5210, NC-5220, NC-5230, NC-5240, and NC-5260 as supplemented by NE E 15-2NC shall also apply to vessels designed to NC-3200.

NC-5260 Fillet and Structural Welds. Add:

ANC-5261 Fillet and Socket Welds. Fillet and socket welds shall be examined progressively by either a magnetic particle or liquid penetrant method. The increments of examination shall be the root layer, the lesser of each one-third of the maximum weld dimension measured parallel to the centerline of the connection or 1/2 in. (13 mm), and the surface of the finished weld.

ANC-5262 Structural Attachments. The welds of permanent structure attachments as defined in NC-4431 shall be examined by a radiographic method where practicable and by either a magnetic particle or liquid penetrant method. When radiography is not practicable, an

ultrasonic method shall be used or the weld shall be progressively examined by a liquid penetrant or magnetic particle method on the root layer and at the lesser of each one-third of the thickness of the weld joint or each 1/2 in. (13 mm). The welds of permanent non-structural attachments as defined in NC-4435 shall be examined by a liquid penetrant or magnetic particle method on the root layer and final layer. A visual examination shall be performed on all attachment welds in accordance with NNC-5290.

For attachments welded directly to weld overlay cladding, the area of attachments shall be examined prior to welding of the attachment over 100% of its volume by an ultrasonic method.

NC-5270 Special Welds. Add:

ANC-5271 Welds of Specially Designed Seals. Welds of specially designed seals shall have each layer of weld metal examined by a liquid penetrant method and shall be visually examined in accordance with NNC-5290.

ANC-5272 Weld Metal Cladding. All weld-metal cladding shall be visually examined in accordance with NNC-5290 and shall be examined over 100% of the clad surface by an ultrasonic method and by a liquid penetrant method. In addition, after each eight hours of weld-metal cladding operations, a chemical analysis shall be made of weld-metal cladding to verify its composition in accordance with specified requirements. This analysis shall be obtained from material removed by drilling or chipping from a depth from the surface of at least 0.020 in. (0.5 mm) but not greater than the minimum cladding thickness. The chemical analysis obtained shall be within the required specified composition range.

ANC-5273 Hard Surfacing. Hard surfacing, including that on valves with the inlet connections 4 in. (102 mm) nominal pipe size or less, shall be examined by a liquid penetrant method and shall be visually examined in accordance with NNC-5290. In addition, hard surfacing shall be examined by an ultrasonic method when the design and size of the part are such as to provide sufficient accessibility for the examination.

ANC-5274 Tube-to-Tubesheet Welds. All face joints shall be examined on all weld surfaces, on 1/4 in. (6.35 mm) of adjacent exposed tubesheet surface, and on all inside surfaces of tubes for a distance of 1/4 in. (6.35 mm) beyond the depth of the weld joint preparation or 2T, whichever is greater, by a liquid penetrant method and shall be visually examined in accordance with NNC-5290.

Where projections are machined from tubesheet material or from weld deposits applied to the tubesheet material for the purpose of providing bosses for welding of butt joints, such projections shall be examined prior to making the weld joints by a liquid penetrant method

in accordance with the requirements for tube-to-tubesheet welds, and shall be visually examined in accordance with NNC-5290. This examination shall be performed on all surfaces of the projections except that liquid penetrant examination is not required for weld edge preparations on such projections. After completion of butt joints, the weld surface and adjacent base metal for a distance of 1 in. (25 mm) on each side of the weld shall be examined on either the inside surface or the outside surface and, where accessible on both surfaces, by a liquid penetrant method. In addition, butt joints shall be visually examined in accordance with NNC-5290 and radiographically examined.

Gas leak testing shall be performed when specified in the Design Specification.

NNC-5277.1 Weld Deposited Pads. Weld deposited pads, except those deposited to form a part of an attachment weld of clips, nameplates, insulation supports, locking devices, and other nonstructural members, but including weld deposited pads which form a part of the pressure boundary, shall be visually examined in accordance with NNC-5290, shall be examined by an ultrasonic method over 100% of the volume, and shall be examined by either a liquid penetrant method or a magnetic particle method over 100% of the finished weld surface.

NNC-5277.2 Joints in Thin Materials. Welded joints in materials less than 1/8 in. (3.2 mm) in thickness shall be examined by the same methods required for the same joint categories in other thicknesses, shall have each layer of weld metal examined by a liquid penetrant method, and shall be visually examined in accordance with NNC-5290.

NNC-5277.3 Examination of Root Layer. When accessibility of the reverse side of single-welded joints in components (either full penetration or partial penetration) precludes magnetic particle or liquid penetrant examination of the reverse side, this examination shall be performed on the surface of the root layer. This examination need not be performed on ferritic welds when the welding procedure requires that preheat be maintained until completion of the weld.

Add: NNC-5290 Visual Examination.

NNC-5290.1 Visual examination of weld joint preparations, welds, weld overlay cladding, hard surfacing, and special weld joints shall be performed in accordance with the following requirements to verify conformance to the written welding procedure, the design requirements, and the requirements of this standard.

(a) Prior to welding, the weld joint edges and adjacent surfaces shall be examined for:

1. Proper edge preparation, dimensions, and finish.

2. Clearance dimensions of backing strips, rings, and consumable inserts.

3. Alignment and fit-up of the pieces being welded.

4. Verification of correct materials by check of records.

5. Burn-through[1] and fuse-through[2] for face type tube-to-tubesheet joints.

(b) After welding, the joint shall be examined in the final surface condition [see Footnote (1) of NNC-5120(a)(1)] for:

1. Size of legs and throat and fillet welds.

2. Contour, reinforcement, and surface finish of welds.

3. Degree of underfill, undercut, and overlap.

4. Weld spatter and impression marking.

5. Burn-through[1] and fuse-through[2] for face type tube-to-tubesheet joints.

6. Radial shrinkage of pipe. A straight edge shall be placed on the pipe such that it spans completely the shrinkage caused by the weld as shown in Fig. NNC-5290. The maximum radial shrinkage values, Δ_1 and Δ_2, shall be measured to the nearest 0.01 in (0.254 mm) on both sides of the weld at 0, 90, 180, and 270 degrees around the pipe. The average of these eight values of Δ shall be in accordance with the requirements specified in ANC-3673.2(b). Weld passes at locations Δ_1 and Δ_2 to decrease the apparent pipe shrinkage shall not be allowed. This examination is not required for pipe having a ratio of nominal outside diameter to nominal wall thickness of 20:1 or less.

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[1]Weld penetration through the tube wall such as to cause metal flow resulting in a change in inside contour of the tube.

[2]Weld penetration through the tube wall to the inside diameter with no resulting metal flow such as to change the inside contour of the tube.

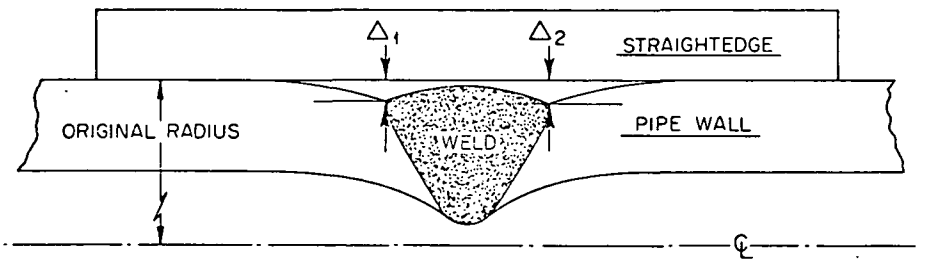

Fig. NNC-5290. Weld Shrinkage Measurement

(c) Prior to weld overlay cladding or hard surfacing, the base metal shall be examined for surface preparation and cleanliness, and after deposition for weld bead contour and surface finish and for impression marking.

NNC-5290.2 All accessible surfaces of the component shall be examined for arc strikes and other damage, such as scratches and gouges, for conformance with the applicable material specification or the Design Specification. Arc strikes shall be examined by a liquid penetrant or magnetic particle method in accordance with NB-2545 or NB-2546. Unacceptable conditions shall be eliminated or, if necessary, repaired by welding in accordance with NC-2500.

NC-5320 Radiographic Acceptance Standards. Add:

NNC-5320(f) Tungsten inclusions with maximum dimensions exceeding the lesser of 1/5T or 3/64 in. (1.2 mm) for thicknesses of 1 in. (25 mm) and less, and exceeding 5/64 in. (2 mm) for thicknesses over 1 in. There shall be no more than five tungsten inclusions in any 6 in. (152 mm) length of weld.

NNC-5320(g) For butt type tube-to-tubesheet welds, and tube-to-tube welds in tube bundles, rounded indications in excess of the following is unacceptable:

1. Any indication with maximum dimension greater than 20% of T, or 1/32 in. (0.8 mm), whichever is smaller, where T is the specified tube wall thickness.

2. Total area of indications (in square inches) in excess of 0.005 times the tube wall thickness in inches, or total area of indications (in square millimeters) in excess of 0.005 times the tube wall thickness in millimeters, in any 1 in. (25 mm) length of weld with this length taken in the most unfavorable location relative to the indications being evaluated.

3. Indications that are separated from one another by less than 3/16 in. (4.7 mm), center to center.

NC-5330 Ultrasonic Acceptance Standards. Add:

NNC-5330(c) Portions of hard surfacing shown by ultrasonic examination to have any lack of bond or defect giving indications equal to or greater than the indication from the size of flat bottom hole specified in the Design Specification shall be unacceptable unless repaired.

NNC-5330(d) Portions of weld metal overlay cladding shown by ultrasonic examination to have any of the following discontinuities shall be acceptable unless repaired:

1. Any lack of bond giving indications equal to or greater than the indication from the 1/2 in. (13 mm) diameter flat bottom hole.

2. Any lack of bond giving indications equal to or greater than the indication from the 1/4 in. (6.35 mm) diameter flat bottom hole but less than the indication from the 1/2 in. (13 mm) diameter flat bottom hole, separated by less than 6 in. (152 mm) of acceptable cladding.

NC-5340 Magnetic Particle Acceptance Standards. Add:

NNC-5342(e) Rounded indications with dimensions exceeding 10% of the nominal weld thickness or 3/16 in. (4.7 mm), whichever is smaller.

NNC-5342(f) Aligned indications in which the average of the center to center distance between any one indication and the two adjacent indications in a straight line is less than 3/16 in. (4.7 mm).

NC-5350 Liquid Penetrant Acceptance Standards. Add:

NNC-5352.1 Welds Other Than Weld Metal Cladding, Tube-to-Tubesheet Welds, Seal Welds, Thin Material Welds, and Hard Surfacing. The following relevant indications are unacceptable:

(a) Rounded indications with dimensions exceeding 10% of the nominal weld thickness or 3/16 in. (4.7 mm), which ever is smaller.

(b) Aligned indications in which the average of the center to center distance between any one indication and the two adjacent indications in a straight line is less than 3/16 in. (4.7 mm).

(c) Weld deposited pads that form a part of the pressure boundary (except those in NNC-5352.2) shall be evaluated as welds.

NNC-5352.2 Tube-to-Tubesheet Welds. For tube-to-tubesheet welds or for weld deposited pads that form a part of the tube-to-tubesheet joint, the following relevant indications are unacceptable unless repaired:

(a) Any cracks.

(b) Any linear indications.

(c) Rounded indications with major dimensions greater than 1/64 in. (0.4 mm).

(d) More than one indication per weld.

NNC-5352.3 Seal Welds and Thin Material Welds. For seal welds and for welded joints in materials less than 1/8 in. (3.2 mm) thick, the following relevant indications are unacceptable unless repaired:

(a) Any cracks.

(b) Any linear indications.

(c) Rounded indications with dimensions exceeding 1/64 in. (0.4 mm).

(d) Rounded indications separated by 1/4 in. (6.35 mm) or less edge to edge.

(e) Five or more rounded indications in any 6 $in.^2$ (3870 mm^2) of surface with the major dimensions of this area not to exceed 6 in. (152 mm) with the area taken in the most unfavorable location relative to the indications being evaluated.

NNC-5352.4 Hard Surfacing. For hard surfacing, the following relevant indications are unacceptable unless repaired:

(a) Any cracks.

(b) Any linear indications.

(c) Rounded indications exceeding the following:

Size of Indication In. (mm)	Maximum Number of Indications Per in.^{2} (645 mm^2)	Per 6 in.^{2} (3870 mm^2)
1/64 (0.4) to 1/32 (0.8)	3	8
Over 1/32 to 1/16 (1.6 mm)	2	5
Over 1/16 to 1/8 (3.2 mm)	1	3
1/8 or above	0	0

The numbers indicated are additive indications within the smaller size ranges [i.e., in a 1 in.^{2} (645 mm^2) area, six indications up to 1/32 in. (0.8 mm) and three indications up to 1/16 in. (1.6 mm) are permitted].

Indications under 1/64 in. (0.4 mm) shall not be counted in determining acceptability.

The number of indications permitted are proportional to the areas stated. For example, if the total hard surfaced area is less than 6 in.^{2} (3870 mm^2), say 3 in.^{2} (1900 mm^2), the number of indications permitted shall be reduced accordingly. Fractional parts shall be rounded to the next lower whole number.

(d) Four or more rounded indications in line separated by 1/16 in. (1.6 mm) or less edge to edge.

(e) Aligned indications in which the average of the center-to-center distance between any one indication and the two adjacent indications in a straight line is less than 3/16 in. (4.7 mm).

NC-5360 Visual Acceptance Standards for Brazed Joints. Add:

NNC-5360(a) All brazes and adjacent base metal shall be free of globules of filler metal or evidence of base metal oxidation.

NNC-5360(b) The joint and adjacent base metal shall be free of stop-off and flux.

NNC-5360(c) There shall be no evidence of poor bonding or base metal erosion.

NNC-5360(d) All brazed joints shall be free of cracks in the base metal or joint area.

NNC-5360(e) Brazed joints shall exhibit a fillet-type contour as follows.

(1) Fluid boundary joints shall have a fillet all around the circumference, length, or periphery.

(2) Non-fluid boundary joints shall have a fillet around 80% of the circumference, length, or periphery. No single interruption shall exceed 10% of the fillet length.

Add: NNC-5390 Visual Acceptance Standards for All Welded Joints and Surfaces. Weld joints and surfaces which are shown by visual examination to have any of the following defects or areas of nonconformance are unacceptable unless corrected prior to welding or repaired:

1. Any nonconformance revealed by the examination required by NNC-5290.

2. Any zone of incomplete fusion or penetration.

3. Any burn-through[1] of face type tube-to-tubesheet joints. D

4. For face type tube-to-tubesheet joints, fuse-through[2] in excess of 10% of the welds in any tube bundle.

NC-6000 TESTING

NC-6120 Preparation for Testing. Add:

NNC-6128 Pressure Relief. The test setup shall be provided with a pressure-relief device set at a maximum level of one and one-third times the test pressure.

NC-6200 Hydrostatic Tests. Add:

ANC-6212(a) Water chemistry shall conform to the requirements of the Design Specification when specified therein.

NNC-6216 Repair and Retests. Any leak, permanent deformation, or failure which occurs during hydrostatic or pneumatic test and any rejectable indication found during post-test examination shall be reported to the Owner. Repair or retests shall not be performed without the prior approval of the Owner.

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[1]Weld penetration through the tube wall such as to cause metal flow resulting in a change in inside contour of the tube.

[2]Weld penetration through the tube wall to the inside diameter with no resulting metal flow such as to change the inside contour of the tube.