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NE E 15-2NB-T

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August 1982

nuclear STANDARD

CLASS 1 NUCLEAR COMPONENTS (SUPPLEMENT
TO ASME BOILER AND PRESSURE-VESSEL
CODE, SECTION III¹, SUBSECTIONS NCA AND NB)

AUGUST 1983

¹1983 Edition

U. S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY PROGRAMS

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

Justification for Revision

Reference to the NE material specifications and the additional requirements for weld metal chemical analysis, examination of materials, and of repair welds, and QA requirements have been deleted. The specification of any supplementary requirements to those imposed by the ASME Boiler and Pressure Vessel Code is to be determined by the component designer/operator.

Previous	NNB 2121(f)	Noted above
paragraphs	NNB 2121(g)	
deleted	NNB 2121(h)	
	ANB 2432.2	
	NNB 2510(d)	
	ANB 2579.4(a)	
	ANB 2610(a)	
	ANB 4122.1	
	ANB 4125	
	ANB 4131	

Paragraphs revised

Table of Contents	Changed to reflect paragraph deletions.
Paragraph 0.5	Deleted reference to Tables on Materials.
Paragraph 0.5.1	Deleted reference to NE F 2-4, which was referenced in ANB 2610(a).
Paragraph NNB-1130	Editorially revised for clarity.
Paragraph 2121(f)	Redesignated paragraph NNB 2121(i) to NNB 2121(f) with deletion of the above noted paragraphs.
Paragraph NNB-2126	Redesignated paragraph NNB 2125 to NNB 2126 due to addition of paragraph NB 2125 in Code, Section III, Subsection NB.
Paragraph NNB 5290.2	Deleted reference to NE material standard requirements for examination of repair welds of arc strikes.
Cover page and page 1	Editorial revision to reflect current Code addition

FOREWORD

This standard supersedes the August 1982 issue of NE E 15-2NB-T and incorporates those changes to that issue of the standard.

This standard is current with the edition of the ASME Boiler and Pressure Vessel Code (Code) Section and Addenda noted on the cover page of this standard.

The NE Code-related standards are reviewed each time the Code or an Addendum to the Code is issued (i.e., twice a year). If changes are necessary in the body of the standard, these are indicated by the marginal indications:

C	Change
D	Deletion
N	New material or addition
E	Editorial

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CLASS 1 NUCLEAR COMPONENTS (SUPPLEMENT TO ASME BOILER AND PRESSURE VESSEL CODE, SECTION III, SUBSECTIONS NCA AND NB)

0. INTRODUCTION

0.1 Scope. This standard supplements the rules for the construction of nuclear components that are covered by Subsections NCA and NB of the 1983 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. | E

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-3200 is designated as "NNCA-3280." 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 subsections 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 15-2NB applications."

0.3 Conflicts. Class 1 components shall be constructed in accordance with the rules of the Code, Section III, Subsection NB, including Addenda as specified in 0.1; applicable Code Cases as specified in NNCA-1140(b); and the supplemental requirements of NE E 15-2NB. 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.

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 3-6T	Nondestructive Examination (Supplement to ASME Boiler and Pressure Vessel Code, Section V)	D
NE F 6-5T	Welding and Brazing Qualifications (Supplement to ASME Boiler and Pressure Vessel Code, Section IX)	D

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. Unless otherwise approved by the Owner, 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 15-2NB.

NCA-3000 RESPONSIBILITIES AND DUTIES

NCA-3250 Contents of Design Specifications. Add:

ANCA-3252 Contents of Design Specifications. The design requirements to permit periodic inservice examinations, testing, and maintenance and to permit the surveillance program required by NNCA-3280 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 are made.

Add: NNCA-3280 Material Surveillance. The Owner shall establish a surveillance program for materials to monitor any deterioration which may occur in service due to radiation effects.

NCA-4000 QUALITY ASSURANCE

NCA-4100 Requirements.

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 NB REQUIREMENTS FOR CLASS 1 COMPONENTS

NB-1000 INTRODUCTION

NB-1100 Scope. Add:

NNB-1130 Additional Requirements. Any Class 1 component which is required to conform to NE E 15-2NB shall meet the rules of Subsection NB of Section III and of NE E 15-2NB. Whenever the requirements of NE E 15-2NB differ from the requirements of Subsection NB, a single operation may be performed, provided the requirements of both NE E 15-2NB and Subsection NB are satisfied. Unless otherwise stated, reference in Subsection NB to materials in Tables I-1.0 of Section III or to design, fabrication, or examination shall mean that such items shall also conform to the requirements of NE E 15-2NB.

NB-2000 MATERIAL

NB-2120 Pressure Retaining Material.

NNB-2121(f) Backing rings and strips shall conform to the requirements of one of the specifications for materials given in Tables I-1.0, and to the requirements of NB-2124, NB-2130, and NB-2150. Backing materials shall be of the same P-number as the materials to be welded except that backing materials used in the welding of P-8, P-42, P-43, and P-45 materials shall, additionally, be of the same type or grade (chemically) as the materials to be joined by welding. Where two different materials are to be joined by welding, the selection of the backing material may be based on either material with respect to the above requirements.

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Add: NNB-2126 Material Grain Flow Requirements. Whenever practical, 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 practical, one of the following shall apply.

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

(2) 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 NB-4000 as supplemented by NE E 15-2NB to a minimum depth of 20% of the base material thickness or 1/4 in. (6.35 mm) whichever is less.

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

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NB-3000 DESIGN

NB-3230 Stress Limits for Bolts. Add:

NNB-3232.4 Bolting Preload. Bolting shall be designed against loss of required preload in service. The designer shall determine the range of preload to meet the requirements for stress limits and the required seating loads. These values shall be included in the Stress Report. Preloading methods and lubricants shall be subject to Owner approval.

NB-3330 Openings and Reinforcement. Add:

ANB-3337.3 Partial Penetration Welded Nozzles. The use of partial penetration welds for nozzle joints, such as those shown in Fig. NB-4244(d)-1 and NB-4244(d)-2 shall be limited to the inside of the vessel.

NB-3350 Design of Welded Construction. Add:

ANB-3352 Permissible Types of Welded Joints. 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 the welder's environment, position, and comfort due to the potential necessity to weld in close quarters while the part is under a high degree of preheat and due to location and orientation of the weld joint.

ANB-3352.2 Joints of Category B. Backing strips which are not to be removed shall not be used without prior approval of the Owner.

ANB-3352.3 Joints of Category C. Joints of Category C for which ultrasonic examination in addition to radiographic examination is required (see NB-5230) shall be permitted only if the Manufacturer demonstrates that meaningful ultrasonic examination can be performed.

ANB-3352.4 Joints of Category D.

NNB-3352.4(f) Ultrasonic Examination. Joints of Category D for which ultrasonic examination is required in addition to radiographic examination (see NB-5240) shall be permitted only if the Manufacturer demonstrates that meaningful ultrasonic examination can be performed.

NNB-3352.5 Tube-to-Tubesheet Joints. Welded tube-to-tubesheet joints shall be either the face joint or the butt joint type and shall meet the requirements of NB-4350.

(a) Face joints may be welded with either fillet welds or fillet reinforced "J" groove welds. Face joints shall be designed to provide an average weld throat of at least 1.5 times the minimum tube wall thickness (T), with no weld having a throat less than 1.25T. The length of the legs of the weld along the tube as measured from the root of the weld shall be an average 2T with no leg length less than 1.5T.

(b) Butt joints shall meet the requirements of NB-3352.4(a) or NB-3352.4(c)(1) and the requirements of ANB-3352, except that the dimensional requirements of Fig. NB-4244(a)-1 and NB-4244(c)-1 shall not apply. Weld reinforcement shall be in accordance with NB-4426, ANB-4426.1, and ANB-4426.2 and as further restricted by design requirements that limit the amount of flow restriction in a tube.

NNB-3352.6 Seal Welded Joints. 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 thus defined include, but are not limited to, specially designed welded seals (NB-3227.7).

(a) The minimum 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. The face or root reinforcement shall not exceed 1/16 in. (1.6 mm) in any location for automatic welds or 3/32 in. (2.4 mm) for manual welds. Maximum concavity at 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.

(b) 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 on the root of such seal welds shall not exceed 3/32 in. (2.4 mm).

NB-3660 Design of Welds. Add:

ANB-3661.2 Socket Welds. Socket welded joints shall be limited to 1 in. (25 mm) nominal pipe size and smaller.

NB-3670 Special Piping Requirements. Add:

ANB-3671.1 Flanged Joints. The use of flanged joints in Class 1 piping shall be limited to those locations in the system where they are necessary for component removal.

NNB-3671.4(d) Flared, Flareless, and Compression Joints. The use of these types of joints shall be subject to Owner approval.

NNB-3671.7(d) Sleeve Coupled and Other Patented Joints. The use of these types of joints shall be subject to Owner approval.

NB-3680 Stress Indices and Flexibility Factors. Add:

ANB-3683.2 B, C, and K Indices. For pipe having a ratio of nominal outside diameter to nominal wall thickness greater than 20:1, the larger of the indices specified in Table NB-3681(a)-1 or the indices determined by Equations 1, 2, or 3 shall apply to girth-butt welds when there is a radial contraction of the finished weld:

$$C_1 = 1.0 + 0.7 \Delta/t \text{ for all } t \text{ and } \Delta/t > 0.2 \quad (1)$$

$$C_2 = 1.0 + 2.9 \Delta/t \text{ for } t > 3/16 \text{ in. (4.7 mm) or } \delta/t \leq 0.1 \quad (2)$$

$$C_2 = 1.4 + 2.9 \Delta/t \text{ for } t \leq 3/16 \text{ in. (4.7 mm) or } \delta/t > 0.1 \quad (3)$$

where

C = secondary stress indices (NB-3653.1)

Δ = radial shrinkage

t = wall thickness

δ = maximum permissible mismatch [see NB-3683.1(a)].

Radial shrinkage shall not exceed 2% of the original outside radius and shall be measured in accordance with NNB-5290.1(b)(6).

NB-4000 FABRICATION AND INSTALLATION REQUIREMENTS

NB-4120 Certification of Materials and Fabrication by Certificate Holder. Add:

ANB-4121.2 Repetition of Tensile or Impact Tests. Whenever ferritic steel products used in Class 1 components are subjected by the fabricator to normalizing or accelerated cooling from the austenitizing temperature, test specimens shall be taken by the fabricator directly from the products after such heat treatment or from separate test coupons taken from the products and which accompany the products through these heat treatment cycles. In accordance with NB-2211, these test specimens shall also be subjected to any additional postweld heat treatment to which the products are subjected during fabrication. These test specimens shall meet all tensile and impact requirements specified for the products.

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NB-4210 Cutting, Forming, and Bending. Add:

ANB-4211 Cutting. After cutting or gouging, the affected surfaces shall be mechanically cleaned and prepared for the 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 and all nonferrous materials. For P-3, P-5, and P-11A 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 edges.

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

(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 materials is prohibited.

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

NB-4300 Welding Qualifications.

NB-4310 General Requirements. Add:

NNB-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.

NNB-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 (see NNB-5280).

NB-4320 Welding Qualifications, Records, and Identifying Stamps. Add:

NNB-4322.2 Welding Records. The record 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.

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

NB-4330 General Requirements for Welding Procedure Qualification Tests. Add:

ANB-4331 Conformance to Section IX Requirements. Welding procedures, procedure qualifications, and performance qualifications shall meet the requirements of NB-4300 and Section IX. Additionally, the requirements of NE F 6-5 shall be met for the following:

1. All new procedures and their qualification.
2. All new performance qualifications.
3. All requalifications.
4. Tube-to-tubesheet welds.
5. Seal welds.

6. Hard surfacing.
7. Welds without the addition of filler metal.

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

NNB-4351.1 Qualification Requirements for Tube-to-Tubesheet Welds. The additional qualification requirements contained in NE F 6-5 shall apply to tube-to-tubesheet welds.

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

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

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

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

NB-4420 Rules for Making Welded Joints. Add:

NNB-4420.1 Weld Metal Layer Requirements. All pressure boundary welds shall have two or more layers of weld metals, 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. (2.3 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 depositing 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.

NB-4423 Miscellaneous Welding Requirements. Add:

NNB-4423(d) Double Welded Joints. Thermal gouging shall be in accordance with ANB-4211 and ANB-4211.1.

NNB-4424(d)(1) Weld Concavity Requirements for Inside Diameter of Piping. 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. (1.6 mm) for material thickness in excess of 3/16 in. (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 radius 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 and less and up to 3/32 in. (2.4 mm) for material over 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.

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

ANB-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	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 (50), 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

^aSee ANB-4424(d)(1) for weld concavity requirements for inside diameter of piping.

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NB-4510 Rules for Brazing. Add:

ANB-4510 All brazing procedures and procedure and performance qualifications shall meet the requirements of Section IX, as supplemented by NE F 6-5.

NB-4610 Welding Preheat Requirements. Add:

ANB-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 15-2NB, and the following additional requirements shall apply.

(a) For welds joining material 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 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 NB-4620.

(b) For welds 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.

NB-4620 Postweld Heat Treatment. Add:

NNB-4620.1 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.

ANB-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 available 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 the sufficient number of locations on the component to ensure that the temperature gradients do not exceed the limits specified.

NNB-4623(c) Temperature Variation During Holding Time. During the holding time, the temperature of welds throughout the component shall not differ from the temperature used for weld procedure qualification by more than minus 25°F (-32°C) or plus 50°F (10°C).

ANB-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 ANB-4622.2.

ANB-4624.3 Local Heating. Temperature measurements shall be made on that 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 treating procedure. The heat treatment procedure, all recorded data, and a report of each heat treatment shall be furnished to the Owner in accordance with ANB-4622.2.

Add: NNB-4670 Test Plates. For Class 1 components of welded construction that are to be heat treated and for which impact testing is required, test plates shall be prepared in accordance with the following requirements.

NNB-4671 Preparation of Test Plates. A separate test plate shall be prepared for each welding procedure employed to make Category A and B joints in vessels and equivalent joints in piping, pumps, and valves. The test plate thickness shall be that of the thickest joint to be welded by that particular procedure. The test plate material shall be taken from one or more of the heats of material used in the component and shall include materials used in reactor vessel walls which directly surround the effective height of the reactor core. The welding procedures and the nondestructive examination methods used shall be the same as those used in the fabrication of the component. These test plates shall be subjected to the same history of heat treatment and other operations performed on the component weld joints which may affect the mechanical or impact properties of the joint and base material.

NNB-4672 Welding Conditions. Test plates for longitudinal butt joints may be welded as an extension of the production weld. The test plates for welds that are not welded as an extension of the production weld shall be welded under the production welding conditions used for the component and shall be welded concurrently with the production welds immediately prior to the start of welding the production welds.

NNB-4673 Impact Tests. After all heat treatments have been performed on the component and test plates, impact tests shall be performed on test specimens taken from base material, weld metal, and the heat affected zone of the test plates. Test specimens shall be treated, prepared, and taken in the same manner and shall meet the same impact requirements as specified for the component base material and welds.

Add: NNB-4680 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 frequency of test shall be specified in the Design Specification (NCA-3250).

NB-5000 EXAMINATION

NB-5110 Procedures, Qualifications, and Evaluation. Add:

ANB-5111 General Requirements. The examinations required by Section III and by NE E 15-2NB shall be performed in accordance with the requirements of Article NB-5000 and NE F 3-6.

NB-5120 Time of Examination of Welds and Weld Metal Cladding. Add:

NNB-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 surface¹ and final heat treated² 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 NB-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. Reexamination by radiography is not required when radiography has been performed and accepted on a surface intended to be the final surface condition, and this surface subsequently suffers minor damage, such as nicks, scratches, arc strikes, or weld splatter, requiring repair by mechanical surface preparation only. Reexamination by radiography is also not required

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

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

when radiography has been performed and accepted on a surface intended to be the final surface condition, and this surface is subsequently repaired and examined in accordance with NB-4450.

NNB-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.

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

NNB-5120(d)(1) Examination of Weld Preparation Area. Before applying weld metal to the second side of double-welded joints to be welded, the weld preparation 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.

NB-5130 Examination of Weld Edge Preparation Surfaces. Add:

ANB-5130 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 NB-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 similar joints, and for the special joints of NNB-3352.5 and NNB-3352.6, shall be examined visually in accordance with NNB-5290.

NB-5200 Required Examination of Welds.

NB-5243 Corner Welded Nozzles, Branch, and Piping Connections.

Add:

ANB-5243(c) The examination requirements of NB-5243(b) shall apply to full penetration corner welded branch and piping connections of all sizes in piping, pumps, and valves except as follows.

(1) For connections of 4 in. (100 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 and at the lesser of each one-third of the thickness of the joint of each 1/2 in. (13 mm), and the root of the weld from the inside surface, in the final surface condition.

(2) For connections 2 in. (50 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 principle in Fig. NNB-5243.1. 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. (50 mm) I.P.S.	1/8 in. (3.2 mm)

Fig. NNB-5243.1. Corner Welded Nozzles.

NB-5245 Partial Penetration Welds. Add:

ANB-5245 Partial-penetration welds shall be examined progressively by a liquid penetrant or magnetic particle method at the intervals specified in NNB-5243(c)(1).

NB-5246 Oblique Full Penetration Nozzles, Branch, and Piping Connections. Add:

ANB-5246 Oblique connections shall meet the same examination requirements as for similar permissible welded configurations, regardless of the angle of the connection. This requirement shall apply also to NB-3352.4(e).

NB-5260 Structural Attachment Welds. Add:

ANB-5260 The welds of permanent structural attachments as defined in NB-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 of 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 nonstructural attachments as defined in NB-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 NNB-5290.

For attachments welded directly to weld overlay cladding as allowed in NB-4434, the area of attachment shall be examined prior to welding of the attachment over 100% of its volume by an ultrasonic method.

NB-5270 Special Welds. Add:

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

ANB-5272 Weld Metal Cladding. All weld-metal cladding shall be visually examined in accordance with NNB-5290 and shall be examined over 100% of the clad surface by an ultrasonic and 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. (0.50 mm) but not greater than the minimum cladding thickness. The chemical analysis obtained shall be within the required specified composition range.

ANB-5273 Hard Surfacing. All hard surfacing, including that on valves with the inlet connections 4 in. (100 mm) nominal pipe size or less, shall be examined by a liquid penetrant method and shall be visually examined in accordance with NNB-5290. The acceptance standards of NNB-5352.4 shall apply for liquid penetrant examination.

In addition, all 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.

ANB-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 NNB-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 NNB-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 NNB-5290 and radiographically examined.

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

NNB-5280 Weld-Deposited Pads. All 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 NNB-5290, shall be examined by an ultrasonic method over 100% of the volume, and shall be examined by either a liquid penetrant or magnetic particle method over 100% of the finished weld surface.

NNB-5281 Joints in Materials Less Than 1/8 In. (3.2 mm) Thick. All 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 NNB-5290.

Add: NNB-5282 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 procedures required that preheat be maintained until completion of the weld.

Add: NNB-5290 Visual Examination.

NNB-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 requirement to verify conformance to the written welding procedures, 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. Verification of cleanliness requirements.

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

1. Size of legs and throat of 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-through¹ and fuse-through² 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. NNB-5290. The maximum radial shrinkage values, Δ_1 and Δ_2 , shall be measured to the

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

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

6. 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 shall be in accordance with the requirements specified in ANB-3683.2. Weld passes at locations 1 and 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.

(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.

NNB-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 NE material standard or the Design Specification. Unacceptable surface conditions, such as scratches and gouges shall be eliminated in accordance with NB-2538 except that NB-2538(a)(3) does not apply.

Fig. NNB-5290. Weld Shrinkage Measurement.

Arc strikes shall be examined by a liquid penetrant or magnetic particle method in accordance with NB-2545 or NB-2546. Unacceptable indications shall be eliminated in accordance with NB-2538.

NB-5320 Radiographic Acceptance Standards. Add:

NNB-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.

NNB-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 indication (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.

NB-5330 Ultrasonic Acceptance Standards. Add:

NNB-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.

NB-5330(d) Portions of weld metal overlay cladding shown by ultrasonic examination to have any of the following discontinuities shall be unacceptable 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 hold, separated by less than 6 in. (152 mm) of acceptable cladding.

NB-5340 Magnetic Particle Acceptance Standards. Add:

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

NNB-5342(d) 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).

NB-5350 Liquid Penetrant Acceptance Standards. Add:

NNB-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 of 3/16 in. (4.7 mm), whichever 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 NNB-5352.2) shall be evaluated as welds.

NNB-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.

NNB-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 (3800 mm²) 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.

NNB-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 Indications. In. (mm)	Maximum Number of Indications	
	Per in. ² (645 mm ²)	Per 6 in. ² (3800 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 mm²) 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 (3800 mm²), say 3 in.² (1900 mm²), the number of indications permitted shall be reduced accordingly. Fractional parts shall be reduced to the next lower whole number.

- (d) Four or more rounded indications in a 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).

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

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

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

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

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

NNB-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: NNB-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 NNB-5290.
2. Any zone of incomplete fusion or penetration.
3. Any burn-through of face type tube-to-tubesheet joints.
4. For face type tube-to-tubesheet joints, fuse-through in excess of 10% of the welds in any tube bundle.

NB-5400 Final Examination of Vessels. Add:

NNB-5420 Final Examination of Components. The requirements of NB-5410 shall apply to piping, pumps, and valves in addition to vessels.

NB-6000 TESTING

NB-6110 Testing of Components, Appurtenances, and Systems. Add:

NNB-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.

NB-6200 Hydrostatic Tests. Add:

NNB-6212(a)(1) Water Chemistry Composition. Water chemistry shall conform to the requirements of the Design Specification when specified therein.

NNB-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.

NNB-6222(a)(1) Multichamber Components. Multichamber components which are tested with pressure simultaneously applied to adjacent chambers to meet the stress limits of NB-3226 shall also be tested with individual chambers pressurized at a pressure meeting the stress limits of NB-3226.

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