electric resistance welding or the high frequency resistance welding process. In addition, the following requirements shall apply:

(a) The heat transfer fins need not be certified material. The material for the heat transfer fins shall be identified and suitable for welding; however, Certified Material Test Reports are not required.

(b) The machine welding process used to weld the heat transfer fins to the tubular material shall be performed in accordance with a Welding Procedure Specification.

(c) The procedure qualification shall require that a minimum of 12 cross-sections through the weld zone shall be examined at 5× minimum magnification. There shall be no cracks in the base material or weld; and the weld penetration shall be limited to 20% of the nominal tube wall thickness.

(d) For P-No. 1 material, the weld that attaches the fins to the tubing shall be heat treated after welding to a minimum temperature of 1,000°F (540°C).

(e) The fin is not considered to provide any support to the tube under pressure loading.

**NB-2127 Seal Membrane Material**

Seal membrane material (NB-4360) shall conform to the requirements of one of the material specifications listed in Section II, Part D, Subpart 1, Tables 2A and 2B. The requirements of NB-2500 are applicable for the appropriate product form when the material thickness is greater than 1/8 in. (6 mm).

**NB-2128 Bolting Material**

(a) Material for bolts and studs shall conform to the requirements of one of the specifications listed in Section II, Part D, Subpart 1, Table 4. Material for nuts shall conform to SA-194 or to the requirements of one of the specifications for nuts or bolting listed in Section II, Part D, Subpart 1, Table 4.

(b) The use of washers is optional. When used, they shall be made of wrought material with mechanical properties compatible with the nuts with which they are to be employed.

**NB-2130 Certification of Material**

All material used in construction of components shall be certified as required in NCA-3861 and NCA-3862. Certified Material Test Reports are required for pressure-retaining material except as provided by NCA-3861. A Certificate of Compliance may be provided in lieu of a Certified Material Test Report for all other material. Copies of all Certified Material Test Reports and Certificates of Compliance applicable to material used in a component shall be furnished with the material.

**NB-2140 Welding Material**

For the requirements governing the material to be used for welding, see NB-2400.

**NB-2150 Material Identification**

The identification of pressure-retaining material and materials welded thereto shall meet the requirements of NCA-4256. Material for small items shall be controlled during manufacture and installation of a component so that they are identifiable as acceptable material at all times. Welding and brazing material shall be controlled during the repair of material and the manufacture and installation so that they are identifiable as acceptable until the material is actually consumed in the process (NB-4122).

**NB-2160 Deterioration of Material in Service**

Consideration of deterioration of material caused by service is generally outside the scope of this Subsection. It is the responsibility of the Owner to select material suitable for the conditions stated in the Design Specifications (NCA-3250), with specific attention being given to the effects of service conditions upon the properties of material. Special consideration shall be given to the effects of irradiation on the properties of material (including welding material) in the core belt line region of the reactor vessel. Any special requirement shall be specified in the Design Specifications (NCA-3252 and NCA-3124). When so specified, the check analysis shall be made in accordance with the base metal specification and in accordance with NB-2420 for the welding material.

**NB-2170 Heat Treatment to Enhance Impact Properties**

Carbon steels, low alloy steels, and high alloy chromium (Series 4XX) steels may be heat treated by quenching and tempering to enhance their impact properties. Postweld heat treatment of the component at a temperature of not less than 1,100°F (595°C) may be considered to be the tempering phase of the heat treatment.

**NB-2180 Procedures for Heat Treatment of Material**

When heat treating temperature or time is required by the material specification and the rules of this Subsection, the heat treating shall be performed in temperature-surveyed and temperature-calibrated furnaces or the heat treating shall be controlled by measurement of material temperature by thermocouples in contact with the material or attached to blocks in contact with the material or by calibrated pyrometric instruments. Heat treating shall be performed under furnace loading conditions such that the heat treatment is in accordance with the material specification and the rules of this Subsection.
NB-4221.2 Maximum Deviation From True Theoretical Form for External Pressure. Vessels designed for external pressure shall meet the tolerances given in (a) through (c) below.

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

(b) The value of $t$, in. (mm), at any cross section is the nominal plate thickness less corrosion allowance for sections of constant thickness and the nominal thickness of the thinnest plate less corrosion allowance for sections having plates of more than one thickness.

(c) The value of $L$ in Figures NB-4221.2(a)-1 and NB-4221.2(a)-2 is determined by (1) through (3) below.

1. For cylinders, $L$ is as given in NB-3133.2.

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

3. For spheres, $L$ is one-half of the diameter $D_o$, in.

NB-4221.3 Deviations From Tolerances. Deviations from the tolerance requirements stipulated in NB-4221.1 and NB-4221.2 are permitted, provided the drawings are modified and reconciled with the Design Report (NCA-3551) and provided the modifications are certified by a Certifying Engineer in an addendum to the Design Report.

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

NB-4222 Tolerances for Formed Vessel Heads

The tolerance for formed vessel heads shall be as set forth in the following subparagraphs.

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

(U.S. Customary Units)

$$\frac{D + 50}{200} \quad \text{and} \quad \frac{D + 12}{100}$$

(SI Units)

$$\frac{D + 1250}{200} \quad \text{and} \quad \frac{D + 300}{100}$$

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

NB-4222.2 Deviation From Specified Shape.

(a) The inner surface of a torispherical or ellipsoidal head shall not deviate outside the specified shape by more than $1\frac{3}{4}\%$ of $D$, inside the specified shape by more than $\frac{5}{8}\%$ of $D$, where $D$ is the nominal inside diameter of the vessel. Such deviations shall be measured perpendicular to the specified shape and shall not be abrupt. The knuckle radius shall not be less than specified. For 2:1 ellipsoidal heads, the knuckle radius may be considered to be $17\%$ of the diameter of the vessel.

(b) Hemispherical heads and any spherical portion of a formed head shall meet the local tolerances for spheres as given in NB-4221.2, using $L$ as the outside spherical radius, in., and $D_o$ as two times $L$.

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

NB-4223 Tolerances for Formed or Bent Piping

The tolerances for formed or bent piping shall be as set forth in the following subparagraphs.

NB-4223.1 Minimum Wall Thickness. In order to assure that the wall thickness requirements of the design calculations are met, the actual thickness shall be measured, or the process shall be qualified by demonstrating that it will maintain the required wall thickness.
NB-5272 **Weld Metal Cladding**

Weld metal cladding shall be examined by the liquid penetrant method.

NB-5273 **Hard Surfacing**

Hard surfacing weld metal shall be examined by the liquid penetrant method in accordance with NB-2546, the acceptance standards applicable to materials less than $\frac{5}{8}$ in. (16 mm) thick shall apply. Penetrant examination is not required for hard surfacing on valves with inlet connections NPS 4 (DN 100) or less.

NB-5274 **Tube-to-Tubesheet Welded Joints**

Tube-to-tubesheet welded joints shall be examined by the liquid penetrant method.

NB-5275 **Brazed Joints**

Flux and flux residue shall be removed from all surfaces prior to examination. Joints shall be visually examined on all accessible surfaces to determine whether there has been adequate flow of brazing metal through the joint. Optical aids may be employed for indirect visual examination of joints which cannot be directly examined.

NB-5276 **Inertia and Continuous Drive Friction Welds**

(a) When radiographic examination is required by this Article, inertia and continuous drive friction welds shall also be examined by the ultrasonic method to verify bonding over the entire area.

(b) The materials used shall be those assigned a P-Number by Section IX, but shall not include rimmed or semikilled steel.

(c) One of the two parts to be joined must be held in a fixed position and the other part rotated. The two faces to be joined must be symmetrical with respect to the axis of rotation.

(d) The weld between the two members shall be a full penetration weld.

NB-5277 **Electron Beam Welds**

In addition to the requirements for the type of weld being examined, all complete penetration welds made by the electron beam welding process shall be ultrasonically examined.

NB-5278 **Electroslag Welds**

In addition to the requirements for the type of weld being examined, all complete penetration welds made by the electroslag welding process in ferritic materials shall be ultrasonically examined.

NB-5279 **Special Exceptions**

When the joint detail does not permit radiographic examination to be performed in accordance with this Article, ultrasonic examination plus liquid penetrant or magnetic particle examination of the completed weld may be substituted for the radiographic examination. The absence of suitable radiographic equipment shall not be justification for such substitution. The substitution of ultrasonic examination can be made, provided the examination is performed using a detailed written procedure proven by actual demonstration to the satisfaction of the Inspector as capable of detecting and locating defects described in this Subsection. The nondestructive examinations shall be in accordance with NB-5110 and meet the acceptance standards of NB-5300.

NB-5280 **PRESERVICE EXAMINATION**

NB-5281 **General Requirements**

(a) Examinations required by NCA-3252(c) shall be completed prior to completion of the N-5 Data Report.

(b) All volumetric and surface examinations shall be documented with results and identified in a form consistent with those required in NCA-4134.17 for transfer to the Owner.

NB-5282 **Examination Requirements**

(a) Components shall be examined as specified in Section XI, IWB-2500. The method of examination for the components and parts of the pressure-retaining boundaries shall comply with those tabulated in IWB-2500. Only the volumetric and surface examinations are required to be performed.

(b) For Control Rod housings, Examination Category B-O, the examination shall be extended to include essentially 100% of the welds in the installed peripheral control rod drive housing only.

NB-5283 **Components Exempt From Preservice Examination**

The following components or parts of components are exempted from the volumetric and surface examination requirements of this subarticle:

(a) piping of NPS 1 (DN 25) and smaller;

(b) reactor vessel head connections and associated piping, NPS 2 (DN 50) and smaller, made inaccessible by control rod drive penetrations; and

(c) integral attachments of supports and restraints that are inaccessible due to being encased in concrete, buried underground, or encapsulated by guard pipe.

NB-5300 **ACCEPTANCE STANDARDS**

NB-5320 **RADIOGRAPHIC ACCEPTANCE STANDARDS**

Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions:

(a) any indication characterized as a crack or zone of incomplete fusion or penetration;