EXHIBIT

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ASME BOILER AND PRESSURE VESSEL CODE

SECTION III

1971

NUCLEAR POWER PLANT COMPONENTS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ASME BOILER AND PRESSURE VESSEL CODE

SECTION III

Rules for Construction of NUCLEAR POWER PLANT COMPONENTS

1971 edition

JULY 1, 1971

ASME BOILER AND PRESSURE VESSEL COMMITTEE
SUBCOMMITTEE ON NUCLEAR POWER

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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ARTICLE NB-3000

DESIGN

NB-3100 GENERAL DESIGN

NB-3110 LOADING CRITERIA

NB-3111 Loading Conditions

The loadings that shall be taken into account in designing a component include but are not limited to the following:

(a) Internal and external pressure;

(b) Weight of the component and normal contents under operating or test conditions, including additional pressure due to static and dynamic head of liquids;

(c) Superimposed loads such as other components, operating equipment, insulation, corrosion-resistant or erosion-resistant linings and piping;

(d) Wind loads, snow loads, vibrations and earthquake loads where specified;

(e) Reactions of supporting lugs, rings, saddles or other types of supports;

(f) Temperature effects;

NB-3112 Design Conditions

The design conditions are the pressures, temperatures and various forces applicable to the design of nuclear power components as defined in the following subparagraphs.

NB-3112.1 Design Pressure. The specified internal and external design pressures shall not be less than the maximum difference in pressure between the inside and outside of the component or between any two chambers of a combination unit, which exists under the specified normal operating conditions. It shall be used in the computations made to show compliance with the stress-intensity limits of NB-3221.1, NB-3221.2, NB-3221.3, NB-3221.4, NB-3227.1, NB-3227.2, NB-3227.4, NB-3228.1, NB-3228.2 and NB-3231. The actual operating pressure at the appropriate time shall be used in the computations made to show compliance with the stress-intensity limits of NB-3222, NB-3228.3 and NB-3232. When the occurrence of different pressures during operation can be predicted for different zones of a vessel, the design pressures of the different zones may be based on their predicted pressures.

(a) All pressures referred to in this Article are to be taken as pounds per square inch, psi, above atmospheric pressure, unless otherwise stated.

(b) The internal design pressure shall include allowances for pressure surges.

NB-3112.2 Design Temperature. The specified design temperature shall be not less than the actual maximum metal temperature which exists under the specified normal operating conditions for each area of the component considered. It shall be used in computations involving the design pressure and coincidental design mechanical loads. The actual metal temperature at the point under consideration shall be used in all computations where the use of the actual operating pressure is required.

(a) All temperatures referred to in this Section of the Code are the metal temperatures expressed in degrees Fahrenheit (F) unless otherwise stated.

(b) Where a component is heated by tracing, induction coils, jacketing or by internal heat generation, the effect of such heating shall be incorporated in the establishment of the design temperature.

NB-3112.3 Design Mechanical Loads. The specific combinations and values of mechanical loadings which must be considered in conjunction with the design pressure and design temperature in evaluating the requirements of NB-3221.1, NB-3221.2 and NB-3221.3 shall be those identified in the Design Specifications (NA-3250) and designated as the Design Mechanical Loads. The actual mechanical loads at the appropriate time shall be used in the computations made to show compliance with the stress-intensity limits of NB-3222.2 and NB-3222.4*(b)*. The re-

NB-3230 STRESS LIMITS FOR BOLTS

NB-3231 Design Conditions

(a) The number and cross-sectional area of bolts required to resist the design pressure shall be determined in accordance with the procedures of Appendix E, using the larger of the bolt loads given by the equations of Appendix E as a design mechanical load. The allowable bolt design stresses shall be the values given in Table I-1.3, for bolting materials.

(b) When sealing is effected by a seal weld instead of a gasket, the gasket factor, m, and the minimum design seating stress, y, may be taken as zero.

(c) When gaskets are used for preservice testing only, the design is satisfactory if the above requirements are satisfied for $m=y=0$, and the requirements of NB-3232 are satisfied when the appropriate m and y factors are used for the test gasket.

NB-3232 Normal Conditions

Actual service stresses in bolts, such as those produced by the combination of preload, pressure and differential thermal expansion may be higher than the values given in Table I-1.3.

NB-3232.1 Average Stress. The maximum value of service stress, averaged across the bolt cross-section and neglecting stress concentrations, shall not exceed two times the stress values of Table I-1.3.

NB-3232.2 Maximum Stress (Except As Restricted by NB-3232.3). The maximum value of service stress at the periphery of the bolt cross-section (resulting from direct tension plus bending) and neglecting stress concentrations shall not exceed three times the stress values of Table I-1.3. Stress intensity, rather than maximum stress, shall be limited to this value when the bolts are tightened by methods other than heaters, stretchers or other means which minimize residual torsion.

NB-3232.3 Fatigue Analysis of Bolts. Unless the components on which they are installed meet all the conditions of NB-3222.4*(d)* and thus require no fatigue analysis, the suitability of bolts for cyclic operation shall be determined in accordance with the procedures of the following subsubparagraphs.

(a) Bolting Having Less Than 100,000 psi Tensile Strength. Bolts made of materials which have specified minimum tensile strengths of less than 100,000 psi shall be evaluated for cyclic operation by the methods of NB-3222.4*(e)*, using the applicable design fatigue curve of Fig. I-9.4 and an appropriate fatigue strength reduction factor (see NB-3232.3*(c)*).

(b) High-Strength Alloy-Steel Bolting. High-strength alloy-steel bolts and studs may be evaluated for cyclic operation by the methods of NB-3222.4*(e)* using the design fatigue curve of Fig. I-9.4 provided:

(1) The maximum value of the service stress (see NB-3232.2) at the periphery of the bolt cross-section (resulting from direct tension plus bending) and neglecting stress concentration shall not exceed 2.7 S_m, if the higher of the two fatigue design curves given in Fig. I-9.4 is used. (The 2 S_m limit for direct tension is unchanged.)

(2) Threads shall be of a V-type having a minimum thread root radius no smaller than 0.003 in.

(3) Fillet radii at the end of the shank shall be such that the ratio of fillet radius to shank diameter is not less than 0.060.

(c) Fatigue-Strength-Reduction Factor (see NB-3213.17). Unless it can be shown by analysis or tests that a lower value is appropriate, the fatigue-strength-reduction factor used in the fatigue evaluation of threaded members shall not be less than 4.0. However, when applying the rules of NB-3232.3*(b)* for high-strength alloy-steel bolts, the value used shall not be less than 4.0.

(d) Effect of Elastic Modulus. Multiply S_{alt} (as determined in NB-3216.1 or NB-3216.2) by the ratio of the modulus of elasticity given on the design fatigue curve to the value of the modulus of elasticity used in the analysis. Enter the applicable design fatigue curve at this value on the ordinate axis and find the corresponding number of cycles on the axis of abscissas. If the operational cycle being considered is the only one which produces significant fluctuating stresses, this is the allowable number of cycles.

(e) Cumulative Damage. The bolts shall be acceptable for the specified cyclic application of loads and thermal stresses provided the cumulative usage factor, U, as determined in NB-3222.4*(e)(5)* does not exceed 1.0.

NB-3233 Upset Conditions

The stress limits for Normal Conditions (see NB-3232) apply.

NB-3234 Emergency Conditions

The stress limits of NB-3232.1 and NB-3232.2 apply.

NB-3235 Faulted Conditions

The limits of NB-3225 apply.

NB-3236 Design Stress Values

The design stress-intensity values, S_m, are given in Table I-1.3 for bolting. Values for intermediate temperature may be found by interpolation. The basis for establishing stress values is given in Appendix III.

NB-3300 VESSEL DESIGN

NB-3310 GENERAL REQUIREMENTS

NB-3311 Acceptability

The requirements for acceptability of a Class 1 vessel design are as follows:

(a) The design shall be such that the requirements of Subarticles NB-3100, General Design Rules, and NB-3200, Design by Analysis, are satisfied, and

(b) The rules of this Subarticle are met. (In cases of conflict between Subarticle NB-3200 and NB-3300 the requirements of NB-3300 shall govern.)

NB-3320 DESIGN CONSIDERATIONS

NB-3321 Design and Operating Conditions

The provisions of NB-3110, Loading Criteria, apply.

NB-3322 Special Considerations

The provisions of NB-3120, Special Design Considerations, apply.

NB-3323 General Design Rules

The provisions of NB-3130, General Design Rules, apply except when they conflict with rules of this Subarticle. In case of conflict this Subarticle governs in the design of vessels.

NB-3324 Tentative Pressure Thickness

The following formulas are given as an aid to the designer to help him arrive at a tentative thickness for use in his design. They are not to be construed as formulas for acceptable thicknesses. However, except in local regions (see NB-3221.2), the wall thickness of a vessel shall never be less than that obtained from the formulas in NB-3324.1 and NB-3324.2 in which

t = thickness of shell or head, in.
p = internal pressure, psi
R = inside radius of shell or head, in.
R_o = outside radius of shell or head, in.
S_m = design stress-intensity values (see Tables I-1.1 and I-1.2):

NB-3324.1 Cylindrical Shells.

$$t=\frac{pR}{S_m-0.5p} \text{ or } t=\frac{pR_o}{S_m+0.5p}$$

NB-3324.2 Spherical Shells.

$$t=\frac{pR}{2S_m-p} \text{ or } t=\frac{pR_o}{2S_m}$$

NB-3330 OPENINGS AND REINFORCEMENT

NB-3331 General Requirements for Openings

(a) For vessels or parts thereof which meet the requirements of NB-3222.4*(d)*, analysis showing satisfaction of the requirements of NB-3221.1, NB-3221.2, NB-3221.3 and NB-3222.3 in the immediate vicinity of the openings is not required if the rules of NB-3330 are met.

(b) For vessels or parts thereof which do not meet the requirements of NB-3222.4*(d)*, so that a fatigue analysis is required, the rules contained in NB-3330 assure satisfaction of the requirements of NB-3221.1, NB-3221.2 and NB-3221.3 in the vicinity of openings and no specific analysis showing satisfaction of those stress limits is required. The requirements of NB-3222.3 may also be considered to be satisfied if, in the vicinity of the nozzle, the thermal stress intensity, including gross but not local structural discontinuities, is shown by analysis to be less than 1.5 S_m. In this case, the requirements of NB-3222.4*(b)* may be evaluated by application of the Stress-Index Method of NB-3338.

(c) The provisions of *(a)* and *(b)* are not intended to restrict the design to any specified section thicknesses or other design details provided the basic stress limits are satisfied. If it is shown by analysis that all the stress requirements have been met, the rules of NB-3330 which are given in the following subparagraphs are waived.

(d) Openings shall be circular, elliptical or of any other shape which results from the intersection of a circular or elliptical cylinder with a vessel of the shapes permitted by this Subsection. Additional restrictions are given in NB-3338.2*(d)*. These restrictions are applicable if the Stress-Index Method is used. In addition, even if fatigue analysis is not re-