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MANDATORY APPENDIX 5

GUIDELINES ON THE APPROVAL OF NEW MATERIALS UNDER THE ASME BOILER AND PRESSURE VESSEL CODE

5-100 CODE POLICY

It is expected that requests for Code approval will normally be for materials for which there is a recognized national or international specification. It is the policy of the ASME Boiler and Pressure Vessel (BPV) Committee on Materials to approve, for inclusion in the Code Sections, only materials covered by specifications that have been issued by standards-developing organizations such as, but not limited to, American Petroleum Institute (API), American Society for Testing and Materials (ASTM), American Welding Society (AWS), Canadian Standards Association (CSA), European Committee for Standardization (CEN), Japan Industrial Standards (JIS), Standards Association of Australia (SAA), and China Standardization Committee (CSC).

Material specifications of other than national or international organizations, such as those of material producers/suppliers or equipment manufacturers, will not be considered for approval. The Committee will consider only official requests for specifications authorized by the originating standardization body and available in the English language and in U.S. Customary and/or SI/Metric units.

For materials made to a recognized national or international specification other than that of ASTM or AWS, the inquirer shall give notice to the standards-developing organization that a request has been made to ASME for approval of the specification under the ASME Code and should request that the issuing organization grant ASME permission to at least reproduce copies of the specification for Code Committee internal use and, if possible, reprint the specification. For other materials, a request shall be made to ASTM, AWS, or a recognized national or international standardization body to include the material in a specification that can be presented to the BPV Committee on Materials.

It is the policy of the ASME BPV Committee on Materials to consider requests to approve new materials only from boiler, pressure vessel, transport tank, nuclear facility component manufacturers, architect-engineers, or end users. Such requests should be for materials for which there is a reasonable expectation of use in a boiler, pressure vessel, transport tank, or nuclear facility component constructed to the rules of one of the Sections of this Code. When a grade does exist in a defined wrought product form, a material producer/supplier may request the inclusion of additional wrought product forms. When a grade

does exist in a defined cast product form, a material producer/supplier may request the inclusion of additional cast product forms.

Any qualified organization requesting that an ASME BPV Committee approve a “new” material for use in their Code book should be aware that only the BPV Committee on Materials provides the appropriate design values for the Construction Codes (Sections I, III, IV, VIII, and XII of the BPV Code and B31 Codes).

The design values are calculated in accordance with the appropriate mandatory Code rules. If the inquirer considers the material to be essentially identical to one that has been approved by the BPV Committee on Materials, the inquirer shall so state in its request, and the BPV Committee on Materials shall evaluate that judgment. If the material is not essentially identical to one that has been approved by the BPV Committee on Materials, the inquirer shall provide all of the data cited in this Mandatory Appendix. Based on those data, the BPV Committee on Materials will provide the appropriate design values.

Before approval of a new material for inclusion in one of the Sections of the Code, use of this material may be permitted in the form of a Code Case. This Case shall fix at least the conditions of use and the necessary requirements linked to these conditions. It is the policy of the ASME BPV Committee to admit, in this way, material for which full experience on all working parameters has not yet been acquired.

5-200 APPLICATION

The inquirer shall identify to the BPV Committee the following:

- (a) the Section or Sections and Divisions of the Code in which the new material is to be approved
- (b) the temperature range of intended application
- (c) whether cyclic service is to be considered
- (d) whether external pressure is to be considered

The inquirer shall identify all product forms, size ranges, and specifications or specification requirements for the material for which approval is desired. When available, the inquirer shall furnish information describing service experience in the temperature range requested.

5-300 CHEMICAL COMPOSITION

The inquirer shall recommend to the BPV Committee on Materials whether the chemical composition specified in the reference specification applies or whether restrictions to this composition shall be imposed for the intended application. When coverage by a recognized national or international standardization body has been requested but not yet obtained, the inquirer shall indicate the detailed chemical composition in the inquiry. The inquirer shall explain the reasons for the chemistry and chemistry limits, and their relationship to the metallurgical structure (e.g., influence on precipitates and their morphology, grain size, and phases), heat treatment effect (e.g., strengthening mechanisms and their stability), and mechanical properties. Elements that significantly influence strength, ductility, toughness, weldability, and behavior under service conditions should be identified.

After review of the submitted data, the Committee reserves the right to modify the permitted compositional ranges for key elements so that they more accurately reflect the range of the elements of the submitted test heats.

5-400 METALLURGICAL STRUCTURE AND HEAT TREATMENT

When applicable for the proposed material, the inquirer shall indicate the intended metallurgical structure(s) to be achieved in order to comply with the mechanical properties requirements and, where applicable, fully describe the heat treatment (including cooling rates) to be applied to achieve this (or these) structure(s), the mechanical properties, and the expected behavior under service conditions.

An explanation for the proposed heat treatment temperature ranges shall be furnished. When such concepts apply, metallurgical transformation curves and information on the transformation points and conditions for appearance of the major phases in the microstructure (e.g., continuous cooling transformation diagram or time-temperature precipitation plots) would be beneficial for the Committee's consideration.

5-500 MECHANICAL PROPERTIES

Test methods employed for the properties tested shall be those referenced in or by the material specifications, or shall be the appropriate ASTM test methods, recommended practices, or test methods described in accepted international standards. The test methods used shall be indicated in the data package.

It is desired that the data be obtained using material representative of the range of effects of the key variables of composition, thickness, mechanical working, and heat treatment. It is desirable that, when applicable, test data also be provided for the range of heat treatment exposures that may influence properties such as tensile strength,

toughness, and stress rupture behavior. After consideration of the submitted data, the Committee reserves the right to modify the specification requirements.

5-600 DEFINITIONS FOR DATA COLLECTION PURPOSES

casting lot: single production pour from a master heat.

heat: quantity of metal with one chemical composition, produced by a recognized production process from a single primary melt of the metal. Remelted ingot material is not recognized as a separate heat unless it is produced from a melt having a different chemical composition than the other heats.

wrought lot: quantity of metal made by melting followed by working or by working and heat treatment as a unique batch. Different lots may come from the same heat and may be made into different product forms. Lot definitions are expected to be found in the applicable material specifications.

5-700 REQUIRED SAMPLING

For all mechanical properties, data shall be provided over the required range of test temperatures from at least three heats of material meeting all of the requirements of the applicable specifications. Data submitted on three heats of one wrought product form for which coverage is requested may be considered to be applicable for all other wrought product forms having the same chemistry.

For wrought materials and especially for those materials whose mechanical properties are enhanced by heat treatment, forming practices, or a combination thereof, and for other materials for which the mechanical properties may be reasonably expected to be thickness dependent, data from one additional lot from material of at least 75% of the maximum thickness for which coverage is requested shall be submitted. If no maximum thickness is given, information shall be provided to support the suitability of the thickness used for the tested samples.

When adoption of cast product forms is requested, data from at least three heats for one of the cast product forms shall be submitted. The cast material shall be considered as a separate material even if its nominal composition is the same or very similar to that of an approved wrought material.

Additional data for other heats tested to a lesser degree than described herein would be beneficial to the Committee's consideration.

5-800 TIME-INDEPENDENT PROPERTIES

For time-independent properties at and above room temperature, the required data include values of ultimate tensile strength, 0.2% offset yield strength (or yield as

otherwise defined in the material specification), reduction of area (when specified in the material specification), and elongation, at 100°F intervals, from room temperature to 100°F above the maximum intended use temperature, unless the maximum intended use temperature does not exceed 100°F. In addition, when specified in the material specification, hardness values shall be provided at room temperature and shall be determined as specified in the material specification.

5-900 TIME-DEPENDENT PROPERTIES

If approval is desired for temperatures where time-dependent properties may be expected to control design, time-dependent data, as itemized below, shall be provided, starting at temperatures approximately 50°F below the temperature where time-dependent properties may govern and extending at least 100°F above the maximum intended use temperature. Exceptions to this rule are permitted, provided the inquirer provides suitable justification for the deviation.

For time-dependent tests, the interval between successive temperatures shall be chosen such that it permits, in all cases, an accurate estimation of the slope of the stress rupture curves. For normally stable materials (e.g., solid solution strengthened materials), test temperatures shall be at 100°F intervals or less. Where there is a possibility of degradation of strength related to metallurgical instability (e.g., for precipitation strengthened materials), test temperatures shall be at intervals of 50°F or less.

In addition, for certain types of steels or alloys, it may be necessary to choose different temperature intervals in order to adequately reflect the evolution of the properties. In such cases, the interval between successive test temperatures shall be chosen such that rupture lives do not differ by more than a factor of 10 at any given stress for two adjacent temperatures. Data to be reported include stress, temperature, time to rupture, and, when available, either or both elongation and reduction of area. Additional comments regarding post-test specimen appearance (e.g., oxidation, necking, intergranular fracture, etc.), as well as photographs and photomicrographs, may be beneficial for the analysis.

Except as provided further below, the longest rupture time at each test temperature shall be in excess of 10,000 hr for each required heat. At least three additional tests shall be conducted for each required heat at each test temperature, at stresses selected to provide shorter rupture times but at least 500 hr (e.g., 500 hr, 1,400 hr, and 4,000 hr).

Tests of shorter duration than about 500 hr are not desired for long-term stress rupture prediction. Obviously, longer times and additional test data are beneficial. At successive temperatures, two or more test stresses should be selected to be preferably identical or in a close range.

Alternative test plans that deviate from the prior description but achieve the overall objective may be considered. This may, in particular, apply to solid solution alloys for which the stability of strength-controlling microstructures is certain.

For new materials for which the expectation of reasonable stability of strength-controlling microstructures is uncertain or suspect, and for extension of allowable stresses of more familiar classes of alloys into much higher temperature applications where such stability might come into question, either creep rupture data with duration of more than 30,000 hr or equivalent experience in service is required. A Code Case may be approved based on shorter duration test data, but inclusion of the material into one of the Sections of the BPV Code may be deferred until longer-term creep rupture data are available or until sufficient service experience is obtained to provide confidence that extrapolations from the existing database reasonably describe the long-term behavior of the material.

For at least two heats, strain-time plots or minimum creep rate (MCR) data shall be provided for at least two test stresses at each test temperature, including at least one stress for each material resulting in MCR values below 3×10^{-4} %/hr. If it can be conclusively demonstrated that creep rate does not control the design stresses, the creep rate data may be sparse in relation to the above requirement. Creep rate data may be obtained in the course of stress-rupture testing or may be obtained on additional specimens.

5-1000 LOW-TEMPERATURE PROPERTIES

If use of the material below room temperature is contemplated, data should be provided at appropriate temperatures down to the lowest contemplated use temperature.

5-1100 TOUGHNESS DATA

Toughness data shall be provided for materials for which Construction Code toughness rules would be expected to apply. The test requirements shall be as required by the requested Construction Code(s). The data shall include test results for the intended lowest service metal temperature and for the range of material thicknesses desired.

5-1200 STRESS-STRAIN CURVES

If the material is to be used in components that operate under compressive loads (e.g., external pressure), stress-strain plots (tension or compression) shall be furnished for each of the three heats of material at 100°F intervals from room temperature up to 100°F above the maximum temperature desired.⁴ Engineering stress-strain data

(stress versus strain) shall be provided in the form of stress-strain plots and digitized data, from which the plots were derived, in tabular form up to 1.2% strain. Digitized data shall be provided at intervals no greater than 0.01% strain. In addition, the minimum yield strength,⁵ modulus of elasticity,⁶ and proportional limit, for materials where a proportional limit can be identified, shall be reported for each temperature. The stress-strain plots (not load versus extension) shall be determined using a Class B-2 or better-accuracy extensometer as defined in ASTM E83. The plots shall include gridlines with the units marked on the gridlines: for strain, minor gridlines at intervals of 0.01% and major gridlines at 0.1%, up to 1.2% strain; and for stress, minor gridlines at 0.2 ksi and major gridlines at 2.0 ksi.

5-1300 FATIGUE DATA

If the material is to be used in cyclic service and the Construction Code in which adoption is desired requires explicit consideration of cyclic behavior, fatigue data for characterized samples shall also be furnished over the range of design temperatures desired, from 10^3 to at least 10^6 cycles.

5-1400 PHYSICAL PROPERTIES

For at least one of the three required heats, the inquirer shall furnish to the BPV Committee on Materials adequate data necessary to establish values for coefficient of thermal expansion, thermal conductivity and diffusivity, modulus of elasticity, Poisson's ratio, and density. Data shall be determined using ASTM E1875, *Standard Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio by Sonic Resonance*, or an equivalent national or international method. Data shall be provided over the range of temperatures for which the material is to be used. It is recommended that data be collected at temperature intervals not greater than 100°F. If the material is intended to be used below room temperature, data should be provided for temperatures down to the minimum use temperature.

5-1500 WELDABILITY

The inquirer shall furnish substantial data on the weldability, weld metal, and weldment properties of material intended for welding, including data on procedure qualification tests made in accordance with the requirements of Section IX. Tensile, ductility, and, where applicable, stress rupture tests shall be made over the full range of thickness in which the material is to be used. Tensile tests shall be consistent with those for the base metal as specified in 5-800. Stress rupture tests shall be consistent with those for the base metal as specified in 5-900. Pertinent information, such as welding processes to be used, applicable welding consumables, postweld heat treatment required,

susceptibility to air hardening, heat-affected zone, weld metal notch toughness if applicable, and the amount of experience in welding the material, shall be given.

5-1600 LONG-TERM PROPERTIES STABILITY

For new materials, and particularly for those whose creep rupture properties are affected by heat treatment or deformation processes or a combination of these, it is important to know the structural stability characteristics and the degree of retention of properties with long-term exposure at temperature. Where particular temperature ranges of service exposure or fabrication heat treatment, cooling rates, and combination of mechanical working and thermal treatments cause significant changes in the microstructure on which the creep rupture properties depend, these shall be brought to the attention of the BPV Committee.

5-1700 REQUESTS FOR ADDITIONAL DATA

The Committee may request additional data, including data on properties or material behavior not explicitly treated in the Construction Code for which approval is desired.

5-1800 NEW MATERIALS CHECKLIST

To assist inquirers desiring Code coverage for new materials, or extending coverage of existing materials, the Committee has developed the following checklist of items that ought to be addressed in each inquiry. While taking into account the intended application of the product, the Committee may require specific information from the inquirer, as shown above for certain material characteristics.

(a) Has a qualified inquirer request been provided?

(b) Has a request either for revision to existing Code requirements or for a Code Case been defined?

(c) Has a letter to ASTM or AWS been submitted requesting coverage of the new material in a specification? Alternatively, is this material already covered by a specification issued by a recognized national or international organization and has an English language version been provided?

(d) Has the Construction Code and, if applicable, a Division, Subsection, or Part been identified?

(e) Have product forms, size range, and the applicable specification(s) been defined?

(f) Has the range (maximum/minimum) of temperature application been defined?

(g) Has the chemistry been submitted and the related requirements been addressed?

(h) Have the metallurgical structure and heat treatment requirements been submitted?

(i) Have mechanical property data been submitted (ultimate tensile strength, yield strength, reduction of area, and elongation at 100°F intervals, from room temperature to 100°F above the maximum intended use temperature, for three heats of appropriate product forms and sizes?

(j) If requested temperatures of coverage are above those at which time-dependent properties begin to govern design values, have appropriate time-dependent property data for base metal and weldments been submitted?

(k) If higher allowable stresses for material to be used below room temperature are requested, have appropriate mechanical property data below room temperature been submitted?

(l) Have toughness considerations required by the Construction Code been defined and have appropriate data been submitted?

(m) Have stress-strain curves been submitted for the establishment of External Pressure Charts?

(n) If cyclic service considerations are required by the requested Construction Code application, have appropriate fatigue data been submitted?

(o) Have physical properties data (coefficient of thermal expansion, thermal conductivity and diffusivity, modulus of elasticity, Poisson's ratio, and density) been submitted?

(p) Have welding requirements been defined, and weld metal and weldment data been submitted?

(q) Has the influence of fabrication practices on material properties been defined?

5-1900 REQUIREMENTS FOR RECOGNIZED NATIONAL OR INTERNATIONAL SPECIFICATIONS

Acceptable material specifications will be identified by date or edition. The latest approved edition(s) will be stated in the subtitle of the ASME specification. Eventually, acceptable previous editions will be listed in Section II, Parts A and B. Minimum requirements that shall be contained in a material specification for which acceptance is being requested include such items as the name of the national or international organization, scope, reference documents, process, manufacture, conditions for delivery, heat treatment, chemical and tensile requirements, forming properties, testing specifications and requirements, workmanship, finish, marking, inspection, and rejection.

5-2000 PUBLICATION OF RECOGNIZED NATIONAL OR INTERNATIONAL SPECIFICATIONS

Specifications for which ASME has been given publishing permission by the originating organization will be published in Section II, Parts A and B. Specifications for which ASME has not been given publishing permission by the originating organization will be referenced on a cover sheet in Section II, Parts A and B. Information on obtaining a copy of those referenced documents will be maintained in those Parts. Additions and exceptions to the material specification will be noted in the subtitle of the specification and in Table II-200-1 or II-200-2 in Section II, Parts A and B.

5-2100 CEN SPECIFICATIONS

European Standards are adopted by CEN in three official languages (English, French, and German) as an EN standard. After the CEN adoption, to become applicable in a member country of CEN, an EN standard shall be given the status of a national standard. During this process

- the text of the EN standard shall remain unaltered and shall be included as adopted by CEN
- national forewords and/or annexes may be added to cover specific national practices, but shall not be in contradiction with the EN standard
- a prefix XX (e.g., XX = BS for the United Kingdom, NF for France, and DIN for Germany) is added to the designation of the EN standard (e.g., BS EN 10028-1 or NF EN 10028-1)
- the date of adoption as a national standard will differ from the date of adoption as an EN standard, and may differ from one country to another

Written or electronic copies can only be obtained from European National Standardization Bodies as XX EN (CEN does not sell standards). Consequently, in order to maintain coherence and homogeneity in the reference system, the mentions in the subtitle of the corresponding ASME specification will only refer to the EN standard number without any prefix and to the year of approval by CEN. It will also be mentioned in the cover sheet that the national parts do not apply for the ASME specification.