ASME Division 4 Fusion Energy Devices

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Abstract

There is an on-going effort within the ASME Section III Codes and Standards organization approved by the ASME Board of Nuclear Codes and Standards to develop rules for the construction of fusion-energy-related components such as vacuum vessel (vacuum or target chamber), cryostat and superconductor structures and their interaction with each other. These rules will be found in Division 4 of Section III entitled " Fusion Energy Devices (BPV III)". Other related support structures, including metallic and non-metallic materials, containment or confinement structures, fusion-system piping, vessels, valves, pumps, and supports will also be covered. The rules shall contain requirements for materials, design, fabrication, testing, examination, inspection, certification, and stamping. The formation of the new Sub-Group Fusion Energy Devices that will develop these rules is just beginning to develop its membership and future working group support structures.

I Introduction

Current ASME Code rules do not adequately cover the design, fabrication or construction of fusion energy devices (e.g. Tokamak or Laser Inertial Fusion Engine devices) that are currently being considered for future DEMO constructions or to provide support to the on-going projects, such as ITER , LIFE and others. The current rules need to be modified to meet some of these future needs. However, it has been recommended that a complete new set of rules be developed specifically for these new devices to cover design, construction and inspection/testing. In addition, it is anticipated that operation and maintenance requirements for these fusion energy devices will also require a new set of rules or major modifications to existing ASME OM Code. It is necessary that these new rules will contain the best available methods and technology in each area.

It is anticipated that the general scope and format of the new fusion device rules will be generally the same as the current scope of Section III but major changes will be reviewed, considered and addressed because of the differences and functions between a fusion-based facility and a typical fission facility.

In order to efficiently develop these new rules, a Division 4 Fusion Energy Device Roadmap is being developed to guide the formation of a Fusion Device Project Plan that will focus resources on all areas of the proposed rules being considered for development, as well as, providing project management to this development effort. The Fusion Device Project Plan development will be based on the assumption that a complete set of new Code rules would be needed by regulators for their future adoption.

The Division 4 Fusion Energy Device Rules will be developed by various project teams within the Sub-Group on Fusion Energy Devices of the BPV Committee on Construction of Nuclear Facility Components (III) and will be coordinated with other impacted organizations both inside and outside ASME. A Stakeholder Task Group reporting to the Chairman of the BPV Committee on Construction of Nuclear Facility Components (III) has been formed to identify stakeholder’s and their needs, develop recommendations and approaches to be incorporated into the new Division 4 Code rules.

It will be necessary to reach a broad consensus from a large stakeholder group at each step of the Code rule development process. These stakeholders are globally based in various countries and organizations consisting of facility owners, standards development organizations (SDO), regulators, governmental agencies, scientific user communities and existing facilities with real-time experiences and needs. It is expected that the development process decisions may indeed deviate from the standard ASME practices and, in some cases, even run counter to normal ASME code direction; but in each case, the resulting Code rules will be in accordance with the ASME Charter for the BPV Committee on Construction of Nuclear Facility Components (III).

As this process evolves, the Fusion Energy Device Project Plan will be updated to consider the effect of each decision on all aspects of the Code rule development activities. As the project teams, task groups, and committees deliberate, it is anticipated that some of these decision and tasks will be modified or eliminated from consideration and others will be added.

The Division 4 Fusion Energy Device Roadmap and Project Plan also recognize that many of the components of a fusion device machine will not fit into the standard ASME Section III component descriptions, its Charter, or even within its historical code equipment rules. In these areas that are outside of the ASME arena of code activities, the project plan, and ultimately the Code rules, will provide a path forward for the Fusion Device users to direct their future efforts of inquire.

The Fusion Energy Device Project Plan will include a suggested organization for the new ASME Division IV Sub-Group on Fusion Energy Devices and will identify project teams to begin the development process for these code rules.

The philosophy used to generate the suggested organization is:

- Designate dedicated project teams to begin exploring proposals for modification of existing rules or pursue new rule development.
- Each project team is to determine the best available technology and if existing standards are available, what current operating facility lessons learned exist for each portion of the rules and consider recent work of other SDOs as well as the technical user base. It is recognized that this process is well underway in many areas of the fusion community and it is desirable to build on those efforts and not duplicate.

The Fusion Energy Device Project Plan will ensure a close liaison is maintained among all project teams and activities to assure that design, construction and post-construction rules are complimentary and consistent. The Fusion Energy Device Project Plan focuses primarily on those tasks that are needed to develop code rules. Tasks that may be needed to demonstrate performance or for specific designs are outside of the scope.

II Organization

This Fusion Energy Device Project Plan proposes a phase approach for the development of ASME rules for the Fusion Energy Device Code

Phase I Activities: Invite from stakeholders design conditions or needs that could be used for immediate application. Those identified design conditions or needs may need ASME code cases or consideration of new rules for materials, R&D needs, and activities that have been identified as potentially important for licensing by a regulator.

Phase II Activities: Develop actual code rules to be incorporated into the new Division IV code to meet the needs identified by stakeholders worldwide for facilities that will be designed 10 years or more from now.

The term R&D as used in this Project Plan is intended to include the following categories of tasks:

- Physical tests to develop material properties and information about the long-term performance of materials.
- Development and validation of new design and analysis methods.
- Development of new methods for fabrication and examination.

A recommended organization will be provided as an attachment to the Fusion Energy Device Project Plan. It has already been stated and understood that in some cases, ASME Code rules will not be developed to address a particular component or item, but that other SDOs or regulatory bodies will provide path forwards with rules or guidance.

III Administrative and Technical Work Activities

1. Establish an organizational structure to oversee the Phase activities.
2. Identify working groups along the lines of the major fusion components, e.g.

    Magnets

    Vacuum Vessel (Vacuum or Target Chamber)

    Primary Containment components

    Structural Components

3. Establish physical boundaries: Establish physical boundaries for the scope of coverage to be considered for fusion design and operating facilities and proposed future fusion facilities. The scope should not be limited to only components that are in or directly support the operation of the Fusion Energy Device, but should include secondary operations as well. These secondary operations or downstream facilities may be constructed and maintained using existing “non-nuclear” codes and standards.

4. Standard Component Classification System: Develop an appropriate system for classification of components and supports.

5. Establish Technical Framework: Examine the technical and organizational approaches in the existing facilities and SDOs such as current ASME code rules including Section III and Section VIII-Division 2, JSME and EN Standards. This activity should involve examining design, fabrication, examination and testing methods being used throughout the world, and then selecting the best of those for inclusion into this Fusion Code. In many cases, alternatives are provided for flexibility.

6. Organization of Fusion Code Section Format: The organization of sections, paragraphs, appendices, etc. should be established to facilitate draft development. The objective should be to maintain a parallel structure so that rules that apply to both new and post-construction activities can easily be jointly developed and maintained

7. Develop Common Terminology and Units of Measure: A common understanding of terminology, acronyms, abbreviations and units of measure must be developed for use in all Fusion Code rules. It is suggested that the SI system be the primary units, but provisions for the use of alternative units should be made as well.

8. Develop Overall Guidance: In order to provide guidance for developing new code rules, it will be necessary to develop general guidelines for Code rules, global interfaces, interaction with other SDOs world wide, copy-write issues and territorial disputes between competing organizations.

9. Develop Rules of Design Requirements: In many cases, components can be designed by various design rules existing within the host country regulations or the adoption of the ASME Design methodology within Section III. Design methodologies should be developed for application at the host country location using their local regulations where practical, for all components for future Fusion Devices. However, regulatory acceptance must be considered.

10. Update rules for welding and post-weld heat treatment

11. Develop rules for NDE for new and post construction

12. Interface Task Force: Establish an Interface Task Force with representatives from impacted SDOs and Regulators to reach a consensus on responsibility for requirements in all areas where standards are needed.

13. Safety Criteria: Develop high-level safety criteria and requirements and obtain approval from the Regulators.

Reach agreement on a process for developing component classification rules

Develop component classification rules and obtain approval from the Regulators.

14. Define responsibility for civil / structural engineering standards.

15. Confinement: Develop a consensus among all stakeholders on a standardized functional specification for confinement methods.

V Recommended ASME Approach and Organization

The following committee organization structure is recommended as a beginning for the timely development of ASME Code rules. This structure is intended to support the tasks and activities that should be completed prior to, or in parallel with, the development of the Code rules. The proposed committee organization involves a large number of project teams that are each responsible for a portion of the Code rules. However, it is important that these teams not work in isolation. It is therefore necessary that each team present a detailed summary of their current activities to the next higher-level group that they report to at each ASME Code Week meeting. Some of the project teams have been designated as “ad-hoc” teams, to indicate that they are not expected to be a permanent part of the Code Committee structure, but would exist only until the task that they have been assigned is complete.

Sub-Group Fusion Energy Devices - A standing Subgroup under the BPV Committee on Construction of Nuclear Facility Components (III) with primary responsibility for developing and maintaining the Section III Division 4 Code Rules.

Stakeholder Task Group- This Task Group, reporting to the Chairman of the BPV Committee on Construction of Nuclear Facility Components (III), is to identify stakeholder’s and their needs, develop recommendations and approaches to be incorporated into the new Division 4 Code rules.

Task Group on Conformity Assessment- This Task Group will develop recommendations for modifications to the existing QA and Stamping requirements that are sensitive to the various international users' local system of control.

Work Group on Design- This work group will review existing design methodologies and activities for possible combination or use "as written" in accordance with the local requirements.

- Project Team on Design Specifications – This Project Team will use the current information for developing a design specification model as well as what stakeholders/SDO are using in other countries as their approach.
- Project Team on Design Rules- This Project Team should develop rules with standardized solutions for common components.

Work Group on Materials- Responsible for material inquires for possible Code Cases as well as new materials identified for inclusion into Section II and Section III respectively.

Task Group on Fabrication- Incorporate most of the rules from the existing books, but consider the need for new rules to address unique requirements of the fusion components

Task Group on NDE-This Task Group should develop compatible NDE requirements for new and post construction. The rules in existing books should be adopted and Section V should be referenced to the extent practicable. However, the Task Group should ensure that the measurements and evaluations made during new construction provide an appropriate baseline for the measurements that will be made during operations