White Paper for the Development of Code and Standards for Fusion Construction Activities

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ABSTRACT

There is an on-going realization within the ASME organization that there exists the need to develop rules for the construction of fusion-energy-related components such as vacuum vessels, cryostats and superconductor structures and their interaction with each other similar to the Section III nuclear code rules for fission facilities. The ASME Board of Nuclear Codes and Standards (BNCS) has approved an effort to begin the development of such code rules. These rules should contain requirements for materials, design, fabrication, testing, examination, inspection and certification. Several recent presentations and papers by the ARIES Design Team and the University of Wisconsin-Madison ANS 2010 presentation[1] also voiced the need for code and standards development for future use in fusion plant licensing and construction. Several papers written and presented by the Korean DEMO program at various international conferences also voiced a similar need for fusion specific codes and standards [3,4].

It is also understood that there is a mandate that where feasible voluntary consensus standards[2] from existing Standard Developing Organizations (SDO) such as ASME, ASTM, IEEE, etc. are to be used by US Government agencies. ASME has long been the leader worldwide in nuclear codes and standards for construction, operations and in-service inspection. This leadership position is recognized by several US Government agencies such as DOE, NRC, DOD and even NASA who also use ASME standards to govern some of their activities.

INTRODUCTION

Currently design and construction codes and standards do not exist for fusion development activities. What are being used globally are country specific rules that are unique to their national interest and use. Current construction rules from ASME, RCC-M or IAEA do not adequately cover the design, fabrication or construction of the magnetic confinement fusion energy devices (e.g. Tokamak devices) that are currently being considered for future DEMO constructions. They do not provide construction rules for the on-going fusion projects, such as ITER nor for other fusion concepts such as

1 Challenges of Fusion Power Plant Licensing: Differences and Commonalities with Existing Systems- ANS 19th Topical Meeting on the Technology of Fusion Energy November 7-11, 2010
2 OMB Circular A-119
3 Safety Classifications for the Fusion DEMO Plant of Korea-TPS5121 IEEE Transactions on Plasma Science
4 FUSION DEMO PROGRAM OF KOREA: OVERVIEW AND DEMO R&D PLANS- SOFE - IEEE/NPSS Symposium on Fusion Engineering-2011

Inertial Confinement Fusion (primarily laser fusion, an example of which is the National Ignition Facility).

The current ASME Section III nuclear construction rules need to be modified to meet some of the immediate fusion needs not only in the U.S. but also worldwide since ASME is used worldwide. 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 Codes. It is necessary that these new rules will contain the best available methods and technology.

In order for these new ASME fusion construction rules to be a code and standard for global use, it will be necessary to reach a broad consensus from the various fusion users at each step of the code development process. These fusion users 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 needs and expectations.

PROPOSAL

To achieve this type of development, the fusion code and standard should be developed using a project team approach with representation from as broad a base of fusion users as possible and managed within the existing Division 4 Sub-Group Fusion Energy Devices of the BPV Committee on Construction of Nuclear Facility Components (III). Each project team should 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.

Using the existing ASME Committee structure as a base for development effort can be coordinated with other impacted standards organizations both inside and outside ASME. It is expected that during the development process, scope and applicability decisions may even run counter to current ASME code direction; but in each case, the resulting code and standards will be in accordance with the ASME Charter for the BPV Committee on Construction of Nuclear Facility Components (III). As this development process evolves, the resulting codes and standards can be updated to consider the

affect of each decision on all aspects of the Code rule development activities, as well as changes in fusion technology resulting from lessons learned from operating fusion facilities. Within the US, such facilities are the fusion devices at PPNL-TFTR, General Atomics DIII-D, MIT Alcator C-Mod, and also the ARIES design efforts. There are also international machines such as JET, KSTAR, EAST, Tore Supra, JT 60U and even ITER, when it matures, would greatly add to the body of knowledge to develop a world class fusion code to be used by the fusion community. As the project teams, task groups, and committees deliberate, it is anticipated that some of these decisions and tasks will be modified or eliminated from consideration and others will be added.

The current draft ASME Fusion Energy Device Roadmap recognizes 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, the codes and standards development process and ultimately the Code rules, should provide a path forward for the fusion users to direct their future efforts of inquiry.

In order to efficiently develop these new rules, the Division 4 Fusion Energy Device Roadmap will guide the formation of a Fusion Device Project Plan to focus resources on all areas of the proposed rules being considered for development, as well as providing project management to this development effort.

The Division 4 Fusion Energy Device Code rules will be developed by various project teams within the Subgroup 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. The ASME Standards Technology, LLC (ASME ST-LLC), as the R&D partner, will manage the research projects that bridges gaps between technology development and standards development.

CONCLUSION

With the current efforts of ASME towards beginning the development of a fusion-based code and standards and the future needs of the DOE Office of Science and Office of Fusion Energy, a partnership between ASME and DOE would be a natural match. This partnership would also help the U.S. in positioning itself in an influential position to be able to capture not only the results of the ITER project activity, but also be a motivating force in the next generation of fusion devices.

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The early experiences of the ITER project without codes and standards to draw from demonstrated the need for codes and standards that address the fusion technologies, not just “making do” using existing codes and standards from the fission reactor design. It was the case within the ITER project that the RCC-M French construction code was used for the Vacuum Vessel. There is a mixture of various codes and standards being used for other components, not only in the EU; but also by other ITER member countries using country-specific standards. This type of mixing of codes and standards leads to inconsistencies and the very real possibility of missing important requirements that can be either ignored or modified to fit the needs of the manufacturer, not the end user’s requirements. If universally accepted fusion codes and standards existed, they would provide a stable framework for people to work to, thus eliminating issues of inconsistencies and missed requirements.