STP-NU-072

SMALL MODULAR REACTOR (SMR) ROADMAP

currently in preview, click buy full versi

ASME STANDARDS TECHNOLOGY, LLC

STP-NU-072

SMALL MODULAR REACTOR (SMR) ROADMAP

Prepared by:

Richard Black
Gene Imbro
Advanced Systems Technology and Management, Inc.

ASME STANDARDS TECHNOLOGY, LLC

currently in preview, click buy full versi

Date of Issuance: June 27, 2014

This report was prepared as an account of work sponsored by ASME Nuclear Codes & Standards and the ASME Standards Technology, LLC (ASME ST-LLC).

Neither ASME, ASME ST-LLC, the authors, nor others involved in the preparation or review of this report, nor any of their respective employees, members or persons acting on their behalf, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe upon privately owned rights.

Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer or otherwise does not necessarily constitute or imply its endorsement, recommendation or favoring by ASME ST-LLC or others involved in the preparation or review of this report, or any agency thereof. The views and opinions of the authors, contributors and reviewers of the report expressed herein do not necessarily reflect those of ASME ST-LLC or others involved in the preparation or review of this report, or any agency thereof.

ASME ST-LLC does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a publication against liability for infringement of any applicable Letters Patent, nor assumes any such liability. Users of a publication are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representative(s) or person(s) affiliated with industry is not to be interpreted as government or industry endorsement of this publication.

ASME is the registered trademark of the American Society of Mechanical Engineers.

No part of this document may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.

ASME Standards Technology, LLC
Two Park Avenue, New York, NY 10016-5990

ISBN No. 978-0-7918-6962-8
Copyright © 2014 by
ASME Standards Technology, LLC
All Rights Reserved

currently in preview, click buy full versi

TABLE OF CONTENTS

LIST OF FIGURES

currently in preview, click buy full versi

FOREWORD

This American Society of Mechanical Engineers (ASME) SMR Roadmap was funded and developed by ASME. Advanced Systems Technology and Management, Inc. (AdSTM) engaged various stakeholders -- particularly Small Modular Reactor (SMR) vendors, the U.S. Nuclear Regulatory Commission (NRC), and ASME Code Committees -- to solicit information that would be used as a basis for the conclusions and recommendations in this SMR Roadmap.

ASME recognizes that critical SMR design information was provided by B&W mPower, NuScale, and Holtec to support the analysis of the ASME Nuclear Codes and Standards in this SMR Roadmap. Finally, ASME acknowledges the NRC staff for its informal input on how the existing Codes and Standards might present potential licensing issues for SMR designs and configurations.

The authors acknowledge, with deep appreciation, the activities of the Peer Review Group (PRG) that consist of Richard Porco, Ralph Hill and Rick Swayne, and the ASME staff and volunteers who have provided valuable technical input, advice and assistance with review of, commenting on, and editing of, this document.

Established in 1880, ASME is a professional not-for-profit organization with more than 135,000 members and volunteers promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. ASME develops Codes and Standards that enhance public safety, and provides lifelong learning and technical exchange opportunities benefiting the engineering and technology community. Visit www.asme.org for more information.

The ASME Standards Technology, LLC (ASME ST-LLC) is a not-for-profit Limited Liability Company, with ASME as the sole member, formed in 2004 to carry out work related to new and developing technology. The ASME ST-LLC mission includes meeting the needs of industry and government by providing new standards-related products and services which advance the application of emerging and newly commercialized science and technology and providing the research and technology development needed to establish and maintain the technical relevance of Codes and Standards. Visit http://www.st-llc.asme.org/ for more information.

currently in preview. click buy full versi

ABBREVIATIONS AND ACRONYMS

ACI	American Concrete Institute
ANS	American Nuclear Society
ANS	American National Standards
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASME ST-LLC	ASME Standards Technology, LLC
ASTM	American Society for Testing and Materials International
AWS	American Welding Society
BNCS	Board on Nuclear Codes and Standards
BPV	Boiler and Pressure Vessel
BPVC	Boiler & Pressure Vessel Code
CFR	Code of Federal Regulations
CNF	Cranes for Nuclear Facilities
CNRM	Committee on Nuclear Risk Management
COL	Construction and Operating License
CONAGT	Committee on Nuclear Air and Gas Treatment
CORDEL	Cooperation in Reactor Design Evaluation and Licensing
DSRS	Design-Specific Review Standard
DOE	Department of Energy
ECCS	Emergency Core Cooling System
FOAK	First of a Kind
FMEA	Failure Modes and Effects Analysis
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
iPWR	Integral Pressurized Water Reactor
ISI	In-Service Inspection
IST	In-Service Testing
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
IWE	Inservice Welding Examination
LWR	Light-Water-Reactor
MWe	Megawatt Electric
NESCC	Nuclear Energy Standards Coordination Collaborative
NIST	National Institute of Standards Technology
NPS	Nominal Pipe Size
NQA	Nuclear Quality Assurance
NRC	U.S. Nuclear Regulatory Commission
OM Code	ASME Operation and Maintenance of Nuclear Power Plants Code
PRA	Probabilistic Risk Assessment
PRG	Peer Review Group
QME	Qualification of Mechanical Equipment
RIM	Reliability and Integrity Management
RTNSS	Regulatory Treatment of Non-Safety Systems
SDO	Standards Development Organization
Section III	BPVC, Section III-Rules for Construction of Nuclear Facility Components
Section XI	BPVC, Section XI-Rules for Inservice Inspection of Nuclear Power Plant Components
SMR	Small Modular Reactor
SRP	Standard Review Plan
SSC	Structures, Systems and Components

currently in preview, click buy full versi

ABSTRACT

Small Modular Reactor (SMR) designs are currently scheduled for NRC licensing reviews in the next 1-2 years. Although there is no definitive schedule for deployment of SMRs, it is currently anticipated that the first commercial deployment will be in approximately the 2022-2024 timeframe. With anticipated domestic and international interest in SMR designs and the near-term licensing schedule, ASME developed this SMR Roadmap to engage all stakeholders -- including SMR vendors, NRC and ASME Code Committees -- to identify any potential ASME Codes and Standards issues that may affect the effective and timely SMR licensing. Generally, the SMR vendors believe that their designs can comply with current ASME Codes and Standards because they are based on existing and licensed light-water-reactor (LWR) technology. However, this SMR Roadmap discusses Code areas in the ASME Boiler & Pressure Vessel Code (BPVC) and ASME Operation and Maintenance of Nuclear Power Plants Code (OM Code) where potential differences between vendors and NRC regarding the proper interpretation and application these Code requirements may present licensing issues. Particularly, this SMR Roadmap discusses potential issues in BPVC, Section III-Rules for Construction of Nuclear Facility Components (Section III), BPVC, Section XI-Rules for Inservice Inspection of Nuclear Power Plant Components (Section XI), and OM Code that may result from certain unique features of the SMR designs. Potential issues that are identified include:

Section III:

- The acceptability of the Section III fracture toughness requirement exemption (paragraph NB-2311) for small parts used for Class 1 components should be reviewed by the Section III for applicability to SMR designs.
- The rules of Subsection NE for the construction of metal containment vessels (Class MC) may need to be revisited for applicability to certain SMR designs.

Section XI:

- The Section XI Inservice Inspection (ISI) exemption for small Class 1 components and piping should be evaluated by Section XI for their applicability to SMRs.
- The inspection of SMR reactor vessels may be problematic in some designs due to compactness of design and limited accessibility.
- The soon-to-be-published (2015) Section XI, Division 2, "Reliability and Integrity Management" (RIM) program may benefit SMR RIM programs. However, reliance on the Division 2 methodology might cause an initial delay in the licensing process since it is a new approach to ISI not yet approved by the NRC.
- SMR pressure vessels clad on both sides may present issues for application of Section XI, Subsections IWE and NB.

OM Code:

- Periodic testing requirements of the OM Code presents an issue to the (a) NuScale design since operating the reactor vessel valves would produce a loss-of-coolant accident, and (b) mPower design which has an extended fuel cycle.

To address these potential issues, this SMR Roadmap recommends that the vendors more thoroughly evaluate their designs against both BPVC and OM Code, and NRC requirements, and engage the ASME Code Committees early in the process to develop appropriate requirements if issues need resolution. This would provide a technical basis, developed through ASME's American National Standards Institute (ANSI)-approved Code consensus process that could be used to support their positions when engaging with the NRC during the design certification licensing process. In addition, some of these potential issues can be addressed through the development of ASME Code Cases. Currently, Code Cases are being developed that will address SMR extended fuel cycle issues.

Currently in preview, click buy for full version

1 SMR INTRODUCTION AND PURPOSE

NRC licensing reviews of several SMR designs will commence within the next 1-2 years upon the filing of Design Certification applications. Pre-application reviews between vendors of SMR designs and the NRC have been ongoing for over 5 years. While these near-term SMR designs are based on proven LWR technology, several new design features and systems may present challenges to their licensing or deployment. Critical to effective and timely licensing, SMR vendors and designers must appropriately interpret and apply ASME Codes and Standards that are NRC licensing requirements.

This SMR Roadmap project was initiated to start a dialogue and interactions between vendors, NRC, ASME and other stakeholders to determine how ASME Nuclear Codes and Standards will be interpreted and applied. These interactions will provide information, insights and strategies to facilitate SMR design development, NRC licensing, and ultimately commercial deployment of these new reactor technologies. This SMR Roadmap identifies critical technology and process issues that are covered by ASME Codes and Standards and may present barriers or unique challenges to effective NRC licensing. This SMR Roadmap identifies those specific ASME Nuclear Codes and Standards that are included by reference in the NRC's regulations and are therefore legally-binding regulatory requirements. This SMR Roadmap discusses areas in these Codes and Standards that might present licensing challenges to all the SMR designs under consideration, as well as unique design-specific challenges. Strategies to address identified challenges for NRC licensing are discussed. This SMR Roadmap does not identify any research and development needed at this time to support Codes or Standards modifications. Included in these strategies is the option for license applicants to propose alternatives to ASME Codes and Standards' requirements to the NRC for their review and approval.

This SMR Roadmap identifies the following potential issues that should be addressed and resolved for effective licensing:

(a) Section III

(1) SMR suppliers have indicated that they are able to comply with the current Section III requirements. Section III, however, was written for large LWRs. Therefore, it may be determined that certain areas of Section III may not be applicable to SMRs, most notably the exemptions in Section III for small components. It is recommended that Section III articulate the bases for these exemptions in order that they can be properly applied by component designers. This also would be useful to the regulator.

(b) Section XI

(1) The requirements in Section XI for Inservice Welding Examination (IWE) for examination of metallic containments were developed for large LWRs and are not applicable to certain of the SMR designs, such as the NuScale design. It is recommended that Section XI consider developing IWE requirements for other containment designs if they are requested by the SMR vendors as their designs are more completely developed.

(2) SMR designs may have unique examination requirements which may require additions to Section XI. It is recommended that SMR vendors engage Section XI to develop examination requirements for unique SMR containment designs.

(3) IWB-1220 provides rules for exempting certain small components from volumetric, surface and visual examination. These exemptions may not be applicable to certain SMR designs. It is recommended that Section XI consider revisiting these examination exemptions for applicability to SMR designs.

(4) Section XI, IWB-2500 contains other exemptions for the examination of small components. It is recommended that Section XI consider revisiting these examination exemptions for applicability to SMR designs.

currently in preview. click buy full versi

Another purpose of this SMR Roadmap is to provide a framework to address other nuclear code or standards issues that might be (a) applicable to other SMR or advanced reactor designs that are not considered "near-term" licensing challenges, and (b) the responsibility of other Standards Development Organizations (SDOs) such as ANS, IEEE, AWS, ASTM, etc. The process used to develop this SMR Roadmap can be used as a model or template to expand the scope of this SMR Roadmap to address, for example, SMR designs from countries outside the U.S., or be used as a model to develop other SMR or advanced reactor roadmaps. As with all roadmaps, information and interactions between all stakeholders are critical to understanding the issues and providing a framework and strategy for resolution. Since nuclear energy remains a critical component of the U.S. energy policy, nuclear technology and licensing issues must be timely addressed and resolved by all stakeholders to properly advance the nuclear energy option for domestic and international applications.

Finally, to the extent that this SMR Roadmap discusses how these new SMR designs interpret and apply ASME Codes and Standards for NRC licensing reviews, it will provide information and insights as to how ASME Nuclear Codes and Standards can be used for licensing purposes by other countries where these Codes and Standards are adopted and referenced to support nuclear power plant designs and licensing.

currently in preview, click buy full versi