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CSA GROUP NUCLEAR STANDARDS AND APPLICABILITY TO SMALL MODULAR REACTORS

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ABSTRACT

With the potential entry of small modular reactors (SMRs) into Canada, there is a need to determine how standards and codes will impact the small reactor community. The objective of the CSA Nuclear Program is to help promote a safe and reliable nuclear power industry in Canada and have a positive influence on the international nuclear power industry. CSA Group nuclear standards specify requirements for the design, construction, monitoring, and inspection of nuclear facilities.

The current suite of CSA nuclear standards covers vast topics including:

- Pressure-Retaining Systems and Components
- Periodic Inspection of Nuclear Power Plant Components
- Management Systems
- Concrete Containment and Safety Related Structure
- Environmental Management
- Seismic Design
- Reactor Control Systems, Safety Systems, and Instrumentation
- Reactor Safety and Risk Management
- Radioactive Waste Management
- Fire Protection
- Decommissioning
- Emergency Management

As various SMR technologies are currently being considered for use in Canada, the applicability and use of these existing CSA nuclear standards will need to be reviewed and evaluated.

This presentation provides an overview of CSA Group and its Nuclear Program, the current use of the existing suite of nuclear standards, and their potential applicability to SMRs. Conclusions on future standards for SMRs and engagement with the small reactor community will be proposed.

INTRODUCTION

About CSA Group

Canadian Standards Association operating as CSA Group (CSA) is a not-for-profit membership-based organization serving business, industry, government, and consumers in Canada and around the world. Standards development is the foundation of CSA. Since 1919, CSA has grown to become the largest Standards Development Organization (SDO) in Canada, with the widest range of subject area recognition. CSA develops standards that help address public and worker health and safety, sustainability, product performance, energy efficiency, and a range of best practices. CSA publishes and maintains more than 3,000 standards and codes addressing subjects that affect the interests of industry, consumers, regulators, and the public at large.

Standards Development

CSA standards are developed through a process accredited by the Standards Council of Canada (SCC) that brings together volunteers representing diverse areas of expertise, viewpoints, and interests to achieve consensus. CSA standards are voluntary documents; compliance with a standard is mandatory only when the standard has been referenced by federal, local, state, provincial, or municipal government, or by a regulatory authority.

Under CSA's standards development methodology, volunteer expert committee members develop standards content and CSA staff facilitate the accredited standards development process. CSA functions as a neutral third party, providing a structure and forum for developing standards.

Decisions are made by consensus and balanced representation. Standards development committees use a "balanced matrix" approach: each committee is structured to capitalize on the combined strengths and expertise of its members, with no single group dominating. The committee considers the views of all participants and develops the content of the standard by a consensus process that includes the principles of inclusive participation, and respect for diverse interests and transparency. Standards committee volunteers are selected to represent various interest groups most likely to be affected by a standard, such as business and industry, regulatory bodies, science and academia, labour, and consumer groups, as applicable.

Once published, standards are living documents, continually revised and refreshed to address changing requirements and emerging technologies. Each standard is reviewed at least every five years in accordance with the SCC requirement for periodic maintenance of standards, which also supports CSA's process of continual improvement.

CSA Nuclear Program

The CSA Nuclear Program was first established over 45 years ago in response to the needs of the Canadian nuclear industry and its regulator for a reliable process to develop key standards to promote the safe and reliable operation of the nuclear power industry in Canada.

The CSA Nuclear Program multi-stakeholder committees, made up of industry, government, and general interest groups, develop and maintain over 60 nuclear-related standards and guidelines. More than 550 expert volunteers serve on the program's committees to develop and maintain these important consensus-based standards. The program structure consists of a governing Nuclear Strategic Steering Committee, 13 Technical Committees, and over 55 Technical Subcommittees and working groups. The Technical Committees cover the following subject areas:

- N285A – Pressure-Retaining Systems and Components

- N285B – Periodic Inspection of Nuclear Power Plant Components
- N286 – Management systems
- N287/N291 – Concrete Containment and Safety Related Structures
- N288 – Environmental Management
- N289 – Seismic Design
- N290A – Reactor Control Systems, Safety Systems, and Instrumentation
- N290B – Reactor Safety and Risk Management
- N292 – Radioactive Waste Management
- N293 / N393 – Fire Protection
- N294 – Decommissioning
- N1600 – Emergency Management

The average timeframe to produce a CSA nuclear standard from project approval to publication is 18-24 months. In addition, the CSA Nuclear Program undertakes periodic process improvement initiatives to further streamline the standards development process and optimize program operations.

USE AND BENEFITS OF CSA NUCLEAR STANDARDS

Standards developed through the CSA Nuclear Program represent the technical requirements for compliance with Canadian nuclear regulations. These standards are referenced and used by the Canadian Nuclear Safety Commission (CNSC) to regulate nuclear power plants and facilities across Canada. Currently, approximately 90% of CSA nuclear standards are referenced in either licences, licence conditions handbooks, or CNSC regulatory documents. CSA nuclear standards form an important part of the CNSC regulatory framework, a clear testament to the strength of the CSA standards development process.

CSA's accredited, consensus-based, transparent process enhances public input and acceptability, while a reputation for acting as a neutral third party brings stakeholders together in a collaborative and consensus-building process – in a way that is balanced, open, and subject to public review.

CSA standards capture minimum requirements, as well as current and leading practices, and promote consistency of practice and interpretation of requirements. Standards also document operating experience in order to capture and transfer knowledge to new generations of nuclear professionals.

CSA standards foster compliance by stakeholders through involvement, collaboration, and balanced representation. Since the standards process invites participation from all key stakeholders and addresses their needs and interests, the final product is both acceptable and applicable.

CSA's process leverages In-kind contributions of key stakeholders, reducing duplication of efforts and providing a practical alternative or supplement to regulation. Standards act as a vital bridge between regulation and implementation. They promote efficiency in practice by working across federal, provincial, and municipal jurisdictions. The standards themselves are living documents, updated and revised based on periodic review, adjusting for experience during applications of the standards.

The CSA standards development process involves benchmarking and harmonization with internationally accepted requirements and practices. Many CSA standards are derived from international standards and customized for the unique needs of Canada. CSA also plays a proactive role in international harmonization, taking leadership roles in many international initiatives, such as International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) committees.

STANDARDS IN THE CSA NUCLEAR PROGRAM

Published standards

The following highlights selected CSA standards that demonstrate impact and value to nuclear sector stakeholders:

- **CSA N286-12 (R2017), *Management system requirements for nuclear facilities***
CSA's suite of nuclear standards provides an interlinked set of requirements for the management of nuclear facilities and activities. CSA N286 provides overall direction for developing and implementing sound management practices and controls, while the other standards provide technical requirements and guidance that support the management system.

The standard identifies management system requirements for nuclear facilities based on 12 management system principles. It applies to top management who have the overall accountability for the nuclear facility and integrates the requirements from management system standards for health, safety, environment, security, economics, and quality.

Although users are required to meet the requirements set out in the standard, they have the ability to define how the graded approach, commensurate with risk, is applied to their management system, allowing for a more logical and cost effective method to address risk profiles. It is expected that the higher the risk, the more substantive a management system will be in place. This ensures adequate mitigation and consistent, predictable performance.

- **CSA N288.4-10 (R2015), *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills***
This standard provides guidance to design, implement, operate, and maintain an environmental monitoring program. This standard provides criteria for establishing and revising a program, detailed guidance for design of program elements, and addresses supplementary studies. It also provides guidance for sampling and analytical procedures, data interpretation, Quality Assurance/Quality Control, reporting, review and audit, and staff qualifications and training.

This standard is one of many CSA N288 environmental management standards; other topics include effluent monitoring programs, environmental risk assessment, and groundwater protection programs.

- **CSA N290.7-14, *Cyber security for nuclear power plants and small reactor facilities***
This standard establishes the requirements for cyber security for nuclear power plants and small reactor facilities and the graded assessment of computer systems to determine the applicability of cyber security controls. The standard provides requirements to establish cyber security throughout a computer system's lifecycle, from conceptual design through installation, commissioning, and decommissioning. The standard emphasizes the need to interface with other organizations and identifies the purpose and expected outcomes but does not attempt to describe detailed methodology. Compliance with this standard will lead to increased cyber security resiliency. This standard was developed with input from representatives of various reactor facilities, including small reactors.
- **CSA N293-12 (R2017), *Fire protection for nuclear power plants***
This standard provides minimum fire protection requirements for the design, construction, commissioning, operation, and decommissioning of nuclear power plants, including structures, systems, and components that directly support the plant and the protected area. The current edition

provides fire protection design criteria for both designers and regulators and creates certainty around design and operating requirements, thereby limiting costs resulting from regulatory/operator interface for both new build and existing nuclear power plants. It also incorporates “lessons learned”, following the introduction of the standard into the Canadian regulatory framework.

The standard enabled the implementation of the first nationally unified fire protection program for all Canadian licensees to minimize the frequency and consequences of fire.

- **CSA N1600-16, *General requirements for nuclear emergency management programs***
This standard was developed as a response to the Fukushima event and is intended to complement the CNSC regulatory document REGDOC-2.10.1 (2014). Prior to the development of the standard, CSA held a workshop that engaged industry stakeholders, regulatory agencies, and municipalities to examine current Canadian practices. The standard establishes criteria for the emergency management programs of on- and off-site organizations that have a role in the management of a nuclear emergency at a Canadian nuclear power plant, as well as requirements to support the effective integration of programs for all organizations. It also provides the unique requirements to develop, implement, evaluate, maintain, and continuously improve a nuclear emergency management program for the prevention, mitigation, preparedness, response, and recovery from a nuclear emergency at a nuclear power plant.

The standard also provides requirements for effective communication between organizations and directly with the public and is well aligned with the fundamental requirements of IAEA Safety Standards Series No. GSR Part 7 (2015).

- **CSA N290.19:18, *Risk-informed decision making for nuclear power plants***
The first edition of this standard describes the risk-informed decision making process, which provides a formalized, rational, and systematic methodology for identifying, assessing, and communicating the various factors that support making a risk-informed decision. The standard provides consistency from one decision to the next, helps ensure that important considerations are not overlooked, and provides a framework for the comprehensive documentation of the basis on which decisions are made. Areas such as fitness for service criteria, periodic safety reviews, post-event actions, and resource allocation are addressed within the standard.

Following the continuous improvement process used for all CSA standards, user feedback and implementation experience with this new standard will be gathered and reviewed to inform future updates.

Upcoming Standards

The CSA Nuclear Program continues to work with all industry stakeholders as well as the CNSC to review its suite of standards against emerging industry needs, changes to the regulatory framework, lessons learned, technology advances, and leading practice. Standards are continually updated to address the changing environment and reflect best practices. For example, development of a new edition of the standard, *CSA N290.7* on cyber security began in early 2019.

Taking into consideration the current landscape of the nuclear sector and stakeholder needs, new opportunities are identified and vetted through the Nuclear Program’s structure and processes. Topics that are currently being assessed for possible new standards or revisions to existing standards include human performance and waste characterization.

SMR ENGAGEMENT AND APPLICABILITY OF CSA NUCLEAR STANDARDS

CSA Engagement in SMRs

In December 2015, the Nuclear Strategic Steering Committee established the CSA Small Reactor Task Force. The primary purpose of the task force is to identify and provide recommendations with respect to addressing requirements for small reactors, including SMRs, in the CSA Nuclear Program. The task force monitors small reactor activities in Canada, engages with impacted stakeholders, obtains information on new developments, and provides updates to the Nuclear Strategic Steering Committee.

In addition, CSA engages with the efforts of other organizations involved in the planning and development of SMRs in Canada, including the CNSC, CANDU Owners Group (COG), Canadian Nuclear Association, and Natural Resources Canada (NRCan). CSA has participated in various forums to better understand the standards needs of the small reactor community. This includes:

- The CNSC workshop on SMRs focusing on the application of the graded approach in the development of safety cases for SMR projects.
- The COG Small and Medium Sized Reactor Technology Forum (SMRTF), including participation in meetings with the vendors as part of the COG SMRTF engagement, and presentation to the Vendor Participant Program.
- The Canadian Small Modular Reactor Roadmap (2018) by providing input to the Regulatory Readiness Working Group and participating in the on-grid applications workshop.
- The 1st International Conference on Generation IV and Small Reactors, hosted by the Canadian Nuclear Society and Canadian Nuclear Laboratories in 2018, including a presentation on the CSA Nuclear Program and the applicability of nuclear standards to SMRs to provide information and to solicit further engagement of the SMR community in CSA standards development.

Applicability of CSA Nuclear Standards to SMRs

In Canada, as all existing nuclear power reactors are CANDU reactors, almost all of the CSA nuclear standards were initially developed for CANDU technology and with primarily CANDU experts. However, in the last decade, there were drivers to publish standards that are technology neutral to address the possibility of new build licence applications that are a non-CANDU design. CSA has been proactive in adopting an approach, where applicable, to capture CANDU-specific requirements, benchmark other international standards, and distinguish CANDU-specific requirements in meeting overall safety goals.

Over the past few decades, CSA has also engaged new stakeholders into the program beyond those working in the area of nuclear power plants, expanding the scope to include standards for other facilities such as mines and mills. Some standards subject areas, such as management systems (*CSA N286*), environmental management (*CSA N288*), and decommissioning (*CSA N294*), address smaller facilities such as universities, hospitals, and laboratories. Specific standards, including *CSA N290.7*, have been developed to apply to small reactors specifically.

Today, based on CSA's assessment, 80% of the current suite of CSA standards is technology neutral, where "neutral" means that the provisions apply to any heavy-water or light-water reactor design; 20% of standards are CANDU design-specific. This definition of technology neutral is consistent with the CNSC's use of the term.

CSA has worked with members to develop a matrix of applicability of current CSA standards to SMRs. The full suite of nuclear standards was preliminarily assessed by Technical Committee Chairs, reviewed by the CSA Small Reactor Task Force, and shared with the COG SMRTF, NRCan, and the CNSC. It is estimated that approximately half of the current suite of CSA nuclear standards could be applicable to

SMRs and that most of the remainder could apply in whole or in part depending on the SMR's design specific details. More specifically, based on the preliminary assessment, it is estimated that:

- 57% of the current suite of CSA standards apply to SMRs. Some of these standards include CSA N286, CSA N290.7, and CSA N1600.
- 40% of the current suite of CSA standards could apply to SMRs depending on the design. For example, the suite of N287 standards addressing requirements for concrete containment, or the standards that apply specifically to water-cooled reactors such as CSA N290.2-17, *Requirements for emergency core cooling systems of nuclear power plants*
- 3% of the current suite of CSA standards would not apply to SMRs. These standards include CSA N285.8-15, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*.

Since SMR design details and concepts are currently under development, it is challenging to confirm in-depth SMR applicability for all standards at this time. CSA committees require further input from SMR vendors to conduct a more complete assessment of the applicability of specific standards.

Future Nuclear Standards for SMRs

The ability to take a technology neutral approach and to integrate new scope and stakeholders into the program may help to further enhance the CSA Nuclear Program with the development of SMR related standards. With many members of the existing nuclear community, including regulators, operators, vendors, and academics, already involved in the CSA forum, the SMR community may find suitable support and value in participating in the Nuclear Program to develop standards to meet specific gaps and needs. Depending on the SMR technology, requirements and guidance may be incorporated and integrated into existing CSA standards. As well, new standards specific to SMR technology and design may need to be developed.

CSA also continues its efforts to engage with COG and NRCAN and to collaborate with the CNSC to determine the standards necessary to fulfil the needs of the small reactor community. More specifically, further investigation and analysis are being conducted to determine which standards could be amended to address SMR needs and which new standalone standards may be necessary to specifically address topics that are specific to SMRs or to a particular SMR design. As some CSA committees begin to investigate the applicability of their standards to SMRs in greater depth, linkage to SMR expertise is being coordinated through the Small Reactor Task Force. This includes CSA's engagement with the COG SMRTF and communication with the Vendor Participant Program to help identify gaps that SMR vendors are facing and to seek input on CSA standards.

Mechanisms for SMR Engagement in Standards Development

CSA Group provides a forum where various stakeholders and views are brought together and, using the consensus process, standards are developed to reflect minimum requirements and best practices. There are various mechanisms for interested stakeholders included the SMR community to further engage in the CSA standard development process, including:

- **Keeping Informed of CSA Activities via Nuclear Community Website**
The Nuclear Community website (<https://community.csagroup.org/community/nuclear>) is a public forum that connects members, stakeholders, and users of standards from around the world in an open and collaborative online environment. The community allows participants to support standards related activities in areas that are relevant to them or their organization. This community's platform is used to discover new ideas and discussions, connect with other users with interest in standards

development, and collaborate in the development of new projects and standards.

- **Participating Directly in Committee Work**

Becoming a CSA committee member would allow the SMR community to directly have a voice in the content development of a new edition or new standard representing the interests of the small reactor community, and to contribute in the drafting and vetting of new requirements. Participating in direct committee work provides the opportunity to network with other nuclear industry professionals and build strategic alliances with other stakeholders.

- **Submitting Comments on Draft Standards Released for Public Review**

As part of the accredited standards development process, all CSA draft standards are made available for a mandatory public review period. Comments submitted on draft standards that could impact SMR technology will be considered for incorporation into the standard.

- **Requesting Interpretation/Clarification of a Specific Provision in Any Published Standard**

As standards are living documents, users have the ability to submit requests for interpretation. Requests for interpretation can be submitted on any published standard at any time and are reviewed by the appropriate Technical Committee. Responses to requests for interpretation are balloted by the appropriate Technical Committee, sent to the submitter, and are posted for public reference.

- **Submitting Proposals for Change to Published Standards**

Requests for change can be submitted for consideration in the development of the next edition of a specific standard. Requests for change provide a method for the public and end users to submit their proposals to enhance or improve any standard.

- **Submitting a Proposal for an Express Document, Workshop, or Research Project**

To quickly introduce a document to fill gaps related to rapidly changing areas, an express document can be developed in a short timeframe (3-9 months) and can potentially become a standard. As well, workshops can be organized to engage interested stakeholders and gather input on a particular topic, resulting in a workshop report that can be used as a baseline for emerging issues. Finally, CSA Group's Research Program is designed to support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and to demonstrate CSA's ongoing commitment to social good. These solutions may be considered as tactical tools to help support the introduction of new ideas, methodologies, and emerging technologies, used to gain early consensus or develop initial seed documents, with the purpose to support new or existing standards development.

CONCLUSION

CSA Group provides a multi-stakeholder forum, interacts as a neutral third party, follows a consensus process to establish industry minimum requirements and best practices, and supports the regulatory framework. As SMRs activities progress, CSA will continue to engage with relevant stakeholders to explore consensus-based standards solutions to address the sector's evolving needs.

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