

Aging management for concrete containment structures for nuclear power plants



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Preface

This is the first edition of CSA N287.8, *Aging management for concrete containment structures for nuclear power plants*.

The purpose of this Standard is to provide aging management requirements to ensure that concrete containment structures satisfy their functional and performance requirements in all different phases of their life cycle and to ensure that for new concrete containment structures, aging is addressed during design and construction phases.

Note: *The functional and performance requirements of concrete containment structures might be different in different phases of the life cycle.*

In Canada, CNSC REGDOC 2.6.3 provides the regulatory requirements for managing the aging of structures, systems and components of a nuclear power plant (NPP). The Standards in the CSA N287 Series of Standards were initiated in response to a recognition by the utilities and industries concerned with nuclear power plant structures in Canada of a need for consistent standards for the design, construction, and testing of concrete containment structures for nuclear power plants.

The CSA N287 Series of Standards consists of eight Standards. The objectives of each Standard are summarized as follows:

- a) CSA N287.1-14, *General requirements for concrete containment structures for nuclear power plants*, specifies general requirements for the design, construction, testing, and commissioning of concrete containment structures for nuclear power plants designated as class containment and is directed to the owners, designers, manufacturers, fabricators, and constructors of the concrete components and parts;
- b) CSA N287.2-08, *Material requirements for concrete containment structures for CANDU nuclear power plants*, specifies requirements for materials used in concrete containment structures;
- c) CSA N287.3-14, *Design requirements for concrete containment structures for nuclear power plants*, specifies requirements for the design of concrete containment structures;
- d) CSA N287.4-09, *Construction, fabrication, and installation requirements for concrete containment structures for CANDU nuclear power plants*, specifies construction, fabrication, and installation requirements that apply to concrete containment structures of a containment system designated as class containment components, parts, and appurtenances for CANDU nuclear power plants;
- e) CSA N287.5-11, *Examination and testing requirements for concrete containment structures for nuclear power plants*, specifies examination and testing requirements that apply to the work of any organization participating in the construction, fabrication, or installation of parts or components of concrete containment structures for nuclear power plants;
- f) CSA N287.6-11, *Pre-operational proof and leakage rate testing requirements for concrete containment structures for nuclear power plants*, specifies requirements for proof by demonstration, before first criticality, that the design and construction of a concrete containment structure are satisfactory with respect to quality and performance as demonstrated by achieving the specified requirements of CSA N287.6 including commissioning leakage rate target;
- g) CSA N287.7-08, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*, specifies uniform requirements whereby, through systematic and periodic examination, the structural and leak-tight integrity of concrete containment structures can be assessed as demonstrated by achieving the specified requirements of CSA N287.7 including the operational leakage rate target; and
- h) CSA N287.8, *Aging management for concrete containment structures for nuclear power plants*, provides aging management requirements for concrete containment structures and their

components for nuclear power plants and is directed to the owners/operators, designers, manufacturers, fabricators, and constructors.

In the preparation of these Standards, it was the decision of the Committee to make use of existing standards, codes, and other reference material wherever possible.

Users of this Standard are reminded that the design, manufacture, construction, commissioning, operation, and decommissioning of nuclear facilities in Canada are subject to the provisions of the *Nuclear Safety and Control Act*, and its supporting Regulations. Thus, requirements additional to those specified in this Standard may be imposed by the Canadian Nuclear Safety Commission.

The CSA N-Series of Standards provides an interlinked set of requirements for the management of nuclear facilities and activities. CSA N286 provides overall direction to management to develop and implement sound management practices and controls, while the other CSA nuclear Standards provide technical requirements and guidance that support the management system. This Standard works in harmony with CSA N286 and does not duplicate its generic requirements; however, it may provide more specific direction for those requirements.

This Standard was prepared by the Subcommittee on Aging Management for Concrete Containment Structures for Nuclear Power Plants, under the jurisdiction of the Technical Committee on Concrete Containment and Safety-Related Structures and the Strategic Steering Committee on Nuclear Standards, and has been formally approved by the Technical Committee.

Notes:

- 1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
- 2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
- 3) *This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*
- 4) *To submit a request for interpretation of this Standard, please send the following information to inquiries@csagroup.org and include “Request for interpretation” in the subject line:*
 - a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
 - b) *provide an explanation of circumstances surrounding the actual field condition; and*
 - c) *where possible, phrase the request in such a way that a specific “yes” or “no” answer will address the issue.*

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.

- 5) *This Standard is subject to review within five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include “Proposal for change” in the subject line:*
 - a) *Standard designation (number);*
 - b) *relevant clause, table, and/or figure number;*
 - c) *wording of the proposed change; and*
 - d) *rationale for the change.*

CSA N287.8:15

Aging management for concrete containment structures for nuclear power plants

0 Background

0.1 General

Concrete can be a very durable construction material under favorable environmental conditions and its performance as concrete containment structures in nuclear power plants has been good. Experience shows that aging degradation can be a result of exposure to aggressive environments, excessive structural loads, accident conditions, use of unsuitable materials, poor material and construction quality, and the lack of or inadequate maintenance or inspections.

Major consequences due to aging of concrete containment structures can include excessive leakage and/or loss of structural integrity. In worst cases, these issues can impact the safe and long term operation of the plant. This could require actions ranging from increased monitoring and trending up to and including mitigating measures such as concrete repair or replacement. However, the functional or performance requirements defined by the design basis and safety analysis of the concrete containment structures should not be affected, provided the structures are kept in good maintenance by timely detection and mitigation of degradations with an aging management (AM) plan.

Functional and performance requirements of concrete containment structures might be different in different phases of the life cycle. While the primary function of containment is to support safe operation of the facility, containment structures may be also used as a confinement barrier during the decommissioning phase which can last anywhere from a few years to decades. Thus, aging management should be structured in consideration of providing assurances of barrier integrity after operation has ceased.

0.2 Fundamental principles

Understanding the relevant aging mechanisms and their potential impact on concrete containment structures is the key to an AM plan. This includes an understanding of material properties, methods of construction, structure models, stressors, operating conditions, aging mechanisms, sites of degradation, consequences of degradation, relevant R&D, relevant OPEX, maintenance history, mitigation measures, and current structure status. As shown in the PLAN-DO-CHECK-ACT cycle in Figure 1, this links to many programs of the nuclear power plant.

The “PLAN” activity in Figure 1 refers to the coordination, integration, modifying existing programs and activities that relate to managing the aging of concrete containment structures and components. This should include, but is not limited to, documenting the regulatory requirements, safety criteria and relevant activities, describing the coordination mechanism and processes, and improving effectiveness of aging management.

The “DO” activity involves the management of aging mechanisms by minimizing the expected degradation of concrete containment structures and components through their operation or use in

accordance with the approved operating procedures and technical specifications. This includes maintaining operating conditions within design limits, establishing proper environmental control, and maintaining operating history including transient records.

The “CHECK” activity includes the timely inspection, monitoring, and assessment of the concrete containment structures and components. Data identified in the AM plan should be collected and recorded to provide a basis for decisions on the type and timing of aging management actions.

The “ACT” activity refers to the timely mitigation and correction of structures and components degradation by the implementation of maintenance, repair, and replacement activities. It includes preventive maintenance, corrective maintenance, spare parts management, and replacement, etc.

The AM plan for the concrete containment structures can consist of existing programs such as periodic inspections, maintenance, condition assessments, obsolescence management and system health monitoring, etc., and if necessary, developing new programs.

0.3 Essential elements of aging management

The essential elements of a systematic approach to managing aging of structures and components in the operation of nuclear power plants include

- a) organizational arrangements;
- b) data collection and record keeping;
- c) screening of structures and components for the purposes of aging management;
- d) evaluation for aging management including
 - i) understanding aging;
 - ii) preventive actions to minimize and control aging degradation;
 - iii) methods for detecting, monitoring, and trending aging effects; and
 - iv) methods for mitigating aging effects and corrective actions;
- e) condition assessment;
- f) development of aging management plans;
- g) management of technological obsolescence;
- h) interfaces with other supporting programs;
- i) implementation of aging management plans; and
- j) review and improvement.

1 Scope

1.1

This Standard provides aging management requirements for concrete containment structures and their components for nuclear power plants and is directed to owners/operators, designers, manufacturers, fabricators, and constructors.

Note: *This Standard may provide guidance for aging management of other concrete structures where applicable.*

1.2

This Standard provides requirements for aging management of existing concrete containment structures to address emerging challenges and ensure that existing concrete containment structures and their components satisfy their functional and performance requirements in all different phases of their life cycle.