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N285.4-09

Periodic inspection of CANDU nuclear power plant components

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Preface

This is the fifth edition of CSA N285.4, *Periodic inspection of CANDU nuclear power plant components*. It supersedes the previous editions, published in 2005, 1994, 1983, and 1978. It is one of the CSA N285 series of Standards on CANDU® nuclear power plant components.

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This Standard provides uniform rules for the periodic inspection of pressure-retaining systems and components in CANDU nuclear power plants. It has been revised and updated to account for new knowledge and experience gained from CANDU research and operations, advances in technology, and changes to the regulatory framework in Canada. It should be noted that the fourth and fifth editions of this Standard include significant changes in the content and structure of clauses pertaining to the supplementary periodic inspection of fuel channel pressure tubes, fuel channel feeder pipes, and steam generator tubes (Clauses 12, 13, and 14, respectively).

Users of this Standard are cautioned that, due to restructuring, a clause in this edition might not be directly comparable to the clause with the corresponding number in the previous edition of this Standard. Users are also reminded that the design, manufacture, construction, commissioning, operation, inspection, maintenance, and decommissioning of nuclear facilities in Canada are subject to the provisions of the *Nuclear Safety and Control Act* and Regulations as well as other regulatory documents of the Canadian Nuclear Safety Commission (CNSC). The CNSC might impose additional requirements to those specified in this Standard.

This Standard was prepared by the Technical Committee on Periodic Inspection of CANDU Nuclear Power Plant Components, under the jurisdiction of the Strategic Steering Committee on Nuclear Standards, and has been formally approved by the Technical Committee.

June 2009

Notes:

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N285.4-09
Periodic inspection of CANDU nuclear power plant components

0 Introduction — Inspection rationale

Notes:

(1) *Clause 0 is an informative section intended to provide background information on the basis of the requirements specified in Clauses 3 to 14.*

(2) *See Annex A for a summary of the inspection logic used in this Standard.*

0.1 General rationale

0.1.1

In the preparation of Canadian nuclear Standards relating specifically to CANDU nuclear power plants, it was considered essential to include a Standard on the periodic inspection of nuclear pressure-retaining systems and components and their supports.

0.1.2

It has long been the practice to carry out extensive in-service inspections of power plant systems and components to provide assurance against plant outages and economic loss from component failures. In addition, in-service inspections are performed in the interest of the safety of plant personnel. In the case of nuclear power plants, periodic functional testing of safety systems and their components is already performed at appropriate intervals to provide assurance that they have adequate availability. Periodic inspection is another form of in-service inspection.

0.1.3

The purpose of periodic inspection is to provide assurance that the likelihood of a failure that could endanger the radiological health and safety of persons has not increased significantly since the plant was put into service. It is necessary, therefore, to first establish the means by which the health and safety of persons might be endangered.

0.1.4

On nuclear sites, a major radiological concern is the accidental release of radioactive products. Generally, Canadian safety requirements demand that there should be at least two barriers or containing boundaries between the hazardous sources and the environment at large. This Standard places emphasis on those systems, or portions thereof, that form part of such a barrier or containing boundary.

0.1.5

Generally, systems whose failure can cause the most severe hazards are ones with the highest residual radiation fields while the reactor is shut down. Inspection of these systems involves some exposure to radiation fields and thus creates a hazard of the same general type as that which it is intended to prevent. Consequently, the approach has been to develop an inspection program that will provide sufficient evidence to adequately assess the integrity of systems and components in the plant while at the same time minimizing the overall hazard.

0.1.6
In determining the basis for periodic inspection it is useful to consider the quality status of the components in question at the time the plant is put into service. It is assumed that the components are in satisfactory condition at the start of the plant operation and that, if operated in accordance with the design intent, the components will last for their intended service life without failure of the fluid-retaining boundary.

If the components are not in such a condition, additional manufacturing inspections should be instituted. Periodic inspection is not intended to discover flaws or weaknesses overlooked during the stages before plant start-up, nor should it be implemented as a means of providing additional manufacturing or installation inspection. In addition, periodic inspection is not a substitute for eliminating potential failures during the design stage; emphasis should continue to be placed on eliminating the possibility of system failure during the design stage.

0.1.7
In summary, design and manufacturing inspections are intended to provide an adequately defect-free product at start-up; periodic inspection is intended to ensure that an unacceptable degradation in component quality is not occurring and that the probability of failure remains acceptably low for the life of the plant.

0.2 Scope of periodic inspection

0.2.1
Periodic inspection is considered to include the fluid boundary portions of components, piping, and supports that comprise

(a) systems containing fluid that directly transports heat from nuclear fuel;
(b) systems essential for the safe shutdown of the reactor or the safe cooling of the fuel, or both, in the event of a process system failure; and
(c) other systems or components whose failure could jeopardize the integrity of the systems described in Item (a) or (b), or both.

0.2.2
In determining the extent of the periodic inspection for the systems outlined in Clause 0.2.1, the following guidelines are applied:

(a) a sufficient sample of system components and piping is included in the inspection to ensure that any general deterioration from corrosion, erosion, wear, or other known or anticipated degradation mechanisms is identified. This is intended to ensure that the basic substantial margins provided in the original design, in terms of pressure boundary operating stresses, are not reduced significantly;
(b) all components whose massive failure could severely tax the capability of any of the safety systems should be included to an appropriate extent; and
(c) all components whose failure could lead to or involve substantial impairment of a safety system, preventing its proper operation, or major damage of a process system that could severely tax the capacity of any of the safety systems should be included to an appropriate extent.

0.2.3
An important aspect to consider in determining the scope of periodic inspection is the common engineering practice of performing pre-service and in-service inspections on sample components when such components or materials are used beyond conditions of proven experience.

Where such components or materials constitute a part of a vital system, they may be considered suitable candidates for inclusion in the periodic inspection program even though they might fall outside the scope of periodic inspection as defined by this Standard. They would then be included in the program until sufficient experience has been gained to determine that periodic inspection is no longer warranted or that appropriate periodic inspection requirements can be specified. The fuel channel pressure tubes used in the CANDU reactor are considered to fall into this category, and dimensional and volumetric inspections and

material surveillance have been included in the periodic inspection requirements. Similarly, volumetric inspections of steam generator tubes, and thickness checks and visual inspections of the fuel channel feeder pipes, have been included.

0.2.4

For other fluid boundary failures, where the probability of occurrence represents only a very small part of the permitted unsafe-process failure frequency or where the resulting hazard is relatively slight, periodic inspection is not required. The cost of such additional inspection is not warranted, and exposing inspection personnel to radiation in such cases is not consistent with the principle of minimizing the overall hazard.

0.3 Inspection samples

0.3.1

If the plant at start-up has adequately defect-free components and piping, periodic inspection can logically be based on a sampling approach, provided that the samples include areas subject to the most extreme conditions. To ensure this, samples should include at least the following:

(a) the most significant acceptable indications discovered during the inaugural inspection;
(b) areas most likely to experience degradation; and
(c) areas having the most severe conditions of service in terms of stresses, particularly cyclic stresses.

Sample areas combining two or more of these factors are most appropriate.

These sample areas would be used for successive periodic inspections. In the absence of new evidence, the basis on which these sample areas were initially chosen would remain appropriate. Should new evidence arise, the inspection areas should be altered accordingly.

0.3.2

In choosing the inspection sample, the effects of abnormal events such as earthquakes or loss of coolant accidents (LOCAs) are excluded from the stress criteria. As a result, inspection is concentrated on those areas experiencing the most severe operational conditions under normal circumstances, and thus having the potential to suffer the greatest deterioration. Extra inspections beyond the scope of this Standard can be required after abnormal events.

0.3.3

The number of samples and the extent of each sample can be determined only with reference to a particular design. Logical criteria include those factors defined in Clauses 0.3.1 and 0.3.2 relating to the choice of samples, and consideration of the number of like components in a system (i.e., components that are similar in initial design, manufacture, and subsequent service environment).

An extension of the consideration of like components applies to a multi-unit power plant. Where it can be demonstrated that units are essentially similar in design and construction and operate under similar conditions, the sampling required is not the same for all units. The first unit of a power plant in service serves as a basis for all units, with enough samples in each of the other units to identify positively the effects of different service conditions, manufacturing differences, etc., between the units.

0.4 Inspection intervals

The interval between periodic inspections should be determined on a logical basis and not by a fixed time cycle. Consequently, the initial period to the first inspection should be relatively short to ensure a conservative approach. Subsequent periods are determined by the severity of operating conditions, evidence from earlier inspections, considerations of any known abnormality in operation and new understanding of material degradation. Using this practice, it can be assumed with a high degree of certainty that the samples represent the worst cases, and that the remainder of each system is not likely to be worse.

0.5 Inaugural inspection

Periodic inspection is a practice for detecting deterioration. This detection involves comparison and thus it is necessary to have a baseline from which to start. An inaugural inspection is thus conducted before start-up of the plant and covers all areas intended to receive subsequent periodic inspection. However, inaugural inspection is not considered to be necessary for items that, for economic reasons, are normally replaced rather than repaired, provided that spares of such items are readily available.

0.6 Inspection methods

The methods and techniques for nondestructive examination are still evolving. There is continuing research on and development of new methods and better techniques. Thus, the requirements of this Standard have been compiled with a degree of permitted flexibility to allow for the use of new techniques and practices that might be developed and to ensure that a better assurance of the actual level of integrity or a reduction in hazards to the inspection staff, or both, can be obtained.

0.7 Summary

An attempt has been made to provide a rational basis for the inspection program by considering not only the consequences of failure but also the factors that determine the likelihood of such failure. Also, the requirements of this Standard offer incentive to designers and plant operators to limit the extent of the required periodic inspection by providing systems that have greater resistance to degradation mechanisms.

1 Scope

1.1

This Standard defines requirements for the periodic inspection of pressure-retaining systems, components, and supports that form part of a CANDU nuclear power plant.

1.2

This Standard addresses

(a) failure aspects;
(b) classification of areas subject to inspection;
(c) provision for access;
(d) inspection techniques and procedures;
(e) personnel qualifications;
(f) frequency of inspection;
(g) responsibilities;
(h) documentation;
(i) records;
(j) evaluation of inspection results;
(k) dispositioning; and
(l) repair requirements.

1.3

In CSA Standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; "may" is used to express an option or that which is permissible within the limits of the standard; and "can" is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.