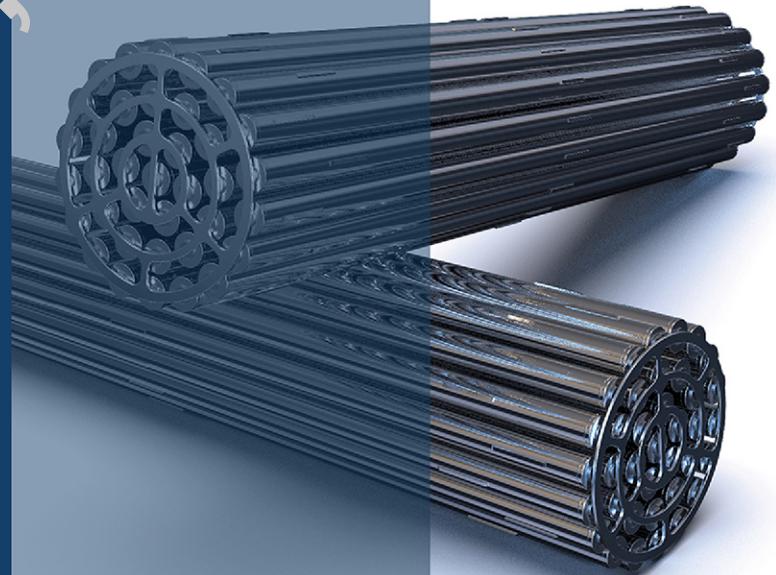


# **Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors**



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*CSA N285.8:21*  
***Technical requirements for  
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# Preface

This is the fourth edition of CSA N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*. It supersedes the previous editions, published in 2010, 2005, and 2015.

This Standard specifies mandatory technical requirements and non-mandatory evaluation procedures for fitness-for-service assessments. Pressure tubes in Canadian CANDU® nuclear power plants are inspected in accordance with CSA N285.4, *Periodic inspection of CANDU nuclear power plant components*. When a detected flaw indication does not satisfy the criteria of acceptance by examination, or when pressure tube to calandria tube contact is detected or predicted, Clause 12 of CSA N285.4 permits a fitness-for-service assessment to determine acceptability. Also, Clause 12 of CSA N285.4 requires evaluation of the results of specified material property surveillance measurements.

**Note:** CANDU (CANada Deuterium Uranium) is a registered trademark of Atomic Energy of Canada Limited.

The major changes to this edition include the following:

- a) removed provision in Clause 5.4.3.2 c) that exempts a Level A overload evaluation;
- b) updated Annex C to be consistent with current methods used in the industry for probabilistic core assessments and probabilistic leak before break (Clauses C.3 and C.4);
- c) revised Clause D.8 to support use of equation for fracture initiation toughness for higher *Heg* concentrations;
- d) added new Clause 6.5 for evaluation of pressure tube to calandria tube (PT-CT) contact to improve clarity of requirements, and to address observed spacer movement;
- e) updated the definition of fitness-for-service (FFS) evaluation to use “...in a degraded condition that was not considered in the design...” to avoid using the terminology “beyond design basis”;
- f) evaluated use of the term “structural integrity” and revised the Standard as appropriate;
- g) included the recently published  $p_C$  statistical equation into Annex D;
- h) included the recently published  $F_{NR}$  for non-ratcheting flaw assessments; and
- i) updated the maximum allowable operating interval ( $\Delta t_{max}$ ) for operation of tubes left in contact (Clause 6.3) accounting for improved knowledge of deuterium ingress rates.

This Standard is one of a series of CSA N285 Standards that provide consistent rules for the design, fabrication, installation, inspection, and assessment of pressure-retaining systems and components in CANDU nuclear power plants. The series outlines requirements that are particularly applicable to nuclear power plants in Canada and references the appropriate requirements of the ASME *Boiler and Pressure Vessel Code*. Users of this Standard are reminded that the site selection, design, manufacture, construction, installation, commissioning, operation, and decommissioning of nuclear facilities in Canada are subject to the *Nuclear Safety and Control Act* and its Regulations. The Canadian Nuclear Safety Commission might impose additional requirements to those specified in this Standard.

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 Group nuclear Standards provide technical requirements and guidance that support the management system. This Standard works in harmony with CSA N286 and does not duplicate the generic requirements of CSA N286; however, it might provide more specific direction for those requirements.

This Standard is based in part on fitness-for-service guidelines developed by a Technical Task Team formed by the CANDU Owners Group (COG).

In order to facilitate adoption by the authority having jurisdiction, this Standard includes some regulatory provisions.

This Standard was prepared by the Subcommittee on Technical Requirements for In-Service Evaluation of Zirconium Alloy Pressure Tubes in CANDU Reactors, under the jurisdiction of the Technical Committee on Periodic Inspection of CANDU Nuclear Power Plant Components 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.*
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  - d) *rationale for the change.*

# CSA N285.8:21

## ***Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors***

### **0 Introduction**

This Standard consists of a mandatory main body and eight non-mandatory annexes. The main body contains the mandatory rules and acceptance criteria for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors. The non-mandatory annexes are as follows:

- Annex [A](#) — Procedures for the evaluation of pressure tube flaws;
- Annex [B](#) — Procedures for the evaluation of pressure tube to calandria tube contact;
- Annex [C](#) — Procedures for the assessment of a reactor core;
- Annex [D](#) — Material properties and derived quantities;
- Annex [E](#) — Notification of in-service evaluation form;
- Annex [F](#) — Guidance on calculating the maximum allowable pressure tube failure frequencies for use in probabilistic assessments for the reactor core;
- Annex [G](#) — Uncertainty analysis in probabilistic evaluations; and
- Annex [H](#) — Acceptable number of simulations for probabilistic assessments performed by repeated random sampling.

Annexes [A](#) to [C](#) contain evaluation procedures that may be used to demonstrate compliance with the acceptance criteria in the main body of the Standard. Annex [D](#) contains the material properties and derived quantities that are required when performing an evaluation in accordance with Annexes [A](#) to [C](#). Annex [E](#) contains a form for providing notification of the evaluation to the authority having jurisdiction (AHJ). Annexes [F](#), [G](#), and [H](#) are used in conjunction with probabilistic assessments of the reactor core that are performed within the scope of Clause [7](#) and Annex [C](#). Annex [F](#) provides a method for calculating the maximum allowable pressure tube failure frequency. Annex [G](#) provides a methodology for performing uncertainty analyses of the probabilistic calculation results. Annex [H](#) provides a convergence criterion for the probabilistic calculations.

This Standard assumes that the typical evaluation process consists of

- pressure tube inspection;
- evaluation of the inspection results;
- documentation of the inspection results and evaluation;
- notification of the AHJ regarding the inspection and evaluation; and
- acceptance by the AHJ of the disposition of pressure tubes prior to returning the reactor to service.

### **1 Scope**

#### **1.1**

This Standard specifies the technical requirements for the owner/operator to evaluate cold-worked Zr-2.5 wt% Nb alloy pressure tubes in operating CANDU reactors for continued operation. Clause 13 of CSA N285.0/N285.6 Series requires that when in-service inspection results or material surveillance results do