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TAC Number(s) (if available)	**MB5765**
Reference Meeting Notice	**ML032250070**
Purpose of Meeting (copy from meeting notice)	**ACR-700 On-Power Fueling and Fuel Design Meeting**

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Belkys Sosa	**Project Manager**

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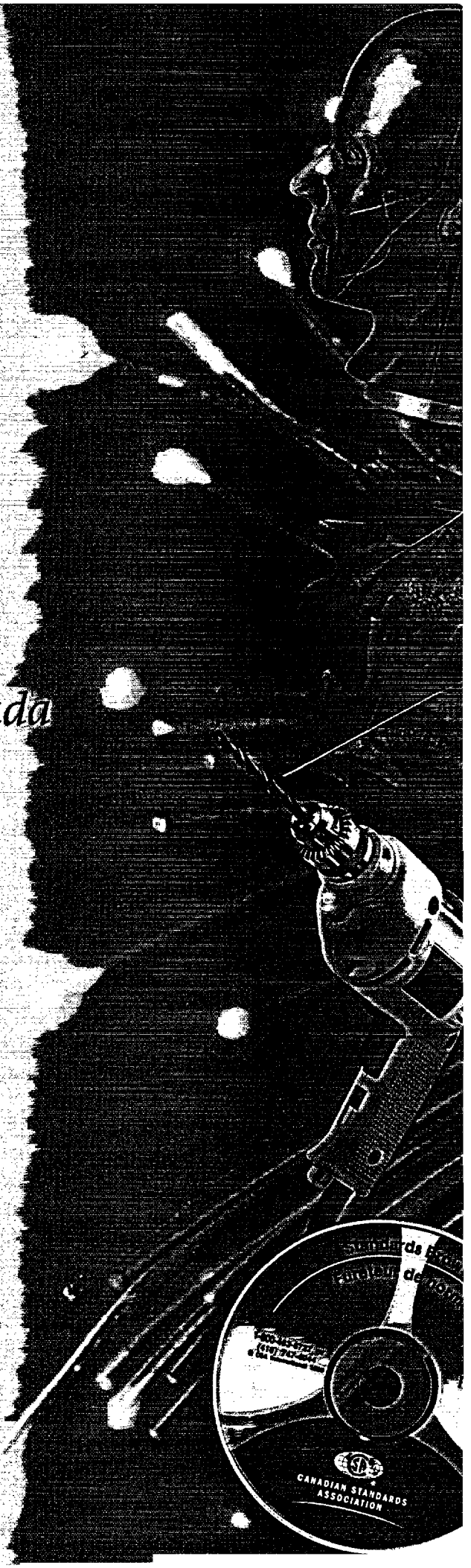
Requirements for Class 1C, 2C, and 3C Pressure-Retaining Components and Supports in CANDU Nuclear Power Plants

A National Standard of Canada

(approved November 2000)



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National Standard of Canada
(approved November 2000)

CAN/CSA-N285.2-99
Requirements for Class 1C, 2C, and 3C Pressure-Retaining Components and Supports in CANDU Nuclear Power Plants

Prepared by

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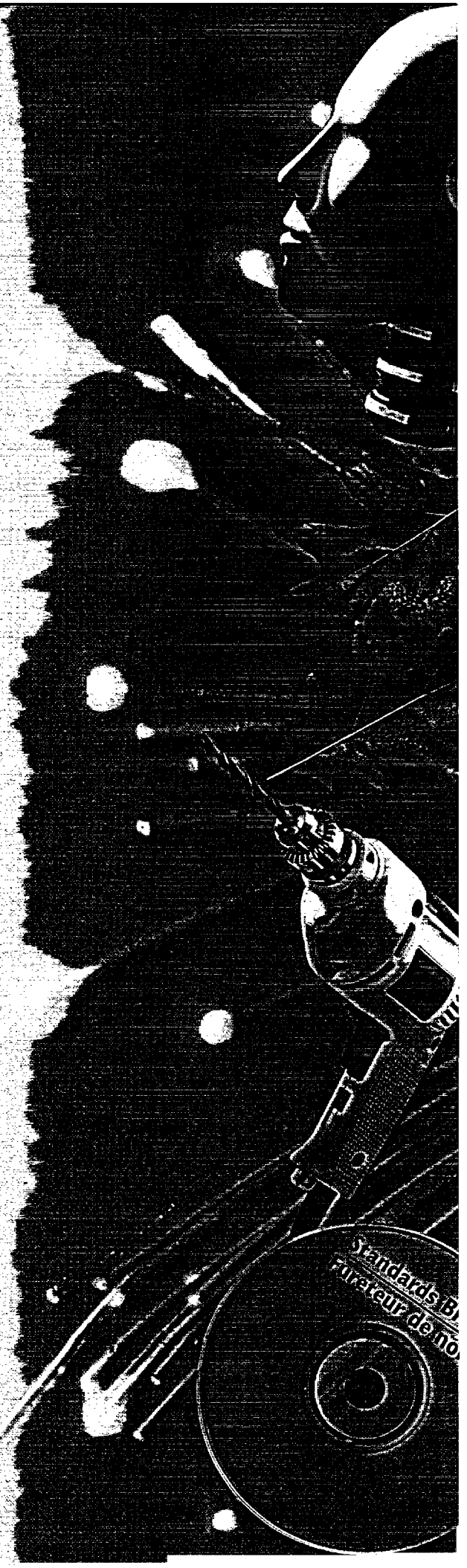

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N285.2-99
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Preface

This is the second edition of CSA Standard N285.2, *Requirements for Class 1C, 2C, and 3C Pressure-Retaining Components and Supports in CANDU Nuclear Power Plants.* It supersedes the previous edition, published in January 1989. This Standard is part of the N285 series, which provides uniform rules for the design, fabrication, installation, and inspection of CANDU nuclear power plant pressure-retaining systems, components, and supports.

The specific objective of this Standard is to establish rules for the design, fabrication, examination, testing, and inspection of components that have been classified by CSA Standard N285.0 as Class 1C, 2C, or 3C. The rules complement those specified in CSA Standard N285.0 and the *ASME Boiler and Pressure Vessel Code.*

This Standard, therefore, is intended to be used in conjunction with CSA Standard N285.0, and in the event of a conflict between the two Standards, the requirements of this Standard govern.

Users of this Standard are reminded that the design, fabrication, installation, commissioning, and operation of nuclear facilities in Canada are subject to the provisions of the Atomic Energy Control Act and Regulations. Thus, requirements additional to those specified in this Standard may be imposed by the Atomic Energy Control Board.

Pressure-containing systems are also subject to provincial Boiler and Pressure Vessel Acts.

This Standard was prepared by the Subcommittee on Pressure-Retaining Systems and Components for Nuclear Power plants under the jurisdiction of the Technical Committee on CANDU Nuclear Power Plant Systems and Components and the Strategic Steering Committee on Nuclear Standards and was formally approved by the Technical Committee. It will be submitted to the Standards Council of Canada for approval as a National Standard of Canada.

May 1999

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 publication 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 publication.*

(4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to CSA International, Standards Development, 178 Rexdale Boulevard, Toronto, Ontario M9W 1R3.*

Requests for interpretation should

(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) be phrased where possible to permit a specific "yes" or "no" answer.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update. *For subscription details, write to CSA Sales Promotion,* Info Update, *at the address given above.*

N285.2-99

Requirements for Class 1C, 2C, and 3C Pressure-Retaining Components and Supports in CANDU Nuclear Power Plants

0. Introduction

This introduction outlines the philosophy and background information that have guided the development of this Standard. It is included to provide guidance and to improve understanding of the Standard, and should not be used to justify deviation from the rules of this Standard.

It is recognized that the *ASME Boiler and Pressure Vessel Code* constitutes a valuable set of requirements for nuclear plant construction; however, although intended to be general, the ASME rules basically address a pressure vessel reactor such as the PWR or BWR type rather than a pressure tube reactor such as CANDU. Modification of the ASME rules as well as additional rules are therefore required to address both the administrative system and the design concepts, which are uniquely Canadian. CSA Standard N285.0 provides general requirements, most of which govern the Canadian administrative system of Classification, Registration, and Quality Assurance, where they differ from *ASME Boiler and Pressure Vessel Code*, Section 3, Subsection NCA.

This Standard provides technical rules to complement those of ASME Code, Section 3. In some cases, ASME Code requirements are modified to properly relate the construction of specific CANDU components to the intent of the ASME Code. In other cases, additional rules are provided when the ASME Code does not address Canadian needs.

Class 1C covers components for installation in Class 1 systems that meet Class 1 requirements as complemented by the rules of this Standard. Similarly, Class 2C and Class 3C cover components for Classes 2 and 3 systems, respectively.

Considerable attention was given to defining the criteria to be used in deciding whether a particular component should be included in this Standard. The criteria that were adopted state that the purpose of this Standard is to provide rules for the pressure-retaining components of CANDU nuclear power plants where, because of the design concept, the rules of the *ASME Boiler and Pressure Vessel Code*, as required by CSA Standard N285.0,

(a) do not exist; or
(b) are not applicable; or
(c) are not sufficient.

An adaptation of this definition is included in N285.0, Clause 5.7.

Several components proposed for inclusion in this Standard fell into the category of upgraded components for use in a system of a higher classification than that for which the component was designed and manufactured. Although the need for upgrading was evident in some circumstances, no consensus could be reached on a generic set of rules to be followed. Each case must, therefore, be specifically proposed to the appropriate provincial regulatory authority for a special registration or other resolution.

At one time it was intended that the use of materials other than those permitted by the *ASME Boiler and Pressure Vessel Code* would be covered in this Standard. The decision was taken to cover such materials

in a separate Standard, CSA Standard CAN/CSA-N285.6. The use of non-ASME Code material is, therefore, no longer considered to be a valid reason for including the component in this Standard. In addition to the material specification, CSA Standard CAN/CSA-N285.6 contains the allowable stresses and other relevant design information for these materials.

It was decided that this Standard should provide rules for elastomeric components, where the consequence of their failure is a significant release of fluid. Items such as hoses are addressed, but seal components such as O-rings and gaskets, the failure of which results in a leak rather than rupture, are not covered.

Fuelling machine supports are addressed in this Standard. Portions of them have a mobility not usually found in supports for pressure-retaining components. As an example, an elevating bridge and carriage is commonly used to move a fuelling machine from one reactor channel to another for on-power fuelling. A mechanism such as a ball screw and nut assembly is often used to produce bridge and carriage motion and to provide support. Rules in this Standard primarily cover the construction of these mechanisms and the control and interlock requirements necessary to prevent overstressing of the pressure boundary, or its support, caused by inappropriate support movement. Reference is made to the ASME Code, Section 3, Subsection NF, for structural support elements.

Instruments and instrument lines are not addressed since they are covered by CSA Standard N285.0.

This Standard does not deal with concrete pressure-retaining components such as a calandria vault. Suitable coverage will be provided in a Standard on safety-related concrete structures, CSA Standard CAN/CSA-N291.

This Standard deals with components for Class 1, 2, and 3 systems. Components for Class 4 systems are addressed in CSA Standard CAN/CSA-N285.3.

1. Scope

1.1

This Standard applies to pressure-retaining components and their supports of CANDU nuclear power plants that have a Code Classification of Class 1C, 2C, or 3C as defined by CSA Standard N285.0.

1.2

This Standard provides rules that complement those in CSA Standard N285.0 for the design, fabrication, installation, examination, and inspection of CANDU nuclear power plant components and supports.

1.3

This Standard provides rules intended to ensure the pressure-retaining integrity of components. Its rules do not address operability. Other design requirements are specified in the appropriate contractual documents.

1.4

This Standard provides rules for the support of fuelling machines.

1.5

This Standard applies only to new construction completed prior to the plant being declared in-service. Repairs or modifications to be made after the plant has been declared in-service should be carried out in accordance with CSA Standard N285.0.

1.6
This Standard does not provide requirements for temporary loads, such as those generated by freeze plugs or other devices used during maintenance operations.

1.7
The values given in SI (metric) units are the standard. The values given in parentheses are for information only.

2. Definitions, Reference Publications, and Abbreviations

2.1 Definitions
In addition to the definitions listed in CSA Standard N285.0, the following definitions apply in this Standard:

Calandria – a cylindrical vessel containing the moderator, closed at both ends by end shields.

Calandria assembly – a multicompartment vessel consisting of a calandria, end shields, and calandria tubes.

Calandria tube – a tube spanning the calandria, separating the fuel channel from the moderator.

Calandria tubesheet – a plate forming part of the end shield that is the common boundary between the calandria and the end shield.

Channel closure safety lock – a device that prevents the accidental or unintentional disengagement of the fuel channel closure.

End fitting – an extension to the pressure tube that provides for connection to the heat transport system and access for refuelling.

End shield – a vessel consisting of a shell and two tubesheets interconnected by lattice tubes, filled with radiation-shielding material.

Fuel channel – an assembly of a pressure tube with end fittings.

Fuel-handling equipment – the equipment used to refuel a reactor and transfer irradiated fuel to the storage bay.

Fuelling machine – a machine used to load new fuel into and remove irradiated fuel from a fuel channel.

Fuelling machine supports – supports that transmit the loads from the fuelling machine pressure-retaining components to the building structure.

Fuelling tubesheet – a plate forming part of the end shield that faces the fuelling machine.

Lattice tube – a cylindrical component joining calandria and fuelling tubesheets, with provision to locate and support an end fitting.

Liquid injection nozzle – a tube spanning the calandria, with holes for discharging neutron-absorbing liquid into the moderator.

Pressure tube – part of the fuel channel assembly located within the calandria tube and designed to contain nuclear fuel and coolant.

Reactivity control units – devices designed to measure and control the neutron flux in a nuclear reactor.

Reinforced elastomeric hoses – flexible conduits formed of elastomers reinforced with braiding or spiral windings, used to convey pressurized fluids.

2.2 Reference Publications

This Standard refers to the following publications and where such reference is made it shall be to the edition listed below.

Note: *New or amended editions of these referenced publications may exist. The user may find it more appropriate to refer to such editions.*

CSA Standards

N285.0-95,
General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants;

CAN/CSA-N285.3-88 (R1994),
Requirements for Containment Systems Components in CANDU Nuclear Power Plants;

CAN/CSA-N285.6 Series-88 (R1994),
Material Standards for Reactor Components for CANDU Nuclear Power Plants;

N291, *Under development,*
Requirements for Safety-Related Structures for CANDU Nuclear Power Plants.

ASME* Boiler and Pressure Vessel Code, 1995

Section 2, Part A, SA-578/SA-578M,
Material Specifications, Ferrous, Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications;

Section 2, Part D, Appendix 1,
Basis for Establishing Stress Values in Tables 1A and 1B;

Section 3, Division 1,
Rules for the Construction of Nuclear Power Plant Components:

Section 3A — Subsection NCA, *General Requirements for Divisions 1 and 2;*

Section 3B — Subsection NB, *Class 1 Components;*

Section 3C — Subsection NC, *Class 2 Components;*

Section 3D — Subsection ND, *Class 3 Components;*

Section 3F — Subsection NF, *Supports;*

Appendix 3,
Basis for Establishing Design Stress Intensity Values and Allowable Stress Values;

Appendix 3-2000,
Fatigue Strength Criteria for All Materials;

Section 5,
Nondestructive Examination;

Section 9,
Qualification Standard for Welding and Brazing Procedures, Welders, Braziers, and Welding and Brazing Operators.

ASTM† Standard
D 380-94,
Standard Test Methods for Rubber Hose.

SAE‡ Standards
AS1933-98,
Age Controls for Hose Containing Age-Sensitive Elastomeric Material;

J343-90,
Tests and Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies;

J1926 Standards — *Connections for General Use and Fluid Power-Ports and Stud Ends with ISO 725 Threads and O-ring Sealing:*
Part 1 (1993) — *Threaded Port with O-ring Seal in Truncated Housing;*
Part 2 (1995) — *Heavy-Duty (S Series) Stud Ends;*
Part 3 (1993) — *Light-Duty (L Series) Stud Ends.*

**American Society of Mechanical Engineers.*
†American Society for Testing and Materials.
‡Society of Automotive Engineers.

2.3 Abbreviations

The following abbreviations apply in this Standard:

AISI	American Iron and Steel Institute
AMS	Aerospace Material Specification
ASM	American Society for Metals
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CSA	Canadian Standards Association
SAE	Society of Automotive Engineers

3. General Requirements

3.1

The following requirements of CSA Standard N285.0 apply, except as otherwise specified, in this Standard:

(a) general requirements in accordance with Clause 3 of CSA Standard N285.0;
(b) responsibilities of the parties in accordance with Clause 4 of CSA Standard N285.0;
(c) classification of components in accordance with Clause 5 of CSA Standard N285.0;
(d) registration of components in accordance with Clause 6 of CSA Standard N285.0;
(e) design of components in accordance with Clause 7 of CSA Standard N285.0;
(f) choice of materials in accordance with Clause 8.1.1 of CSA Standard N285.0 for Class 1C components, Clause 8.1.2 for Class 2C components, and Clause 8.1.3 for Class 3C components;

(g) fabrication and installation in accordance with Clause 9 of CSA Standard N285.0;
(h) quality assurance in accordance with Clause 10 of CSA Standard N285.0;
(i) inspection, examination, and testing in accordance with Clause 11 of CSA Standard N285.0;
(j) certification and overpressure protection in accordance with Clause 12 of CSA Standard N285.0;
(k) in-service requirements in accordance with Clause 13 of CSA Standard N285.0; and
(l) supports in accordance with Clause 14 of CSA Standard N285.0.

Note: *CSA Standard N285.0 directs the user to the relevant paragraphs or clauses of the* ASME Boiler and Pressure Vessel Code *and to other CSA Standards.*

3.2

Where a reference is made to another Clause in this Standard, all of its subsidiary Clauses shall apply.

4. Specific Requirements

Class 1C, 2C, and 3C components shall comply with the design, fabrication, inspection, examination, test, and installation requirements of CSA Standard N285.0 for the class of system in which they are to be installed, except as otherwise required by this Standard.

Note: *CSA Standard N285.0 directs the user to the relevant paragraphs or clauses of the* ASME Boiler and Pressure Vessel Code *and to other CSA Standards.*

5. Fuel Channel Assemblies

5.1 General

With the exceptions specified below, the fuel channel pressure boundary components shall be constructed to meet the Class 1 requirements of CSA Standard N285.0, which specifies the relevant clauses of the *ASME Boiler and Pressure Vessel Code.*

5.2 Pressure Tube to End-Fitting Joints

5.2.1

The requirements of Clause 8 shall be met, except that both Clauses 8.1(c)(i) and (c)(ii) shall apply.

5.2.2

For mechanical joints made by roll expansion, the load required to pull the pressure tube out of the end fitting shall be measured on at least four prototype joints. This pullout load shall exceed three times the design condition axial load, including pressure, when the test is performed at design temperature, or four times if the test is at ambient conditions.

5.2.3

The reduction in wall thickness required to produce joints of adequate strength shall be determined during the prototype tests.

5.3 Pressure Tubes

5.3.1 Material

5.3.1.1

The material for pressure tubes shall be selected from CSA Standard CAN/CSA-N285.6.1.

5.3.1.2
The material properties listed in CSA Standard CAN/CSA-N285.6.7 shall be used in design calculations and shall be supplemented by the following:
(a) the effects of irradiation enhancement of material properties may be included if supported by testing and if incorporated in allowable values using the factors of conservatism given in the rules of the *ASME Boiler and Pressure Vessel Code*, Section 3, Division 1, Appendices 3 and 3-2000;
(b) the effect on ductility and resistance to fatigue shall be used in the design calculations; and
(c) irradiated fatigue curves shall be constructed using the criteria in the *ASME Boiler and Pressure Vessel Code*, Section 3, Division 1, Appendices 3 and 3-2000.

5.3.2 Design

5.3.2.1
The requirements of CSA Standard N285.0, Clause 7, shall apply.

5.3.2.2
The minimum wall thickness assumed in the analyses shall include allowances for internal and external corrosion, thinning due to diametral and axial creep, and wear from fuel movement.

5.3.2.3
Pressure tubes made from zirconium alloys shall be protected against delayed hydride cracking by ensuring that the maximum tensile stress, under design level A (normal) and level B (upset) conditions, plus the maximum initial residual tensile stress, shall at no time exceed 67% of the tensile stress required to initiate delayed hydride cracking as determined in the laboratory by tests on unnotched specimens.

5.3.2.4
Pressure tube material shall be capable of sustaining a subcritical through-wall crack (ie, leak before breaking).

5.3.2.5
A system capable of detecting leaks before through-wall cracks grow to unstable lengths shall be provided.

5.3.2.6
The design and stress analyses shall include the effects of creep deformation. This includes axial creep, diametral creep, and creep-sag of the pressure tubes.

5.3.3 Support

5.3.3.1
Pressure tubes shall be supported such that they will not contact the calandria tube during the life of the channel.

5.3.3.2
The effects of calandria tube sag in relation to other core components shall be considered in the design.

5.3.3.3
Devices used to maintain pressure tube and calandria tube separation shall be shown to be metallurgically compatible with the materials they contact. Such devices shall be designed to remain in their design location for the lifetime of the plant.

5.4 Channel Closure

5.4.1
The channel closures installed on a CANDU reactor shall be locked in place by closure safety locks in accordance with Clause 9.2.

5.4.2
The closure body shall close off the end-fitting bore so that any failure of the seal disc does not result in a loss of coolant in excess of the capacity of the make-up system.

5.4.3
The components of the channel closure that support the flexible seal disc shall be designed, manufactured, and tested to the requirements of Class 1 pressure-retaining components.

5.4.4
Channel closures shall be tested for leakage each time they are installed and prior to removal of the fuelling machine.

5.4.5
The channel closure components shall be designed so that the effects of partial engagement or misalignment do not lead to progressive distortion or failure of the pressure boundary.
Note: *Flexible seal discs act as self-energizing gaskets that flex during installation, operation, and removal.*

6. Calandria Assembly

6.1 Calandria Tube to Tubesheet Rolled Joint

6.1.1
The rules given in Section 3, paragraph ND-3671.2, of the *ASME Boiler and Pressure Vessel Code* shall be used for the design of the calandria tube to tubesheet joint where the calandria is to be registered as a Class 3C component.

6.1.2
The rules given in Section 3, paragraph NC-3671.2, of the *ASME Boiler and Pressure Vessel Code* shall be used for the design of the calandria tube to tubesheet joint where the calandria is to be registered as a Class 2C component and designed to the rules of paragraph NC-3300.

6.1.3
The requirements of Clause 8 of this Standard shall apply to the calandria tube to tubesheet joint where the calandria is to be registered as a Class 1C component, or a Class 2C component designed to the rules of Section 3, paragraph NC-3200, of the *ASME Boiler and Pressure Vessel Code.*

6.2 External Pressure Design of the Calandria Tube

The requirements of CSA Standard N285.0, Clause 7, shall be met, except that in lieu of meeting the requirements of the *ASME Boiler and Pressure Vessel Code*, Section 3, paragraph NC-3133.3, it shall be shown by test or analysis that deformation of the calandria tube onto the pressure tube, due to external pressure under all service conditions, will not cause rupture of the calandria tube.

6.3 Lattice Tube to Calandria Tubesheet Joint

6.3.1

As an alternative to the requirements of Section 3, paragraph NC-4243.2 of the *ASME Boiler and Pressure Vessel Code*, it is permitted to machine hubs onto the calandria tubesheet, provided that the following requirements are met:

(a) tubesheet plate material, after having been rolled to size, heat treated, and descaled, shall be ultrasonically examined over 100% of both sides, in accordance with the requirements of the *ASME Boiler and Pressure Vessel Code*, Section 2, SA-578, and Section 5;

(b) the plates shall be examined by moving the search unit in parallel paths with a 10% minimum overlap; and

(c) a response, at any depth, equal to or greater than that which would be given by a 6.33 mm (0.25 in) diameter flat-bottomed, open-top hole drilled to the same depth shall be cause for rejection and subsequent repair in accordance with the requirements of Section III, paragraph NC-2530, of the *ASME Boiler and Pressure Vessel Code*.

6.3.2

When welding of each lattice tube is complete, the following examinations shall be made:

(a) ultrasonic examination of a 100 mm (3.94 in) wide annulus around each tubesheet bore, in accordance with Clause 6.3.1, except that the examination shall be performed from one side only; and

(b) liquid-penetrant examination of all bores in the calandria tubesheet, in accordance with Section 3, paragraph NC-2546, of the *ASME Boiler and Pressure Vessel Code*.

6.4 Radiography of Lattice Tube to Calandria Tubesheet Welds

6.4.1

As an alternative to the requirements of Section 3, paragraph NC-5254, of the *ASME Boiler and Pressure Vessel Code*, it is permitted to radiograph only a statistical sampling of the lattice tube to calandria tubesheet welded joints, provided that the requirements of Clauses 6.4.2 to 6.4.6 are met.

6.4.2

Only automatic welding (as defined in the *ASME Boiler and Pressure Vessel Code*, Section 9, QW-492) is permitted, except for repair welding. Before commencing production welding, each welding operator shall make three consecutive, acceptable sample joints for each lattice tube to tubesheet joint design, using the geometry, materials, interference fits, procedure, and welding equipment to be used for the production joints. All welds in these sample joints shall be examined in accordance with the requirements for production joints and shall also be fully radiographed.

6.4.3

The lattice tube to calandria tubesheet joints shall be welded in batches. A batch shall consist of a maximum of 10 welded joints made by one welding operator using one automatic welding machine in one day without change in any variable.

6.4.4
The root and final passes of each weld shall be examined by the liquid-penetrant method.

6.4.5
After a welding operator completes a batch of lattice tube to calandria tubesheet welds (see Clause 6.4.3), and before proceeding to the next batch, one joint, selected at random from that batch, shall be 100% radiographed. If the weld is not acceptable, all welds made by that welding operator, after the acceptance weld of the previous batch, shall also be radiographed.

6.4.6
All defective welds shall be repaired, reexamined, and reradiographed.

6.5 Lattice Tube to Fuelling Tubesheet Joint and Alternative Lattice Tube to Calandria Tubesheet Joint
As an alternative to the requirements of Section 3, paragraph NC-3252.4(d), of the *ASME Boiler and Pressure Vessel Code*, partial penetration welds for the lattice tube to tubesheet joint are permitted, provided the following requirements are met:
(a) the joint strength shall be demonstrated by analysis or test to be adequate for imposed service loading;
(b) the tube shall have an interference fit with the tubesheet bore after fabrication is completed; and
(c) the root and final pass of each weld shall be examined by the liquid-penetrant method.

6.6 Lattice Tube Radiography
As an alternative to the requirements of Section 3, paragraph NC-2577.2(a), of the *ASME Boiler and Pressure Vessel Code*, centrifugally cast lattice tubes may be radiographed in a partially machined condition that exceeds 120% of finished thickness prior to installation into the end shields. The penetrameter size shall be based on final machined thickness.

7. Reactivity Control Units

7.1 Control Rod Drive Housings
Control rod drive housings shall meet the requirements of Clause 5 of CSA Standard N285.0. (The requirements of Section 3, paragraph NCA-1271, of the *ASME Boiler and Pressure Vessel Code* are not applicable to CANDU reactors as they are not part of the heat transport system pressure boundary.)

7.2 Liquid Injection Nozzle
The requirements of Clause 8 shall apply to the joint between the injection tube and injection nozzle.

8. Joints Between Tubular Components
Joints, other than welds between metallic tubular components for which requirements are not provided in CSA Standard N285.0, may be used, provided the following requirements are met:
(a) provision shall be made to prevent separation of the joints under all specified service loadings;
(b) the joints shall be accessible for inspection, maintenance and/or removal, and replacement;
(c) either of the following two criteria shall be met:
  (i) prototype joints shall be subjected to performance tests to determine the structural integrity of

the joints under simulated service conditions; all significant design and operating parameters affecting the integrity of the joints shall be included in the qualification tests; or

(ii) joints shall be designed in accordance with the rules of Section 3, paragraph NB-3200, of the *ASME Boiler and Pressure Vessel Code*; and

(d) production joints shall be produced using the same tooling design and procedures that have been qualified in the manufacture of prototype joints; each joint shall be inspected for structural integrity by ensuring that the required parameters determined from the prototypes have been achieved.

9. Fuel-Handling Equipment

9.1 Reinforced Elastomeric Hose Assemblies

9.1.1 General

Elastomeric hose may be used in Class 2 and 3 systems, provided that the requirements of Clause 9.1 are met; however, it should only be used where system function cannot be readily achieved using other acceptable methods.

9.1.2 System Design

9.1.2.1

Elastomeric hose may be used only if a failure will not cause the dose limit for the general public or operating personnel to be exceeded. This may be achieved by combining the hose installation with a reliable quick-acting closing device to stop leakage and to minimize the spread of activity following a hose failure, or by ensuring that personnel are excluded or shielded from the hose operating area and the area is suitable for containing any radioactive fluids lost from the system.

9.1.2.2

The effect of a hose failure on the safe functioning of the process system shall be considered by the process system designer, although operation of the system is beyond the scope of this Standard.

9.1.3 Materials

9.1.3.1

The hose shall be reinforced with either fabric or metal. The materials used shall be compatible with the fluid being conveyed, the service conditions, and the environment.

9.1.3.2

The hose end-fitting material shall conform to CSA Standard N285.0, Clause 8, for the class of the system in which it is installed. Alternatively, the material shall conform to an established material specification (eg, CSA, ASTM, ASME, AMS, SAE, or AISI) as well as supplementary testing for chemical and mechanical properties, etc, such that material properties and a level of control equivalent to that required by ASME are established. The hose assembly manufacturer shall supply documentation for approval by the system designer that specifies all material test requirements and shall furnish a Certificate of Compliance for the materials used.

9.1.4 Design

9.1.4.1
The design of a hose assembly shall be qualified by performing the same tests as required for each production batch of hose, as described in Clause 9.1.5. The tests shall be repeated for each hose size.

9.1.4.2
The hose design specification shall stipulate where additional tests are required to show resistance to oil, ozone, radiation, vacuum, or any substance that may be present and might have a detrimental effect on the life of the hose. Additional tests are not normally required where sufficient knowledge of the material's physical and chemical properties is documented.

9.1.5 Fabrication

9.1.5.1
The fabrication of each hose assembly or bulk hose shall be qualified by performing, as a minimum, the following tests, using the procedures described in ASTM Standard D 380. The results of the tests shall be included in the history docket for the hose assembly. In cases of conflict between the ASTM Standard and the following test requirements, the latter shall govern:
(a) Three sample hose assemblies from each production batch of hose shall be burst tested. The minimum free length of hose in each sample shall be 450 mm (18 in). The pressure shall be increased at a constant rate so as to attain the minimum burst pressure within a period of not less than 15 s nor more than 30 s. There shall be no indication of leakage or hose failure below the required minimum burst pressure of four times the design pressure.
(b) Three sample hose assemblies, with a minimum free length of hose of 300 mm (12 in), from each production batch of hose shall be leak tested as described in SAE Standard J343.
(c) Each hose assembly shall be hydrostatically proof tested to two times its design pressure for a period of not less than 30 s nor more than 60 s. There shall be no indication of leakage or hose failure.
(d) Three sample hose assemblies from each production batch of hose shall be impulse tested as described in SAE Standard J343. Unaged hose assemblies may be used, except where otherwise indicated in the hose design specification. The test fluid circulated through the assemblies shall be at an operating temperature specified in the hose design specification. The assemblies shall withstand the number of cycles specified by the hose design specification without any indication of leakage or hose failure. In the absence of a specified requirement, the assemblies shall withstand a minimum of 100 000 cycles without any indication of leakage or hose failure. The test pressure shall be 125% of the system design pressure.
(e) All hose shall be visually examined for defects and proper identification. In addition, hose assemblies shall be inspected to ensure that the hose end fittings have been properly installed.
(f) Each hose and hose end fitting shall be dimensionally checked in accordance with SAE Standard J343.
(g) Tests to show change in length, flexure, or other such characteristics shall be performed as required by the hose design specification.

9.1.5.2
The hose shall be legibly marked with the manufacturer's name, hose identification number, batch number, and date of manufacture. The markings shall be repeated at intervals not greater than 450 mm (18 in).

9.1.6 Hose Replacement

9.1.6.1

Elastomeric hose assemblies have a finite life. The process system designer, therefore, shall provide a hose replacement schedule for the system operator. An example of a hose replacement schedule is provided in SAE Standard AS1933. The process system designer shall take into consideration the following:

(a) the hose manufacturer's recommendations for installation, operation, and hose replacement;

(b) previous experience with the hose in similar applications;

(c) that hose life can be considerably reduced by flexing the hose to less than the minimum bend radius, twisting the hose, kinking, rubbing, or crushing the hose, and subjecting the hose to high temperature or high pressure surges; and

(d) that reusable hose end fittings have limited remake capabilities.

9.1.6.2

The operator of the process system in which the hose is used shall replace the hose assemblies as recommended by the process system designer until in-service experience indicates that the hose life is other than expected. At that time the hose replacement schedule shall be changed to ensure that all hose assemblies will be replaced before failure.

9.1.6.3

Hoses assembled into hose assemblies by the operator (ie, by attachment of new or existing end fittings to lengths of hose) shall be inspected and pressure tested in accordance with Clause 9.1.5.1(c) and (e) before being used in-service.

9.1.6.4

Elastomeric hose assemblies have a limited shelf life. The process system designer shall specify the storage conditions and shelf life of new and spare hose assemblies in a way similar to that for new hoses (see Clause 9.1.6.1).

9.2 Reactor Fuel Channel Closure Safety Lock

9.2.1 General

For reactor systems in which on-power fuelling is used, a safety lock shall be provided on each channel closure to prevent it from being unintentionally released from a fuel channel.

9.2.2 Materials

The materials used for the safety lock shall conform to an established material specification (eg, CSA, AISI, ASM, ASTM, ASME, or SAE) and shall be determined by the system designer to be adequate for the conditions. A material test report shall be required for the materials used. In addition, for any portion of the safety lock that performs a pressure-retaining or pressure boundary support function, the additional material requirement of the applicable code class shall apply.

9.2.3 Design

9.2.3.1

The safety lock shall be designed within the allowable stress values established by the *ASME Boiler and Pressure Vessel Code*, Section 2, Part D, Appendix 1.

9.2.3.2
The safety lock shall be a positive mechanical locking device. Frictional-type locking devices shall not be permitted.

9.2.4 Examination
The load-carrying members shall be examined by either the magnetic-particle or the liquid-penetrant method in accordance with the *ASME Boiler and Pressure Vessel Code*, Section 5, except for sizes which are normally exempt from such tests in the *ASME Boiler and Pressure Vessel Code*, Section 3, Subsection NB. The acceptance standards those given in the *ASME Boiler and Pressure Vessel Code*, Section 3, paragraphs NB-5340 and NB-5350.

9.3 Fuelling Machine to Channel Coupling Interlocks

9.3.1 General
For reactor systems where on-power fuelling is used, two independent and diverse interlocks shall be provided to prevent uncoupling of a fuelling machine from a reactor fuel channel when the channel closure is removed. The diversity of the interlocks shall not preclude the use of similar pressure-sensing technology for both interlocks. The two interlocks used when the reactor is operating at normal on-power pressures may be different from the two interlocks used at low or shutdown pressures.
Note: *The term "diverse" is used here to mean different in nature (eg, hardwired, software, mechanical interlocks).*

9.3.2 Materials
The materials for a mechanical locking device shall conform to an established material specification (eg, CSA, AISI, SAE, ASME, ASTM, or ASM) and shall be determined by the system designer to be adequate for the conditions. A material test report certifying the chemical and mechanical properties of the material used shall be required. In addition, for any portion of an interlock that performs a pressure-retaining or pressure-retaining support function, the material requirements of CSA Standard N285.0 shall apply.

9.3.3 Design

9.3.3.1
When the fuelling machine is coupled to a reactor fuel channel at normal on-power pressures, one of the two interlocks shall be a positive mechanical locking device that is actuated by reactor pressure while the fuelling machine is open to the fuel channel. At other pressures, a mechanical interlock shall not be required. A locking device that depends on friction shall not be acceptable.

9.3.3.2
The allowable stress values and the method of analysis for pressure-retaining components and their supports in the interlock system shall conform with the requirements for the applicable code class. Other load-carrying members shall be designed using allowable stress values not greater than those in Section 2, Part D, Appendix 1, of the *ASME Boiler and Pressure Vessel Code.*

9.3.3.3
The interlocks shall be engaged prior to removal of the channel closure and shall remain engaged until the channel closure has been inserted and secured. A mechanical connection between the interlocks and the closure securing mechanism shall not be required.

9.3.4 Examination

Pressure-retaining components and their supports in the interlock system shall be examined in accordance with the requirements of CSA Standard N285.0. All accessible surfaces of other load-carrying components shall be examined by either the magnetic-particle or the liquid-penetrant method in accordance with the *ASME Boiler and Pressure Vessel Code*, Section 5. The acceptance standards shall be those given in the *ASME Boiler and Pressure Vessel Code*, Section 3, paragraphs NB-2545, NB-2546, NB-5340, and NB-5350.

9.3.5 Testing

9.3.5.1

To ensure operability, the mechanical locking device shall be tested both during commissioning and after maintenance, which could affect interlock operation. The test shall include a deliberate attempt to unclamp the fuelling machine, using the maximum force available during normal operation. It shall be performed on a test channel at normal on-power pressures and/or shutdown pressures as appropriate.

9.3.5.2

Hardwired and software interlocks shall be tested for proper operation during commissioning and after any changes or repair of interlock components or any changes to the control system interlock logic.

9.4 Fuelling Machine Supports

9.4.1 General

Fuelling machine supports for on-power fuelling systems may include features that provide for mobility of the components of the support assembly. Such support systems are usually composed of structural supporting elements and mechanisms. They shall be acceptable when the requirements of Clauses 9.4.2 to 9.4.5 inclusive are met.

9.4.2 Classification

The code class of a fuelling machine support (Class 1C, 2C, or 3C) shall be determined by the class of service performed by the fuelling machine while the support is providing support.

9.4.3 Structural Supporting Elements

Structural supporting elements shall meet the requirements of Clause 14 of CSA Standard N285.0. Materials specified in CSA Standard CAN/CSA-N285.6 shall be acceptable.

9.4.4 Mechanisms

Mechanisms that produce or control motions and carry support loads, whose failure would result in a loss of support, shall meet the following requirements:

(a) a stress analysis, experimental stress analysis, or load rating, similar to that required in the *ASME Boiler and Pressure Vessel Code*, Section 3, paragraph NF-3140, shall be required to show that the stresses resulting from the applied loadings satisfy the limits of the requirements of paragraphs NF-3200 and NF-3300;

(b) for materials not conforming to the requirements of paragraph NF-2000 of the *ASME Boiler and Pressure Vessel Code*, Section 3, or CSA Standard CAN/CSA-N285.6, allowable stresses shall be based on the rules of the *ASME Boiler and Pressure Vessel Code*, Section 3, Appendix 3, paragraph 3210; and

(c) mechanisms shall be equipped with controls and interlocks to prevent motion of the support that could result in overstressing a pressure-retaining component or its support. Means shall be provided to verify the operation of controls and interlocks.

9.4.5 Documentation

A design specification, a design report, and a product specification for the complete fuelling machine support system shall be provided. The design report shall contain the fuelling machine support stress analysis or load rating, and the mechanism stress analysis required by Clause 9.4.4. In addition, a complete description of the controls and interlocks, installed to prevent overstressing of the pressure boundary or its support, shall be included.

9.5 Fuelling Machine Threaded Process and Instrumentation Connections

Threaded connections to Fuelling Machine Class 1 vessel walls may be used provided they meet the following requirements:

(a) The thread shall be either
  (i) a straight thread 1-5/16 in outside diameter or less; or
  (ii) a tapered pipe thread NPS 1/2 in or less.

(b) The applicable requirements of paragraph NC-3671.3 of the *ASME Boiler and Pressure Vessel Code,* Section 3, shall be satisfied. Connections using a straight O-ring boss in accordance with the SAE J1926 Standards may be used, providing these have been shown to be suitable for the specified service conditions. The basis for establishing the adequacy of the seal shall be included in the design report. Seal welds shall not be used.

(c) Threaded connections shall be accessible for inspection and maintenance.

(d) The reinforcement in the vessel wall shall be integral with the portion of the vessel penetrated. The dimensions of the reinforcement shall be established in accordance with paragraph NB-3300 of the *ASME Boiler and Pressure Vessel Code,* Section 3. The opening diameter, "d", shall be equal to the major diameter of a straight thread, or the outside pipe diameter for a tapered pipe thread.

(e) All other applicable requirements of Subsection NB of the *ASME Boiler and Pressure Vessel Code,* Section 3, shall be met.

Proposition de modification

N'hésitez pas à nous faire part de vos suggestions et de vos commentaires. Prière d'utiliser le formulaire qui suit pour formuler les propositions de modification aux normes CSA et autres publications CSA. Il est recommandé d'inclure

- le numéro de la norme/publication
- le numéro de l'article, du tableau ou de la figure visé
- la formulation proposée
- la raison de cette modification.

Proposal for change

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