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**CSA N290.16:16**
*(reaffirmed 2021)*

# Requirements for beyond design basis accidents

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# ***Requirements for beyond design basis accidents***

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# Contents



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# Preface

This is the first edition of CSA N290.16, *Requirements for beyond design basis accidents*.

This Standard provides requirements regarding beyond design basis accidents (BDBAs) at water-cooled nuclear reactor facilities. It incorporates work done by operators of Canadian nuclear reactor facilities, the Canadian Nuclear Safety Commission, and the International Atomic Energy Agency to define the requirements for BDBAs, and also reflects guidance from various industry organizations, including the CANDU Owners Group, the Nuclear Energy Institute, and the World Association of Nuclear Operators.

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 Standards provide 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 was prepared by the Technical Committee on Reactor Safety and Risk Management, under the jurisdiction of 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.*

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# *CSA N290.16:16*
# *Requirements for beyond design basis accidents*

## 0 Introduction

### 0.1 Background

This Standard was developed to reflect Canadian regulatory requirements and industry practice established to prevent and mitigate beyond design basis accidents (BDBAs) and applies to both existing and new reactor facilities post-Fukushima.

**Notes:**

1) *"Reactor facilities" refers to small reactors and nuclear power plants.*
2) *"Existing reactor facilities" refers to reactor facilities initially licensed for operation before 2016.*
3) *"New reactor facilities" refers to reactor facilities initially licensed for operation after 2015.*
4) *The requirements for new reactor facilities and existing reactor facilities might differ. Where requirements differ in this Standard, the difference is explicitly stated.*
5) *Compliance with this Standard for existing reactor facilities will depend on the reactor facility's operating licence and regulatory commitments.*

### 0.2 Context of the use of terminology

#### 0.2.1 General

The term "beyond design basis accident" (BDBA) envelopes a spectrum of accidents more severe than design basis accidents and includes

a) design extension condition (DEC) (see Clause 3);
b) severe accidents (see Clause 3); and
c) practically eliminated conditions (see Clause 3).

**Note:** *This Standard focuses on*

a) *the identification of DECs and the development of complementary design features; and*
b) *the development of emergency response and accident management strategies to address BDBAs and support practical elimination of public risk related to BDBAs.*

#### 0.2.2 Reactor state

See Figure 1 for an overview of reactor states, including accident conditions.

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**Figure 1**
**Overview of reactor states**
(See Clauses 0.2.2 and 4.2.1.)

<table>
<tr><td colspan="2">Operational states</td><td colspan="3">Accident conditions</td></tr>
<tr><td rowspan="3">Normal operation</td><td rowspan="3">Anticipated operational occurrences</td><td rowspan="3">Design-basis accidents</td><td colspan="2">Beyond-design-basis accidents</td></tr>
<tr><td>Design-extension conditions</td><td>Practically eliminated conditions</td></tr>
<tr><td>No severe fuel degradation</td><td>Severe accidents</td></tr>
<tr><td colspan="3">Design basis</td><td>Design extension</td><td>Not considered as design extension</td></tr>
<tr><td colspan="5">Reducing frequency of occurrence →</td></tr>
</table>

**Note:** *This Figure is reproduced from CNSC REGDOC-2.5.2.*

### 0.2.3 Use of BDBA and DEC terminology

In this Standard, the terminology described in Clause 0.2.1 is used as follows:

a) The term "DEC" (including conditions arising from some severe accidents) is used only for provisions related to upfront activities such as design, planning, and procurement that apply specifically to these reactor states.
b) The term "BDBA" is used for general provisions, such as those presented in Clause 7.

### 0.2.4 Design features and complementary design features

The following distinction between design features and complementary design features is used in this Standard:

a) Design features (see Clause 3) are developed as part of the design basis.
b) Complementary design features (see Clause 3) are developed to cope with DECs.

**Note:** *"Emergency mitigating equipment" (EME) is part of complementary design features, since EME functionality is typically determined by DECs.*

**Note:** *Design and analysis rules for design features are conservative and provide high confidence in the outcome of the design or analysis activity. Design and analysis rules for complementary design features are best estimate and provide reasonable confidence in the outcome of the design or analysis activity.*

### 0.2.5 Containment

Where the term "containment" is used in this Standard, it refers to both containment systems applicable to large nuclear reactors and to containment or confinement systems used for small reactors.

### 0.3 Graded approach

A graded approach, commensurate with risk, may be defined and used when applying the requirements and guidance contained in this Standard.

**Note:** *CSA N286 provides direction with respect to a graded approach.*

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### 0.4 Reactor technology context

This Standard reflects the operating experience of the Canadian nuclear industry, which uses CANDU® reactor technology, but is written to be technology-neutral (that is, to apply to all water-cooled reactor facilities).

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## 1 Scope

### 1.1

This Standard provides requirements and guidance regarding beyond design basis accidents (BDBAs) at existing and new water-cooled reactor facilities with the fundamental objective of protecting the public and environment from the harmful effects of ionizing radiation. This includes

a) determination of the functional DEC requirements for the structures, systems, and components (SSCs) that prevent and mitigate BDBAs, including severe accidents;

   **Note:** *This also includes guidance related to reliability, inspections, and operations considerations.*

b) development of strategies to mitigate or terminate, or both, BDBAs, including severe accidents; and

c) management of BDBAs within and beyond site boundary.

**Note:** *The prevention of long-lived radionuclide releases following a BDBA is the single most important objective for protecting the public and the environment. Thus, a focus on maintaining the barriers to ionizing radioactive releases is essential.*

### 1.2

This Standard also provides guidance on the use of safety analyses (e.g., deterministic safety analysis and probabilistic safety assessment) and operational experience (OPEX).

### 1.3

This Standard applies to water-cooled reactor facilities. It does not apply to other nuclear facilities.

### 1.4

This Standard does not specifically address accidents caused by malevolent acts; however, the requirements and guidance in this Standard could provide useful information in developing strategies in this area.

**Note:** *In Canada, malevolent acts are dealt with separately under the CNSC* Nuclear Security Regulations*.*

### 1.5

This Standard does not provide specific guidance related to the safety classification of SSCs developed and implemented to address DECs (see Clause 0.2) since this is a developing area of industry work. This Standard does provide guidance related to procurement, redundancy, testing, maintenance, and other operational activities for SSCs providing DEC and BDBA mitigation.

### 1.6

In this Standard, “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; and “may” is used to express an option or that which is permissible within the limits of the standard.

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