CANADIAN REGULATORY APPROACH TO ENHANCEMENT OF THE ‘PASSIVE’ SAFETY CONCEPT

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Outline

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Established May 2000, under the Nuclear Safety and Control Act

Replaced the AECB, established in 1946, Atomic Energy Control Act

Canada’s Independent Nuclear Regulator - 71 Years Of Experience
CNSC Regulates All Nuclear-Related Facilities and Activities

- Nuclear power plants
- Small reactors
- Uranium mines and mills
- Uranium fuel fabricators and processing
- Waste management facilities
- Industrial and medical applications
- Nuclear research
- Export/import control
Introduction

• CNSC staff reviewed and compared the use of the passive concept in regulatory requirements and guidelines published by international organizations and some national nuclear regulators
Passive Concept

- The term ‘passive’ describes a particular strategy used in assuring an improved degree of safety of a reactor design.

- Application of a ‘passive’ safety concept varies from country to country, among vendors, regulators, or across specific nuclear applications.
REGDOC 3.6, *Glossary of CNSC Terminology*, refers to the following passive items in the current CNSC regulatory framework:

- Passive components, systems, buildings, vessels
- Passive engineered (nuclear) criticality safety control
- Passive measures
- Passive control (e.g. institutional or engineered control)
- Passive fire protection means
IAEA Safety Glossary defines the following passive items in the current IAEA framework:

- Passive components, systems, elements
- Passive measures (for institutional control)
- Passively safe (for end state)
IAEA documents refer to:

- Four categories of passive (A, B, C, D) with corresponding characteristics
- Concept and degrees of passivity
- Concepts of active and passive safety
- Passive fuel load
- Passive component and system
- Passive response
- Passive safety design

- Passive operation
- Passive processes
- Passive safety characteristics
- Passively triggered
- Passive observation and confirmation
- Passive failure
Passive Concept - International Context (WENRA)

Western European Nuclear Regulators Association (WENRA) refers to:

- Failure of a passive component
- Passive safety functions
- Passive provisions
- Means of passive safety features
- Passive means
- Passive components
European Utility Requirements (EUR) distinguish:

- Passive component - function requires only structural integrity
- Passive equipment - function requires only structural integrity but there are several degrees of passivity

Passive Safety Features consist of Passive Systems or Passive Equipment - these perform passive safety functions
US NRC considers:

- Adjusting emergency planning zones for advanced reactors with passive design safety features
- Age-related degradation on the performance of structures and components of passive safety systems

Korea’s KINS considers:

- Aging management programs for the long-lived passive components
Russian Federation *Gostechnadzor* distinguishes:

- Passive systems with mechanical moving parts (e.g. check valves)
- Passive systems without mechanical moving parts (e.g. pipelines, vessels)

French IRSN defined:

- Main characteristics of passive safety systems
- Main difficulties associated with assessing the performance and reliability of passive safety systems
The United Kingdom Office for Nuclear Regulation (ONR):
• Defines the difference between inherent safety and passive safety
• System PSA models should include passive component failures
• Reliability of passive features or passive systems should be assessed and confirmed by testing

Finnish Radiation and Nuclear Safety Authority (STUK):
• Requires defining a design basis passive failure
• A passive failure can be completely ignored if its probability can be demonstrated as sufficiently low
Current CNSC regulatory framework does not include explicit requirements or expectations with respect to the passive concept in NPP design.

Passive concept appears in grading of requirements, e.g., Single Failure Criterion principle can be excluded for passive SSCs.

CNSC experience shows that vendors develop their own approach to passive systems design and credit it in safety analysis.

In 2015 CNSC initiated a project on establishing a comprehensive approach to the passive concept with the objective of developing consistent passive design regulatory requirements.
Possible Improvements

The following terms have been identified throughout literature as virtually synonymous:

- Passive safety, passive provisions, passive means, passive function, passive design, passive layer, passive principle, passive System, Structure, Component (SSC)
Possible Improvements

New definitions and guidance have been developed on:

- Passive barrier
- Passive conditions
- Categories of passivity
- Passive end state
- Passive failures
Possible Improvements – Definitions

Passive barrier:
• A physical barrier which uses passive means (SSC, phenomena) only

Passive conditions:
• Conditions of SSCs at defined plant states for which passive action is available as designed

Example:
✓ reactor is critical or subcritical,
✓ PHT is hot or cold etc.
✓ state of containment, e.g., locked airkocks
✓ SSC seismically qualified
Possible Improvements – Definitions

Adoption of categories A, B, C, and D of passivity similar to the IAEA is proposed:

• As per IAEA TECH DOC 626, transition from fully passive to fully active components/systems is defined as:

  A: 1+2+3+4  
  B: 2+3+4  
  C: 3+4  
  D: 4

  1. no moving working fluid  
  2. no moving mechanical part  
  3. no signal inputs of ‘intelligence’  
  4. no external power input or forces
Possible Improvements – Definitions

Passive end state:
• A safe and controlled state of nuclear facility or substance when all required safety functions are performed by passive SSC (categories from A to D)

Passive failure:
• Loss of integrity of a component or structure or the blockage of the flow path of a process
• Passive failure shall refer to a failure mode that can be treated as an operational deficiency

Note: passive failure and failure of passive SSC (loss of passive function) are different concepts
Possible Improvements – Passive Failure

• Passive failures are characterized in general by material failure or long-term degradation

• A passive failure relates to both reliability and availability of both passive and active SSCs

• Passive component failures should be included in the system reliability models since they can lead to the failure of passive SSCs

• Therefore, passive SSCs have limited reliability and capability and may fail or be insufficient under certain conditions
Possible Improvements – Definitions

- Passive System, Structure, Component (SSC):
  - passive component - a component of one of Passive Categories A, B, C or D
  - passive system – a system built of Passive Category A, B, C or D components
  - passive system category - determined by lowest category component in the context of the intended safety function

Note: passive containment system is built of passive SSCs of cat. A, B, C or D; the structural elements are inherently passive

Guidance has been developed on:
- Passive administrative control – no definition required – generally not considered passive
- Passive phenomenon – no generic definition required – define driving phenomena case-by-case
- Inherent safety – needs work– currently means that ‘harm cannot happen’
Possible Improvements – Inherent Safety

The term “inherent safety” is widely used by regulators - consideration should be given to the merits of:

• possible “levels” of “inherent safety”
• existence of “inherent hazards” as opposed to “inherent safety”
• regulatory requirements for design dependent on the “levels” of “inherent” features
Steps to consolidate the risk-informed approach to the passive concept:

- International cooperation for developing more systematic and consistent approach, e.g., IAEA, NEA, WENRA Reactor Harmonisation WG (RHWG), MDEP WG or other international organizations fora
- Development of requirements and guidance for the application of passive concept based on the international approaches and best practices
Path Forward

The proposed path forward is the development of:

• Accepted passive design rules and passive safety analysis methodology

• Examples and guidance for application of passive safety concept to various design solutions, including:
  ✓ specific SSC for large NPPs
  ✓ SMRs as integrated facilities or with integrated reactor design
  ✓ research reactors with “zero” power
  ✓ quality requirements for passive SSCs
Conclusions

In Canada the following activities are needed:

• Finalize draft definitions and guidance
• Review and develop potential amendments to the identified CNSC documents
• Interface and cooperate internationally on consistent approach to passive design principles

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Conclusions

• The current international regulatory framework needs improvements with respect to the rigorous interpretation of the application of passive and inherent safety concept and its impact on safety assessment.
Thank You!