Canadian Nuclear Safety Commission: Licensing Process in Canada

SAMOSAFER (Simulation Models and Safety Assessment for Fluid-fuel Energy Reactors)

Final meeting & Exploitation workshop

November 29, 2023

Sean Belyea

Our Mandate

- Regulate the use of nuclear energy and materials to protect health, safety, security and the environment

- Implement Canada's international commitments on the peaceful use of nuclear energy

- Disseminate objective scientific, technical and regulatory information to the public

OVER 75 YEARS OF REGULATORY EXPERIENCE

INDEPENDENT COMMISSION

Transparent, science-based decision making

- Quasi-judicial administrative tribunal
- Agent of the Crown (duty to consult)
- Reports to Parliament through Minister of Natural Resources
- Commission members are independent and part time
- Commission hearings are public and Webcast
- Decisions are reviewable by Federal Court

THE CNSC REGULATES ALL NUCLEAR FACILITIES AND ACTIVITIES IN CANADA…

- Uranium mines and mills
- Uranium fuel fabrication and processing
- Nuclear power plants
- Nuclear substance processing
- Industrial and medical applications
- Nuclear research and educational activities
- Transportation of nuclear substances
- Nuclear security and safeguards
- Import and export controls
- Waste management facilities

… over the entire Lifecycle

Licensing Process

Basis of a Licensing Decision by the Commission

No licence may be issued, renewed, amended or replaced unless, in the opinion of the Commission, the applicant:

(a) is qualified to carry on the activity that the licence will authorize the licensee to carry on; and

(b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

- **Section 24(4) of the *Nuclear Safety and Control Act* (NSCA)**

Applicant must make a case supported by evidence.

The regulatory framework establishes the basis for what a case is expected to consider.

Regulatory Decision-Making

Decisions made by the Commission take into consideration:

- Regulatory requirements
- Analyses and recommendations from CNSC staff, based on their assessment of both licensee and stakeholder submissions to the Commission
- Best available information, arising from regulatory research or credible research by third parties
- Public input, through the hearing process

Understanding risks and mitigating those risks play a significant role in the decision-making process

Pre-licensing Engagement and Licensing Process Overview

Pre-licensing engagement (Optional)
No regulatory decision making

Potential applicant

Determine appropriate application assessment strategy

Prepare application and submissions

Vendor design review

Vendor leverages VDR results in discussions with potential applicant

- **Feedback for reactor vendor(s)**
- **REGDOC-3.5.4, *Pre-licensing Review of a Vendor's Reactor Design***

Potential Impact Assessment

Licensing Process

Transparent regulatory decision making

Site preparation licence — REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities*

Construction licence — REGDOC 1.1.2, *Licence Application Guide: Guide to Construct a Reactor Facility* (under revision)

Operation licence — REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*

Decommissioning licence — REGDOC-2.11.2, *Decommissioning*

REGDOC-1.1.5, *Supplemental Information for Small Modular Reactor Proponents*

Safety and Control Areas

Management

- Management Systems
- Human Performance Management
- Operating Performance

Facility and Equipment

- Safety Analysis
- Physical Design
- Fitness for Service

Core Control Processes

- Radiation Protection
- Conventional Health and Safety
- Environmental Protection
- Emergency Management and Fire Protection
- Waste Management
- Security
- Safeguards
- Packaging and Transport

Graded Approach

Graded Approach

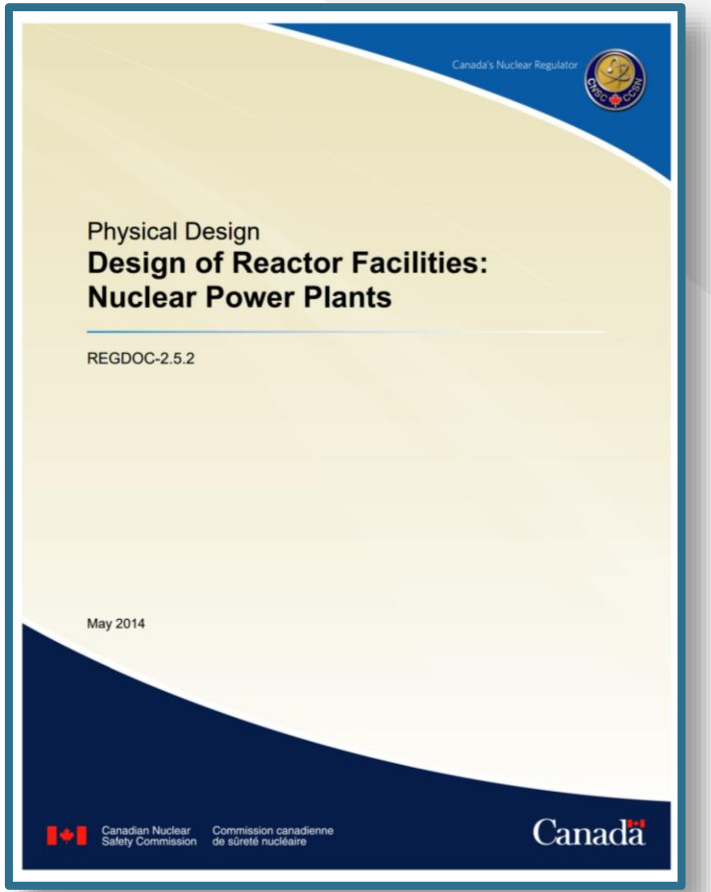
REGDOC 3.6, *Glossary of CNSC Terminology* defines graded approach as:

> *"A method or process by which elements such as the level of analysis, the depth of documentation and the scope of actions necessary to comply with requirements are commensurate with:*
>
> – *the relative risks to health, safety, security, the environment and the implementation of international obligations to which Canada has agreed*
>
> – *the particular characteristics of a nuclear facility or licensed activity"*

The Graded Approach can be considered to be a collection of tools for conducting risk informed decision making under different situations. It ensures the stringency of safety measures are commensurate with the level of risk.

Key Principles used by CNSC staff to Address Novel Features & Approaches

- Fundamental safety objectives must be met
- Safety margins must be identified and maintained
- Credible scientific information should be leveraged to the extent practicable



Non-Nuclear Example - Seat Belts

Fundamental Safety Objective: *"Restrain occupants to manage collision energy and mitigate injuries"*

Racing Car – Professional Driver

- Different technical standards for: Restraint material and manufacturing requirements
- Testing and qualification requirements
- Driver training and qualification requirements

Passenger Car – Qualified Driver

Both result in an acceptable level of protection appropriate to the risks presented if the vehicle is driven within an acceptable operating envelope

But if the operator operates outside of the normal operating envelope?

- Increased uncertainties in performance of safety provisions
  - Some may no longer be effective
- Higher risk of unacceptable consequences

Courtesy: Insurance Institute for Highway Safety, IIHS.org

A poor driver can (un)consciously defeat safety provisions
This is why regulators place significant focus on conduct of activities <u>in addition</u> to technical provisions

Safety and Control Measures: commensurate with uncertainties

Prototypical experiments	To collect specific scientific/ engineering information on (proof of concept)	Low state of proven-ness – risks and uncertainties are higher – additional safety & control measures needed
Demonstration reactor / First-of-a Kind	Demonstration of integrated components / systems and collection of OPEX to refine design for nth of a kind	Varying amounts of OPEX – proving in progress- varying risks and uncertainties to be addressed – some additional safety & control measures needed where uncertainties are high
Nth-of-a-Kind	Commercial operation – information used to improve operational performance	High state of proven-ness – uncertainties generally well understood and ongoing R&D supports management of uncertainties

‘Proven’ is both technical and process-driven

"Proven-ness" impacts use of Graded Approach

- What supporting information is needed to support a proposal that specific requirements have been met?
  - Is the information (e.g. operating experience) relevant to this specific case? How much?
  - Is the information quality-assured? (i.e. the older the information, the more challenging it is to prove this)
  - Has another regulatory body analyzed and accepted the information
- If existing guidance in a REGDOC is not useful in the specific case then more judgement is needed by all parties to decide what is needed to support the proposal

How are safety margins demonstrated to be adequate to defend a conclusion of "no unreasonable risk" to the public?

Characteristics of Suitable Information

- Facts and data derived through validated and quality assured (i.e., traceable and repeatable) scientific and engineering processes, such as:
  - experimental or field-derived data
  - operating experience
  - computer modelling
- Uncertainties have been characterized and accounted for
- Information is demonstrated to be relevant to the specific proposal

The greater the uncertainty or safety significance, the greater the burden of evidence needed to support a proposal

Using Industry Standards

- Standards represent proven practices that are supported by:
  - accumulated experience
  - results of research and development activities
  - knowledgeable users
- CNSC regulatory documents may reference certain standards that are generally used in Canada but does not prescribe their use
- Applicants are responsible for selecting and justifying the practices they use
  - Standards may have constraints on applicability
  - Gaps in practices need to be addressed with suitable information

Challenges for Licensing Molten salt reactors

Licensing challenges for Molten Salt

- Heavy reliance on “inherent” negative reactivity
  - Provenness for first of a kind (FOAK) designs will be limited
- Provenness of modelling calculations
  - Modelling calculations need to consider items such as:
    - Full operating spectrum of reactor for normal operation and accident conditions
    - Reactor life – including the effects of aging
    - Thermal expansion of core structures
    - Molten salt pressure and volume changes
    - Xenon behavior
- Fuel damage criteria need to be defined
  - Systems to detect fuel damage then need to be designed and implemented

Licensing challenges for Molten Salt

- Understanding long term fuel waste storage
  - Details on long term storage and handling of spent fuel will be needed
  - System(s) used for detecting degraded fuel will be needed
  - Information will be needed final waste storage state – focusing on long term stability

- Understanding the effects of corrosion from molten salt

- Understanding Fire mitigation when molten salt is involved

Summary

- Current Regulatory framework in Canada is ready to regulate SMRs – including those utilizing molten salt technology
  - Graded approach will be needed
  - Provenness of R&D data is key
  - Engineering judgement will be needed
  - Compensation for unkowns or less proven data will be needed – especially for (FOAK) designs, which can include things such as:
    - Extra safety margin in design
    - Extra means of shutdown or reactor control margins
    - Extra heat removal capacity
    - Operational limits until operational experience is gained.

JOIN THE CONVERSATION

nuclearsafety.gc.ca

Appendix (Extra Slides)

Pre-Licensing Process

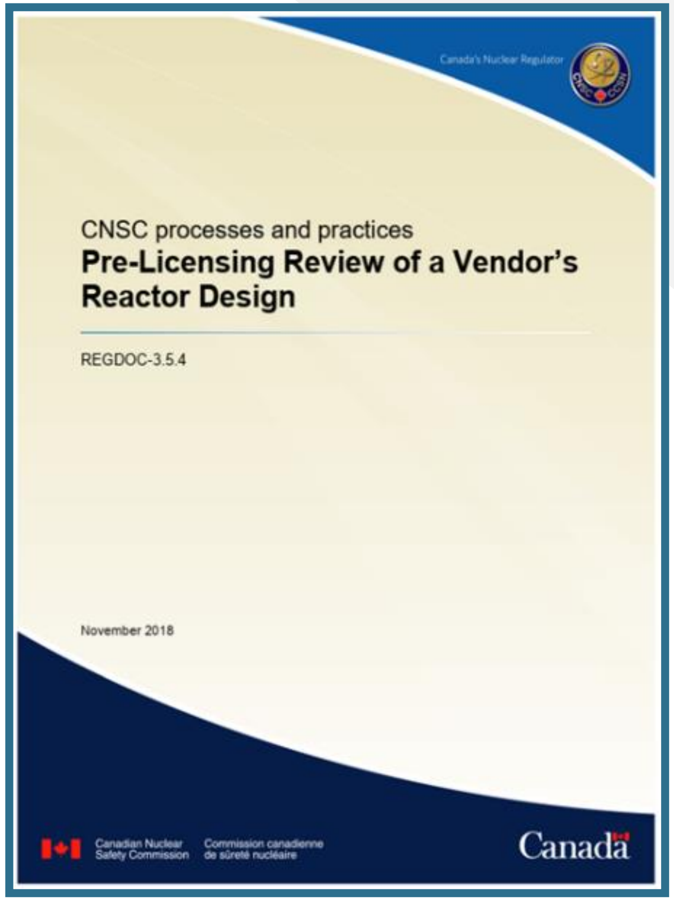
Vendor Design Review Purpose

Opportunity for vendors

- Verify understanding of Canadian requirements
- Obtain early feedback from CNSC staff
  - Canadian requirements for design and safety analysis are being addressed
  - Novel design features and approaches are being demonstrated

Opportunity for CNSC staff

- Develop an understanding of both the vendor and its design concept
- Anticipate regulatory challenges before a licensing process is triggered


CNSC processes and practices
Pre-Licensing Review of a Vendor's Reactor Design
REGDOC-3.5.4
November 2018
Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire
Canada

Vendor Design Review Process

VDRs are carried out in 3 phases:

- ***Phase 1***: whether the vendor's design and management system complies with the Canadian regulatory requirements
- ***Phase 2***: whether fundamental barriers to licensing exist, and whether any major, generic safety issues exist with the design
- ***Phase 3***: provide the vendor the opportunity to follow-up with specific focus areas with more scrutiny by the regulator

Provides information that can be leveraged to inform licensing for a specific project – it is neither a design certification nor a licence.

No regulatory decisions are made

VDR Focus Areas – Design and Safety Analysis Centric

1	General plant description, defence in depth, safety goals and objectives, dose acceptance criteria	**11**	Pressure boundary design
2	Classification of structures systems, and components	**12**	Fire Protection
3	Reactor core nuclear design	**13**	Radiation Protection
4	Fuel design and qualification	**14**	Out-of-Core Criticality
5	Control system and facilities	**15**	Robustness, safeguards and security
6	Means of reactor shutdown	**16**	Vendor research and development program
7	Emergency core cooling and emergency heat removal systems	**17**	Management system of design process and quality assurance in design and safety analysis
8	Containment /confinement and safety-important civil structures	**18**	Human factors
9	Mitigation of Design Extension Conditions	**19**	Incorporation of decommissioning in design considerations
10	Safety analysis (PSA, DSA, hazards)		

How VDRs Inform CNSC Workforce Readiness

Extensive knowledge and skills exist in the CNSC

- Expert skills grounded in scientific and engineering fundamentals gained through education and experience
- Can generally be applied to any technology

Technology Reviews under the CNSC VDR Program

- Expose staff to cutting edge technological issues and
- Exercise the use of our regulatory requirements and guidance

VDRs also allow for early engagement with other regulators looking at the same designs

VENDOR DESIGN REVIEWS

Vendor	Design	MWe	Phase	Review start date	Status
Terrestrial Energy Inc.	Integral Molten Salt Reactor	200	Phase 1	April 2016	Complete
			Phase 2	December 2018	Complete
Ultra Safe Nuclear Corporation	MMR-5 and MMR-10 high-temperature gas	5-10	Phase 1	December 2026	Complete
			Phase 2	June 2021	Assessment in Progress
ARC Nuclear Canada	ARC-100 Liquid Sodium	100	Phase 1	September 2017	Complete
			Phase 2	February 2022	Assessment in Progress
Moltex Energy	Moltex Energy Stable Salt Reactor molten salt	300	Phase 1 & 2 combined	December 2017	Phase 1 Complete
SMR, LLC (Holtec International Company)	SMT-160 Pressurized Light Water	160	Phase 1	July 2028	Complete
GE-Hitachi Nuclear Energy	BWRX-300 Boiling water reactor	300	Phase 2	January 2020	Complete
X Energy, LLC	Xe-100 High-temperature gas	80	Phase 2	July 2020	Assessment in Progress
Westinghouse Electric Company, LLC	eVinci Micro Reactor Solid core and heat pipes	Up to 5 Mwe	Phase 1 & 2 combined	June 2023	Assessment in Progress