Application of the CNSC Risk-Informed Decision-Making Process in Nuclear Power Regulation: An Example

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Abstract

This paper provides an overview of the CNSC risk-informed decision-making (RIDM) process, as well as an example of its use in a licensing application in power reactor regulation.

The CNSC developed the RIDM process as a tool for:

- ensuring that all risks are identified and considered for making decisions,
- ensuring that interests of affected stakeholders are considered,
- enabling the decision-makers to make easier-to-explain, and better justified, decisions,
- providing a standardized set of terms to describe risk issues contributing to better communication, and
- providing an explicit treatment of uncertainty.

The risk management process follows a set of steps, initiated by a decision to be made that could affect a regulatory objective. The problem is identified, a team is established, and risks are determined by identifying and analyzing hazards, evaluating the risks involved to determine the their level and the risk control measures to reduce the levels of risk. The options are then presented to the decision-maker and action is taken; monitoring the impact/effectiveness of the risk control measures concludes the process.

The CNSC's approach is consistent with practices of other nuclear regulatory bodies which factor risk into their decision-making process.

1. Introduction

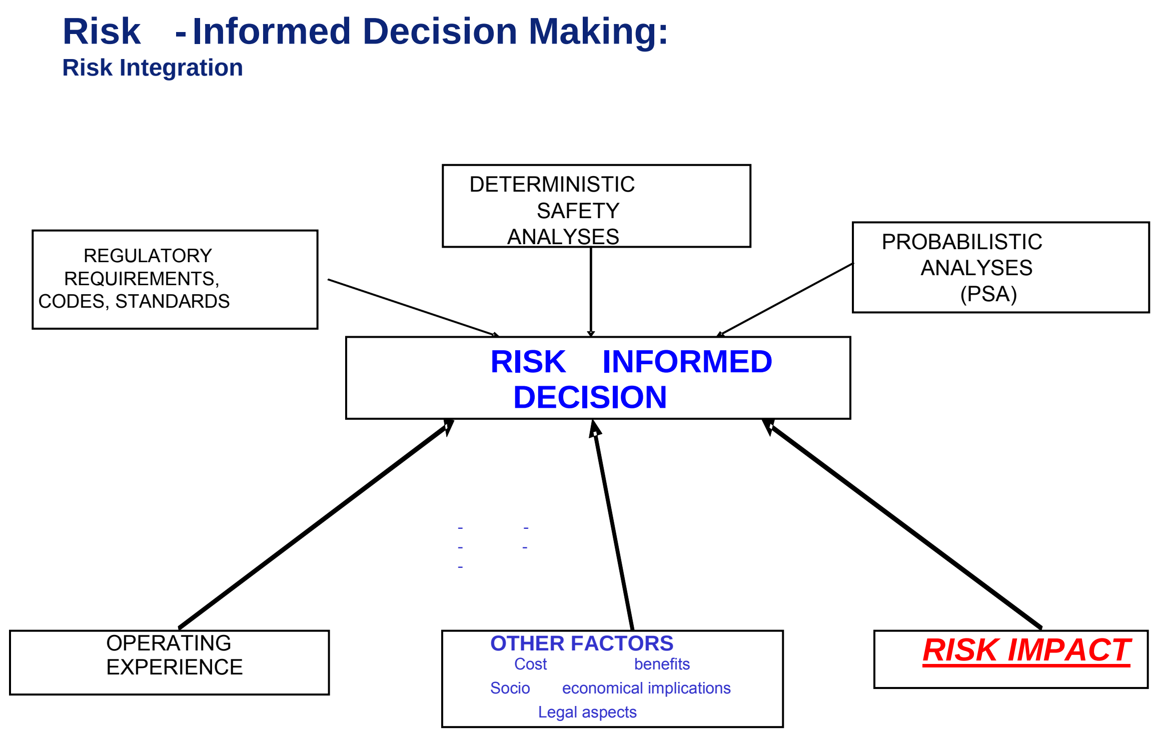
To support a common, reasonable, and consultative decision-making process, the CNSC Management Committee has adopted “CSA-Q850” as the basis for its risk management approach. Designed by the Canadian Standards Association and endorsed by the Standards Council of Canada, *CAN/CSA Q850 Risk Management: Guideline for Decision-Making* is a tool to aid decision-makers in identifying, analyzing, evaluating and controlling risks, including risks to safety and health. This tool also helps with priority setting, which is an inevitable part of the management of risk due to limited available resources. As such, it is well suited to CNSC’s philosophy of a “shared commitment to safety.” In addition, Q850 reinforces the importance of communications to effective risk management by involving and consulting people, especially those who would normally be directly affected by a given decision, and documenting each step. Overall, this tool:

* ensures that all aspects of the risk problem are identified and considered when making decisions,
* ensures that legitimate interests of affected stakeholders are considered,
* provides decision makers with a solid justification in support of decisions,
* enables decision-makers to make easier-to-explain decisions,
* provides a standardized set of terminology used to describe risk issues contributing to better communication about risk issues, and
* provides an explicit treatment of uncertainty.

The risk-informed decision-making process depicted in Figure 1 is elaborated in subsequent sections of this paper.

It should be emphasized, though, that Q850 *does not* guarantee a single, correct course of action, and *does not* direct the individual or the organization to pre-determined courses of action.

Figure 1:



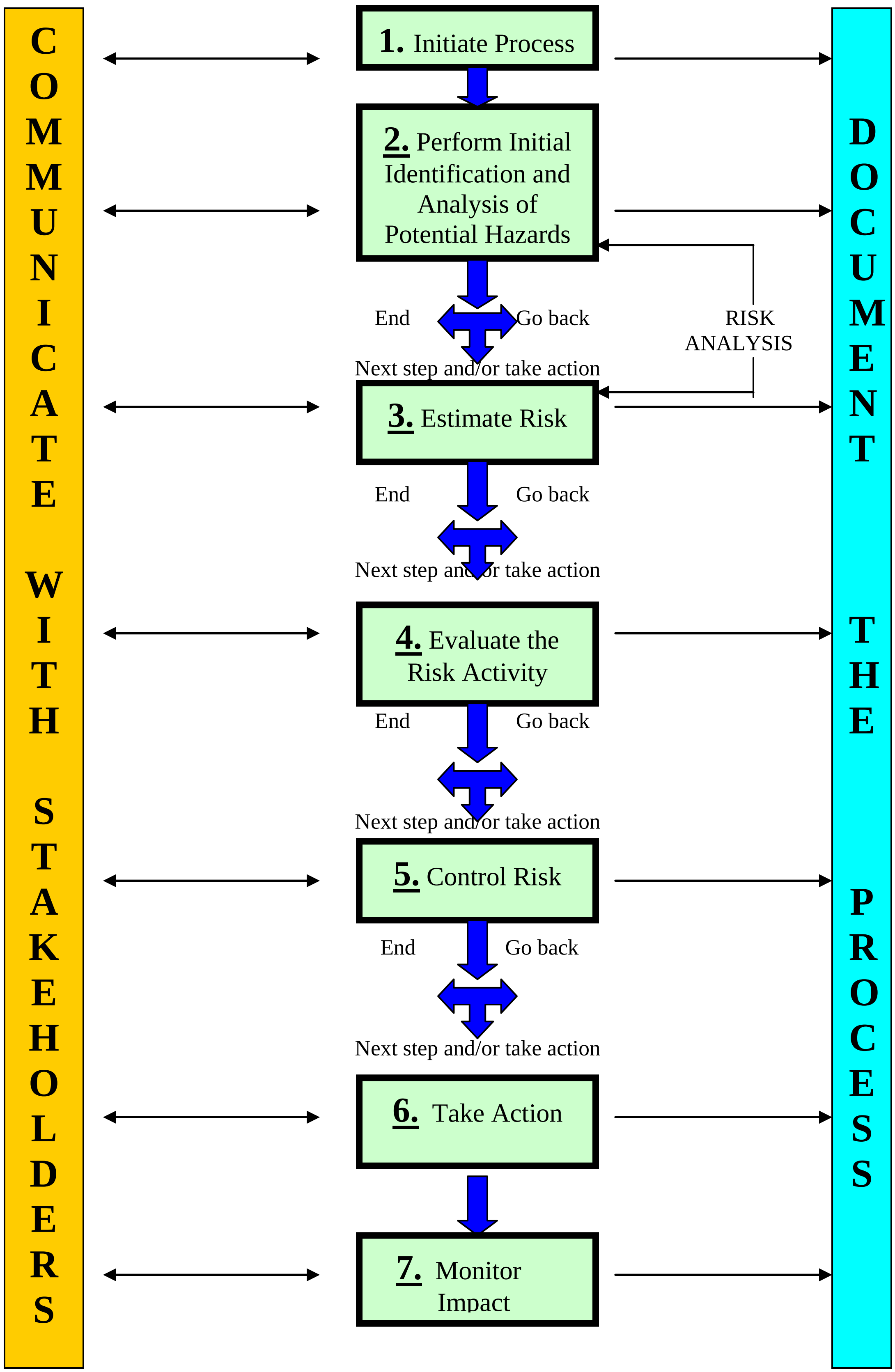


Figure 2: The CNSC risk management process.

1.1. Initiate Process

The person called upon to make a particular decision initiates the process by defining the objective(s) of the exercise, the specific regulatory objective(s) that could potentially be affected, and the problem (or opportunity), along with any associated issues. He/she makes an initial determination of all parties that should be involved in resolving the problem, and communicates to them the process or actions required, along with the time frame and any other applicable constraints. He/she also assigns the responsibilities and resources if, for example, a team is needed, and involves stakeholders (those who may affect or be affected by the decision) at the outset; a consultation process is established with clear points of contact.

1.2. Perform Initial Identification and Analysis of Potential Hazards

The team undertakes preliminary analyses to define the risk(s) associated with the situation at hand. This entails an initial scoping, identification and analysis of the potential hazard(s) and associated risk(s) to determine if immediate action is required, whether further study is advised, or if no further action is needed because the problem is determined not to be an issue. This step includes the team's determination if external help is needed and if all parties/disciplines that should be involved are indeed involved.

1.3. Estimate Risk

The team develops risk scenarios, which describe the severity and consequence of different situations, drawing from many sources and using both qualitative and quantitative information. At the CNSC, sources of information/inputs about risk include:

* deterministic requirements (regulations, license conditions, policies,....)
* licensee documents (e.g. safety report, probabilistic risk assessments, environmental impact assessment for the facility),
* results of audits and inspections,
* operating experience (formal and informal - engineering judgment),
* performance indicators, and
* perceptions (CNSC staff, licensees, public).

The team then examines the probability and consequences of the identified risk scenarios. Uncertainties about risk will always exist, no matter how reliable the information is. Stakeholders should continue to be consulted so that their perceptions about the risk(s) involved are accurate and understood.

1.4. Evaluate the Risk Activity ("Is the risk acceptable? Do we care?")

This step involves more in-depth evaluation of the risk(s) that have been identified. An estimate of the benefits and costs of the activity with which the risk is associated should be completed. Stakeholder feedback is considered, particularly in terms of the level of acceptance (tolerance) regarding that risk; this should contribute to a better understanding of alternatives available for mitigating it. At the end of this step, it should be determined:

the risk is acceptable as it currently stands

OR

the risk is unacceptable at any level

OR

if the risk could be reduced, it would be acceptable.

1.5. Control Risk ("How can that risk be dealt with?")

The team suggests various options for mitigating the risk, and discusses their advantages /disadvantages. The team should also propose contingency plans to deal with any residual risk that cannot be mitigated to the satisfaction of all concerned; the feasibility of financing these plans should be discussed. The process initiator should make stakeholders aware of pending decisions, and should give them the opportunity to comment (in any case, they are consulted throughout the process).

1.6. Take Action ("What options do we have? What are the trade-offs?")

At this point, the team presents the options and trade-offs to the person who initiated the process (who, most likely, is the primary decision-maker). He/she selects the most viable course of action for implementation; the strategy for communicating it is executed. Controls may need to be placed on the implementation plan to ensure target dates for various components are met.

1.7. Monitor Impact

It is important to agree on how the effectiveness of the decision is going to be monitored over time (who does what and when). Monitoring provides an opportunity to identify new risks, or to assess the impact of changes in known risks. Documenting the impact of the actions taken will provide confirmation of the appropriateness of the decision(s) taken.

NOTE:

In Figure 2, the decision to "Go Back," "End," or "proceed to the next step or take action" depends on the outcome of the previous step. For example, after Step2, it is possible that the team (or the decision maker) could have identified a particular regulatory requirement which addresses the "issue" fully, such that the licensee need only be instructed to apply that requiremnent and thus no "risk assessment" would be necessary (here, the "deterministic" requirement would have dominated the decision.) The process in that case would end after Step 2. The decision to "Go back" would normally be made if, for example, insufficient information were provided or the results of the previous step were inconclusive to the extent that proceeding would be impractical.

2. Detailed Example of RIDM Application at the CNSC

In response to a power reactor licensee's request, the CNSC formulated a risk-informed decision with respect to operating one NPP unit for a limited time, in a configuration not previously analyzed. The RIDM process described above was applied as follows:

STEP 1:Process Initiation

This step identifies, during a startup meeting, the decision-maker, the team members, the stakeholders (including who should be consulted), the issue description, any constraints (e.g. time) and the applicable references. The startup meeting was held and all those points decided. The issue was determined to be the adequacy of:

a) the subcriticality measurement and margin,
b) detection of, and protection against, the onset of a power excursion, and
c) procedures and training in place to make up for the lack of automatic protection (unavailability of startup instrumentation on Shutdown System 2 - SDS2), and to ensure that personnel activities do not result in inadvertent criticality.

The applicable regulatory objective for that application was to ensure that the CNSC position and requirements are sound, defensible, consistent across facilities, maintain the assurance of plant safety, and communicated clearly to the licensee. The acceptance criteria were maintaining sub-criticality margins and ensuring protection against power excursions. The applicable regulatory documents were R8: *"Requirements for Shutdown Systems for CANDU Nuclear Power Plants,"* S-294: *"Probabilistic safety assessment for nuclear power plants,"* and the plant's operating license.

STEP 2:Preliminary Analysis

This step consists of a preliminary analysis of the hazards and consequences associated with the existing and projected gaps between regulatory requirements and licensee proposals (this is basically a summary of the process), to determine if immediate action is required and to determine the level of risk. This step addresses the following questions:

- is immediate action required?
- the "risk of what?" must be specified (e.g. is it the risk of death, injury, radiation exposure, contamination spread),
- the risk to whom/what? (workers, public, environment)
- the risk from what? (a proposed design or design change, a particular work activity, an organizational configuration, machines or processes),
- are there any precedents or applicable previous studies?
- are all parties involved that should be involved?

For this particular application, the team determined that no immediate action was required since the unit was, at that time, in the "moderator drained guaranteed shutdown state (GSS)."

The risk of what, from what, and to whom - the level of harm:
In general, the risks are those posed by existing gaps between licensee proposals and corresponding regulatory requirements, and/or posed by licensee proposals that are not addressed by regulatory requirements. In summary, the increased risk was determined to be due to:

- *the licensee's inability to meet the provisions set out in its operating manuals,*
- *uncertainty of subcriticality margins,*
- *uncertainty with respect to operator action and maintaining defence-in-depth,*
- *unavailability of automatic trip coverage at very low power levels (below ion chamber sensitivity,) and*
- *reduction in defence-in-depth.*

The relevant risk areas for this RIDM application were therefore:
- "public health and safety," in the event of criticality followed by a failure to shutdown (Tables 1, 2 and 3),
- "negative impact on plant safety," due to a reduction in defence in-depth (Tables 4, 5 and 6),
- "worker health and safety," in the event of inadvertent re-criticality followed by a shutdown (Tables 7, 8 and 9), and
- "risks to the CNSC," in the event that the CNSC fails to meet one or more of its objectives (Tables 10, 11 and 12).

The areas of reactor physics, human factors and reliability were considered.

This was the first time that such a proposal has been made to the CNSC and the first time that such a configuration ever existed in a CANDU NPP.

STEPS 3 & 4: Risk Estimation *(Step 3)* **and Risk Evaluation** *(Step 4)*
These two steps, which could be done concurrently, involve the development of risk scenarios describing the severity and consequence of different situations on the basis of the information and preliminary analysis discussed in the previous steps, followed by determining the associated risk significance levels. At the end of these steps it should be possible to decide whether the risk:

(i) is acceptable as it currently stands, or
(ii) is unacceptable at any level, or
(iii) the risk would be acceptable if reduced (this would then be the springboard for the next step which is the means for controlling the risk).

The following assumptions were made in carrying out these two steps:
a) Containment and Emergency Core Cooling are available and unaffected by the issue.
b) Sequences involving failures of the post-shutdown heat sinks are unaffected by the issue.
c) Performance/reliability of startup instrumentation is adequate.
d) Indications of actual position of shutoff/adjuster/absorber rods are reliable.

In order to perform Steps 3 and 4, the Tables given below (risk-ranking matrices), taken from Reference 18, were used. Tables 3, 6, 9 and 12, give the "Risk Significance Levels - RSLs" for each risk area respectively.

Definitions of Risk Significance Levels:

RSL1: There is no additional risk due to the issue (the "Matter of Concern" or MC) or the additional risk is negligible. The uncertainties in making this estimation are not relevant. It may be appropriate to recommend addressing the risk as part of actions to resolve higher ranked risks.

RSL2: The MC causes a moderate increase of the risk but it is still well-within the tolerable region. Margins to accepted limits are eroded. There are uncertainties in risk estimation but they are relatively well understood such that it is judged that meeting the accepted limits is not challenged. Risk control measures should be taken if it is reasonably practicable to do so.

RSL3: The increase of the risk from the state when the MC is absent is significant. The risk is in a range that encompasses the limit between tolerable and intolerable risk. While RSL 3 does not necessarily involve exceeding regulatory limits, it does represent significant concerns. Epistemological uncertainties, and uncertainties in the largely qualitative estimations of the potential consequences and of their probabilities, render it difficult to determine whether the regulatory limits are exceeded or not. Interim measures may have to be recommended.

RSL4: Highest risk increase. The accepted limits are exceeded. The risk is intolerable. The uncertainties in making this estimation can hardly challenge this conclusion on the magnitude and tolerability of the risk. Immediate actions should be recommended. For issues involving plant safety, the CNSC may instruct the licensee to stop operation until compensatory measures are implemented.

Table 1: Criteria for Consequence Categories for Radiological Risk to Public at Design Basis Accidents (DBA)

Consequence Category	Criteria
C4	- The radioactive releases would require initiation of evacuation.
C3	- The radioactive releases would lead to public doses may exceed the limits for the applicable class of the accident. The releases would not trigger evacuation.
C2	- The radioactive releases would lead to public doses greater than those determined in the Safety Report, but still less than limits for the applicable class of the accident.
C1	- No significant additional radioactive releases would occur, such that the public doses calculated in the existing Safety Report are expected to be bounding.

Table 2: Criteria for Likelihood Categories for Radiological Risk to Public at DBA

Likelihood Category	Criteria
L3	- Frequency of the accident scenario is significantly greater than that considered in the Safety Report; the accident sequence may have to be re-classified into a higher frequency category (example: from Class 3 to Class 2 in C-6, or from DBA to AOO in S-310).
L2	- Frequency is not significantly different from, or is the same as that, originally assigned in the Safety Report; re-classification of the event is not necessary.
L1	- Frequency of accident scenario is greater than 10^{-7} /year but less than the DBA frequency limit; the accident is beyond design basis.

Table 3: Risk Matrix for Radiological Risk to Public at DBA

CONSEQUENCES

C4	3	4	4
C3	1	3	4
C2	1	2	3
C1	1	1	2
	L1	L2	L3

LIKELIHOOD

Table 4: Qualitative Criteria for Consequence Categories for Risk of Negative Impact on Safety

Consequence Category	Criteria
C3	- Defense in depth is insufficient or unacceptable (one or more barriers are lost, or the safety function is disabled) - Impossibility (i.e. lack of knowledge, data, tools) to assess conditions relevant for safety when compliance verification is impossible - Continuous deterioration of plant safety - Excessive increase of the time at risk of plant operation
C2	- Defense in depth is degraded (one or more barriers are affected, or the safety function is impaired) - Difficulty (i.e. insufficient information, data, tools) to assess conditions relevant for safety when compliance verification is impossible - Incomplete restoration of safety - Significant increase of the time at risk of plant operation
C1	- Levels of protection / safety functions are affected but not significantly - Inaccuracy of data, models and code predictions - Non-sustainable long term safe operation - Increase of the time at risk of plant operation

Table 5: Criteria for Likelihood Categories for Risk of Negative Impact on Safety

Likelihood Category	Criteria
L3	- The consequences will very likely occur (> 75% chance)
L2	- The consequences will likely occur (25% - 75% chance)
L1	- The occurrence of consequences is unlikely (< 25% chance)

Table 6: Risk Matrix for Risk of Negative Impact on Safety

CONSEQUENCE

C3	3	4	4
C2	2	3	3
C1	1	2	3
	L1	L2	L3

LIKELIHOOD

Table 7: Criteria for Consequence Categories for Health and Safety Risks to Workers and for Risks to Environment due to Radioactive Releases and Spills of Hazardous Substances

Consequence Category	Health and Safety Risks to Workers	Risks to Environment due to Radioactive Releases and Spills of Hazardous substances
C3	- Severe health effects or death of a worker	- Releases of nuclear substances significantly higher than the Derived Release Limits (DRL) requiring implementation of off-site protection measures. - Releases of hazardous substances requiring implementation of off-site protection measures.
C2	- Exposure of a person, organ or tissue to radiation may exceed the applicable radiation dose limits prescribed by the Radiation Protection Regulation - Doses to workers may be greater than the limits specified in CNSC regulations (unplanned dose of above 1mSv to an individual, or a collective dose of above 5mSv).	- Releases of nuclear substances may exceed DRL - Uncontrolled release of nuclear substances (rate, amount, name), or releases through an unauthorized point, without exceeding DRL. - Releases of hazardous substances reportable immediately to CNSC.
C1	- Lost time injury. - Undue staff radioactive exposure or contamination.	- Releases of hazardous substances that have the potential to harm the environment (not reportable immediately to CNSC). - Event (such as fire, explosion) leading to releases of hazardous substances.

Table 8: Criteria for Likelihood Categories for Health & Safety Risks to Workers and for Risks to Environment due to Radioactive Releases and Spills of Hazardous Substances

Likelihood Category	Criteria
L3	Frequent occurrences expected - several times during the life of the plant.
L2	It can happen once or very few times during the life of the plant.
L1	Unlikely during the life of the plant.

Table 9: Risk Matrix for Health and Safety Risks to Workers and for Risks to Environment due to Radioactive Releases and Spills of Hazardous Substances

CONSEQUENC

C3	3	4	4
C2	2	3	3
C1	1	2	3
	L1	L2	L3

LIKELIHOOD

Table 10: Criteria for Consequence Categories for Risks to the CNSC

Consequence Category	Criteria
C3	- loss of public trust in organization's capability to deliver its mandate - strong criticism by review agencies
C2	- perception of organization's inability to ensure safety - perception of conflicts of interest - strong negative media attention - criticism by review agencies
C1	- some unfavorable media attention - some unfavorable observations by review agencies - perception of excessive regulation (excessive regulatory risks)

Table 11: Criteria for Likelihood Categories for Risks to the CNSC

Likelihood Category	Criteria
L3	- The consequences are expected to occur in most circumstances (> 75% chance)
L2	- The consequences should occur sometimes (25% - 75% chance)
L1	- The occurrence of consequences is unlikely (< 25% chance)

Table 12: Risk Matrix for Risks to the CNSC

CONSEQUEN				
	C3	3	4	4
	C2	2	3	3
	C1	1	2	3
		L1	L2	L3

LIKELIHOOD

Risk scenarios

The risk scenarios in the following paragraphs were based on the licensee's submissions. It should be noted that in deciding on the applicable "Consequence" and "Likelihood" levels, professional judgment is a necessary element.

Scenario I) Moderator drained:

This is the accepted GSS - there are no further risk considerations in the context of the current assessment.

Scenario II) Moderator fill with overpoisoned heavy water:

- Moderator is full and over-poisoned.
- Moderator purification is guaranteed out of service.
- SDS2 is poised.
- Adjusters are in core.
- Shutoff and control absorber rods poised.

Here the risk is primarily due to uncertainty with respect to gadolinium behaviour and hence with respect to the subcriticality margin. The risk area of most significance in this case would be "negative impact on safety," (Tables 4, 5 & 6). The consequences and their likelihood are judged to be C1 and L2 respectively. This results in RSL2 (from Table 6).

Justification/rationale:
In this scenario, since both shutdown systems are available and poised, the only incremental risk would be due to the uncertainty of the gadolinium behaviour. The applicable "risk area" would thus be "plant safety" and, more specifically, "the level of protection, or the safety function (in this case the addition of negative reactivity) is affected, but not significantly." This corresponds to "C1" in Table 4 above. Considering Table 5 "Likelihood," we can see that the uncertainty of gadolinium behaviour leads to "L2" since we can neither be certain that the consequences will "very likely occur" nor can we be sure that the consequences are "unlikely." From Table 6, the "risk significance level (RSL)" corresponding to C1 and L2 is "2." This means that, for this particular scenario, "The issue causes a moderate increase of the risk but it is still well-within the tolerable region. Margins to accepted limits are eroded. There are uncertainties in risk estimation but they are relatively well understood such that it is judged that meeting the accepted limits is not challenged. Risk control measures should be taken if it is reasonably practicable to do so."

Scenario III) Establish the licensee's proposed plant state:
- Moderator is full and poison is being removed.
- Moderator purification is in service.
- SDS2 is poised.
- All shutoff, adjuster and control absorber rods are in core.
- SDS1 is unavailable ("de-poised").

There are several contributors to the risk :
- the plant is in an unanalyzed state - unit conditions are ill-defined for GSS, - there is uncertainty with respect to the adequacy of procedures and personnel training - inadvertent rod withdrawal cannot be ruled out,
- subcriticality margin is uncertain, and
- there is no automatic trip coverage for power levels beyond ion chamber capability.

In this case, all the risk areas (Tables 1 through 12) are applicable. The results are:
Tables 1, 2 and 3: C2, L2, RSL2.
Tables 4, 5 and 6: C2, L2, RSL3.
Tables 7, 8 and 9: C2, L2, RSL3.
Tables 10, 11 and 12: C3, L3, RSL4.

Justification/rationale:
In this scenario, since the unit conditions are ill-defined for a guaranteed shutdown state, and since the uncertainty in the subcriticality margin is coupled with the unavailability of an automatic trip in the very low power region and inadequately-trained operators to cope with such a configuration, inadvertent re-criticality cannot be ruled out with a reasonable degree of confidence. The following arguments would then follow, applying Tables 1 and 2, 4 and 5, 7 and 8, plus 10 and 11:

- From Tables 1 and 2: "The radioactive releases would lead to public doses greater than those determined in the Safety Report, but still less than limits for the applicable class of the accident" (hence C2), but the "frequency is not significantly different from, or is the same as that, originally assigned in the Safety Report" (L2). The combination of C2 and L2 yields from Table 3 a risk significance level of "2," defined previously.

- From Tables 4 and 5: "There is "Difficulty (i.e. insufficient information, data, tools) to assess conditions relevant for safety when compliance verification is impossible" (hence C2), and the uncertainty associated with this consequence yields a likelihood between 25 and 75% (hence L2). The combination of C2 and L2 yields from Table 6 a risk significance level of "3." This means that for this scenario "The increase of the risk from the state when the issue is absent is significant. The risk is in a range that encompasses the limit between tolerable and intolerable risk. While RSL 3 does not necessarily involve exceeding regulatory limits, it does represent significant concerns. Epistemological uncertainties, and uncertainties in the largely qualitative estimations of the potential consequences and of their probabilities, render it difficult to determine whether the regulatory limits are exceeded or not. Interim measures may have to be recommended."

- From Tables 7 and 8: "Doses to workers may be greater than the limits specified in CNSC regulations" (hence C2), and the likelihood is at least once in the lifetime of the plant (due to the licensee's request for one temporary deviation); the likelihood would thus be "L2." The combination of C2 and L2 would yield a risk significance level from Table 9 of "3," defined in the previous scenario.

- From Tables 10 and 11: In the unlikely event that an accident should occur due to the licensee's having received Commission's approval, there would be an immediate "loss of public trust in the organization's capability to deliver its mandate, and strong criticism by review agencies" (hence C3); such a reaction is judged to have chance of occurrence greater than 75% (hence L3). The combination of C3 and L3 would yield a risk significance level of "4" from Table 12, which is defined as being an "intolerable risk," requiring immediate action. This particular organizational risk can be described as "a consequential risk," since it would disappear if appropriate actions were implemented by the licensee to control the other risks.

Scenario IV) Monitor gadolinium concentration (exiting the licensee's proposed state):

- Moderator is full and over-poisoned
- Moderator purification is guaranteed out of service.
- SDS2 is poised except when being tested.
- Adjusters are in core.
- Shutoff and control absorber rods poised.

Here the risk is primarily due to uncertainty with respect to gadolinium behaviour and hence with respect to the subcriticality margin. There is also a period of time (short time at risk) when SDS2 is unavailable due to testing. In this scenario successive barriers are being removed and there is heavy reliance on procedures, training and vigilance.

The risk area of most significance in this case would be "negative impact on safety," (Tables 4, 5 & 6). The consequences and their likelihood are judged to be C2 and L2 respectively. This results in RSL3 (from Table 6).

Justification/rationale:

In this scenario, although the safety systems are available and poised, there is once again the uncertainty associated with gadolinium behaviour and the subcriticality margin. This is compounded by the successive removal of barriers and the strict reliance on (sometimes unproven) procedures and personnel vigilance. The applicable risk tables in this case would be 4 and 5, with the resulting risk significance level given in Table 6. More specifically, there is a 25 - 75% chance (L2 from Table 5) that "one or more defence in depth barriers are affected, and there is difficulty to assess conditions relevant for safety" (hence C2). The resulting risk significance level from Table 6 is "3."

The risk significance levels resulting from the risk estimation and evaluation can thus be summarized as follows:

Scenario I: This is an acceptable state with no associated incremental risk increase.
Scenario II: RSL 2.
Scenario III: RSL 2, 3 and 4.
(RSL 4 can be discounted **if appropriate risk control measures were taken by the licensee** as discussed above.)
Scenario IV: RSL 3.

STEPS (5) & (6): **Controlling the Risk** *(Step 5)* **and Taking Action** *(Step 6)*

These two steps involve identifying the actions necessary for dealing with the risks identified above in accordance with the priorities determined by the risk-ranking. Since the onus is on the licensee to decide on specific modifications or actions that should be implemented, CNSC response to the licensee identifies the conditions which have been determined to be unacceptable (unless design modifications effectively changed the corresponding scenario) and those other conditions that should also be dealt with but on a lower priority basis, or which could result in acceptable conditions if appropriate administrative controls were in place.

The CNSC therefore specifies the "Risk Control Measures" (Step 5) and the licensee proposes specific actions to satisfy those measures. Upon the CNSC's acceptance of those measures, the licensee proceeds to implement them (Step 6). It can be seen from the results of Steps 3 and 4 above that "RSL4" for the risk area of "organizational risks" is a "consequential risk" which would be removed if the scenarios resulting in "RSL3" were alleviated.

Considering the RSL definitions given above, "RSL3" signals a border-line situation between tolerable and intolerable risks, such that interim measures may have to be recommended.
Since subcriticality margin uncertainties could not be dealt with in the short-term, the recommended short-term actions to reduce the risk significance levels were to request the licensee to:

a) reduce the risk of reactivity addition by introducing a hardware barrier to rod withdrawal, such as locks, to supplement administrative controls,
b) provide assurance of SDS2's response and adequacy as a backup to the proposed plant state,
c) provide assurance of the reliability of the rod position indication,
d) provide assurance that personnel are well-trained to follow updated procedures,
e) provide assurance that gadolinium behaviour is well-understood under all planned operating conditions,
f) provide assurance that proper signage and barriers are in place on the reactivity deck to protect against staff inadvertently working on the wrong unit, and
g) provide assurance that procedures are adequate to reduce the likelihood of human error and to exclude any configuration of equipment that could significantly increase the risk of a reactivity excursion.

If (a), (b) and (d) could not be assured then startup instrumentation should be connected to SDS2 to maintain automatic trip coverage at all power levels.

STEPS (7): Monitoring the Impact

This step would normally be completed after the licensee's implementation of the necessary actions.

Conclusions

This paper describes basic concepts of the CNSC RIDM process, in the context of nuclear power regulation in Canada. The CNSC approach, with respect to factoring risk in decision-making, is consistent with practices by nuclear regulators in some of the other countries with major nuclear power programs. The CNSC decision-making process for managing risk has been validated by the CNSC and industry, has been used satisfactorily in numerous applications, and has been approved by CNSC management for wider and more systematic use, and for incorporation in the CNSC Management System Manual. The paper furthermore gives a detailed example of applying the RIDM in a major CNSC decision-making situation.

References

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4. Canadian Standard “CAN/CSA Q850 Risk Management: Guideline for Decision-Making (1997),”
5. CNSC Standard S294 "Probabilistic Safety Assessment (PSA) for NPPs."
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7. OPG submissions and station documents.