Agenda Item W 7.2
Considerations for Inadvertent Human Intrusion in a Safety Case for Radioactive Waste Disposal – For information –

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Introduction

- Policy document of the IAEA Safety Standards Series

States the basic objectives, concepts and principles involved in ensuring protection and safety

1. Objective

10 safety principles

People and the environment, present and future, must be protected against radiation risks

- Responsibility for safety
- Role of government
- Leadership and management for safety
- Justification of facilities and activities
- Optimisation of protection
- Limitation of risks to individuals
- Protection of present and future generations
- Prevention of accidents
- Emergency preparedness and response
- Protective actions to reduce existing or unregulated radiation risks
Introduction

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- Concentrate and Contain is considered best alternative, but increases risk should someone inadvertently disrupt facility.

- Inadvertent human intrusion (IHI) following loss of controls must be addressed.

- Consideration of potential IHI is unique to radioactive waste disposal and provides defense-in-depth/robustness and added confidence.

- Some uncertainty and inconsistency in Member States in how IHI is being addressed.
IAEA, ICRP and NEA on Inadvertent Human Intrusion

- Intrusion considers case where memory of facility is lost in the future
- Protect inadvertent intruder, not deliberate
- Geologic disposal has inherent advantages against intrusion relative to near-surface disposal
- Limited stylised scenarios, current habits and technology
- Intrusion considered in the context of existing exposures and optimisation rather than dose constraint
- Challenges in developing probabilities
IAEA Radioactive Waste Classification

- Exempt Waste (EW)
- Very Short Lived Waste (VSLW)
- Very Low Level Waste (VLLW)
- Low Level Waste (LLW)
- Intermediate Level Waste (ILW)
- High Level Waste (HLW)
Requirement 12: Assessment of safety over the lifetime of a facility or activity
The safety assessment shall cover all the stages in the lifetime of a facility or activity in which there are possible radiation risks

4.43. In the case of a disposal facility for radioactive waste in significant quantities, radiation risks shall be considered for the post-closure phase. Radiation risks following closure of the disposal facility may arise from gradual processes, such as the degradation of barriers, and from discrete events that could affect isolation of the waste, such as inadvertent human intrusion or abrupt changes in geological conditions.
HIDRA project

• Human Intrusion in the Context of Disposal of Radioactive Waste (HIDRA)
  – The HIDRA project considered how to counter potential future human actions that could disturb areas occupied by radioactive waste disposal facilities
  – Such human intrusions could potentially give rise to radiological consequences

HIDRA Objectives

➢ Share experience and practical considerations for the development and regulatory control of activities to consider potential IHI during development of the safety case
➢ Develop general approach (Phase I) and hypothetical working examples to test and illustrate practical application (Phase II)
➢ Address development and implementation of regulations for IHI
➢ Identify considerations for effective communication
➢ Provide recommendations to WASSC for future updates of safety standards.
IHI and Decision-Making

- Maintain perspective that IHI not considered in other industries – adds robustness to safety case
- IHI not strictly a “yes or no” decision-maker – use IHI to inform design and WAC (optimisation context)
- Caution to not create a situation where extreme or overly cautious intrusion scenario could cast doubt on a very good site and facility design
- Consider how IHI contributes to decisions through life-cycle
HIDRA Linked to PRISM/PRISMA Decision-Making

Evolving Safety Case

**Time Line**

Need for Action

Waste Manager

Interested parties involvement throughout the process is encouraged

Operator

Role and Responsibility

- Government
- Regulator
- Operator

License Termination?
HIDRA Phase I General Approach

Three Working Groups

Safety Framework
- Safety Case Context
- Safety Strategy
- Disposal System Description

Inadvertent Human Intrusion Considerations
- Stylised Scenarios
- Protective Measures
- Facility-Specific Scenarios and Measures

Assessment/Analysis and Additional Considerations

Implement Measure(s)?
- Yes: Modify Safety Framework
- No: Unchanged Framework

Societal Factors

Proceed to next step in lifecycle
Stylised Scenarios – general approach to develop stylised scenarios and basic categories of scenarios identified:
- Near surface – excavation (e.g., basement, road) and drilling
- Geologic – drilling and mining

Protective Measures – extensive database of potential measures developed (administrative, design, etc.) and general approach to test and identify effective measures

Societal Factors – Importance of communicating:
- purpose of considering IHI,
- built-in pessimistic assumptions for IHI, and
- all measures adopted to limit potential for IHI and consequences should IHI occur
HIDRA II – Working Groups

➢ Near-Surface Disposal
  ➢ Practical development of scenarios
  ➢ Considerations for quantitative evaluations and evaluation of measures
  ➢ Link with development of WAC (waste acceptable for near-surface disposal)

➢ Geologic Disposal
  ➢ Inherent protectiveness of geologic disposal
  ➢ Identification and evaluation of measures
  ➢ Qualitative evaluations
Topical Questions and Issues

A number of topical questions and issues were discussed throughout both phases of the HIDRA project and summarized in the draft HIDRA II report:

- Isolation in the context of IHI
- Retrievability
- IHI Analyses: Exposure to waste
- Stylised Scenarios
- Inadvertent and deliberate intrusion
- Regulatory considerations
  - Quantitative or qualitative assessment
  - Prescriptive or non-prescriptive (extent of stylisation)
  - Worst case or random assumed contact with waste
  - Role of IHI for siting
  - Consideration of Radon in IHI assessment
  - Consideration of water use for IHI
- Effectiveness of controls during time frame of hundreds of years (near-surface disposal)
Compare/Contrast Geologic & Near-Surface

Similarities for both groups

➢ HIDRA approach worked well in test applications

➢ Less structured application of the approach in early phases of life-cycle (prior to design), commensurate with availability of data

➢ Recognize need to have multiple iterations of HIDRA approach within some steps of the life-cycle (especially design and operations when changes can be occurring)
Compare/Contrast Geologic & Near-Surface

Differences

➢ Measures and scenarios

➢ Geologic
   ➢ Emphasis on effectiveness of measures rather than development of scenarios
   ➢ Qualitative evaluation of benefits of measures

➢ Near-surface
   ➢ Need to develop reasonable scenarios in order to compute quantitative impacts
   ➢ Important to identify what waste can be disposed in a near-surface facility

➢ Application of optimization …
Differences (cont.)

➢ Application of optimisation

➢ Geologic

➢ Emphasis on magnitude of improvement provided by different measures rather than whether a given disposal is acceptable (recognizing that geologic disposal is the most effective approach to address IHI)

➢ 20 mSv bound for optimisation is not relevant for IHI for geologic disposal

➢ Near-surface

➢ Need quantitative doses and optimisation threshold to determine what barriers or measures are essential for near-surface disposal of a specific waste

➢ Need specific scenarios to use as a basis for the evaluations
Differences (cont.)

➢ Emphasis of communication

➢ Geologic

➢ Clear explanation that protection for IHI is addressed by the choice to use geologic disposal and isolate the waste

➢ Focus on low likelihood of potential impacts and benefits of measures that have been implemented

➢ Near-surface

➢ Focus on pessimism that is built-in to IHI analyses (e.g., complete loss of memory of site)

➢ Discuss hazards posed by the waste and measures that provide protection for several hundred years to allow for decay of majority of the activity
Recommendations to WASSC (1)

➢ Definition of Inadvertent Intrusion in Safety Glossary and SSR-5 – suggest minor modification

➢ Current emphasis of the definition (1.10 b) is on actions that affect “integrity” of facility rather than on actions that could lead to waste being brought to the surface

➢ Quantitative evaluations for near-surface disposal all focus on potential for waste to be brought to the surface rather than affecting the integrity of the facility

➢ Subtle difference, but important, because near-surface scenarios do not consider creation of migration pathways, it is a hypothetical situation with waste brought to the surface.
Concepts relating to disposal (and storage) of radioactive waste

1.10. A number of design options for disposal facilities have been developed and various types of disposal facility have been constructed in many States and are in operation. These design options have different degrees of containment and isolation capability appropriate to the radioactive waste that they will receive. The specific aims of disposal are:

(a) To contain the waste;

(b) To isolate the waste from the accessible biosphere and to reduce substantially the likelihood of, and all possible consequences of, inadvertent human intrusion\(^2\) into the waste;
Recommendations to WASSC (2)

➢ Suggest reconsidering requirement in SSR-5 to consider alternative disposal if “possible” to have doses greater than 20 mSv/yr (2.15 d).

➢ Extreme, improbable scenarios like drilling through a waste package would lead to such doses, especially if you must assume a probability of 1 per the current ICRP and IAEA requirements

➢ Need to keep perspective that geologic disposal is specifically selected to provide for protection for intrusion
RADIATION PROTECTION IN THE POST-CLOSURE PERIOD

2.15. The safety objective and criteria for the protection of people and the environment after closure of a disposal facility are as follows:

Criteria

(c) In relation to the effects of inadvertent human intrusion after closure, if such intrusion is expected to lead to an annual dose of less than 1 mSv to those living around the site, then efforts to reduce the probability of intrusion or to limit its consequences are not warranted.

(d) If human intrusion were expected to lead to a possible annual dose of more than 20 mSv to those living around the site, then alternative options for waste disposal are to be considered, for example, disposal of the waste below the surface, or separation of the radionuclide content giving rise to the higher dose.

(e) If annual doses in the range 1–20 mSv are indicated, then reasonable efforts are warranted at the stage of development of the facility to reduce the probability of intrusion or to limit its consequences by means of optimization of the facility’s design.
6. SPECIFIC ISSUES

HUMAN INTRUSION (6.52-6.65)

6.65. As discussed above, the relevance of human intrusion scenarios for geological disposal facilities is limited, as the depth and location of such facilities makes it unlikely. The time frames of concern are also far too large to enable meaningful estimates of possible impacts from intrusion events to be made. Nevertheless, it may be decided to make an assessment of the consequences to demonstrate the robustness of the disposal system. The scenarios considered are speculative and somewhat arbitrary owing to uncertainties in the boundary conditions and other parameters, such as when it is assumed that the event will take place and what the state of the facility and its host environment will be at the time of intrusion. As a consequence, for geological disposal facilities, care should be taken when making quantitative use of the results obtained for human intrusion scenarios, in particular when comparing these to other scenarios (e.g. for purposes of optimization of protection and design). The most effective measures against inadvertent intrusion involve establishing the disposal facility in deep geological formations and providing knowledge maintenance in the long term.
“Public area”


The HIDRA project considered how to counter potential future human actions that could disturb areas occupied by radioactive waste disposal facilities. Such human intrusions could affect the integrity of the disposal facilities and potentially give rise to radiological consequences.

The time radioactive waste takes to become harmless can range from a few days to millions of years, depending on the type of radioactive material in the waste. Disposal facilities for waste that remains radioactive for a very long time must consider that in the future, control over the disposal facility might be disrupted, and information about hazard lost or not understood. This could result of human intrusion in the facilities and should be addressed in the safety case.

As part of the HIDRA project, Member States developed an approach for identifying and selecting scenarios to be assessed, and protective measures to reduce the potential for and consequences of inadvertent human intrusions. The project also fostered information sharing and communication about potential inadvertent intrusion.

The HIDRA project developed an approach that supports operating organizations, regulatory bodies and government organizations as they work uphold safety in a consistent and structured manner in line with the IAEA safety standards. The approach is flexible and enables the consideration of different disposal concepts, site conditions, regional habits, and stages of development. This makes the approach useful to a broad range of Member States in their work to improve the robustness of radioactive waste disposal facilities.

The first phase of the project, conducted 2013-2015, focused on potential scenarios, societal factors and protective measures. Project participants developed guidance on how to assess the consequences of potential future inadvertent human intrusions and incorporate them in the safety case for a radioactive waste disposal facility. The guidance also describes how to use those assessments to optimize site, design and waste acceptance criteria within the context of a safety case.

The second phase of the HIDRA project, conducted 2016-2018, focused on practical implementation of the HIDRA approach and documentation of country-specific examples. It provided a forum for regulators, operators and other interested parties to share information about approaches to consider human intrusion.
Thank You