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To:

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From:

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Re: Comments and questions pertaining to:

REGDOC-1.2.1, Canadian Nuclear safety Commission (CNSC): Class 1B Facilities: Guidance on Deep Geological Repository Site Characterization, Draft October 2018

Introductory Remarks

This draft regulation [REGDOC-1.2.1] is intended to "set out guidance for licence applicants on technical aspects that may be considered during the site characterization stage of the siting process for a deep geological repository (DGR) facility for radioactive waste."[p.i]

As indicated in CNSC's draft guidance document, a deep geological repository (DGR) is intended to provide the long-term isolation and containment of nuclear substances from the biosphere. Thus, it requires a deep, stable geological formation. After closure, there is no intention to retrieve or transfer the radioactive waste."[p.1]

The radioactive wastes (i.e., irradiated fuel) designated for disposal in the DGR contain highly radioactive substances, some of them with extremely long half-lives, as long as hundreds of thousands to millions of years as well as other contaminants. Any degradation and contamination of the environment resulting from radionuclides leaking out of the repository will have far-reaching consequences. Thus, the very serious concern related to a DGR site is whether its characteristics would contain this waste and prevent the migration of radionuclides and other contaminants from the repository for eons. It is inconceivable that no measures are taken to ensure that these wastes would be retrievable, especially in the event such that unforeseen circumstances have caused the repository to fail. This is not a precautionary approach towards the long-term management of nuclear wastes.

This submission comments on specific sections of the guidance regulation with respect to factors to be considered by the licence applicants and the CNSC if it is to ensure long-term stability of the DGR.

It questions whether the guidance and range of factors considered are robust enough or even suffice to ensure that the DGR would provide safe storage of radioactive waste while in use and for tens of thousands of years or more after its closure, and that this waste would remain "isolated" from the environment indefinitely.

It also includes additional salient factors that could compromise or breach containment of the radioactive waste not specifically addressed in the draft document and are of utmost concern as to the long-term safety of this waste.

Comments on Siting Process and Characterization

Overview

As stated, "The objective of the siting process, which includes site characterization, should be to select a site that, along with a proper design and engineered barriers, has properties that provide adequate containment and isolation of radionuclides and hazardous substances from the accessible environment for the desired period of time, usually the assessment timeframe."

"The data gathered in the preliminary stages of the siting process may form part of the initial licence application and part of the safety case. Information gathered at this stage may be used as baseline information to support the demonstration of safety throughout the lifecycle of the DGR facility."[p.3]

Site characterization activities are normally expected to continue into the site preparation, construction and operational phases until closure of the DGR "in order to contribute further to an adequate baseline for future monitoring, as well as to help confirm assumptions made in earlier safety cases and reduce any residual uncertainties in the safety case". "The safety case and associated safety assessment should identify uncertainties and assess the robustness of the facility so that the geoscience verification program can be developed and a research program designed and executed to address these uncertainties throughout the lifecycle of the DGR." [p.3, 4]

Comments/Questions

Q: What constitutes "**adequate** containment and isolation" of radionuclides? Does adequacy imply that there is no breach whatsoever in the containment of the waste?

Q: While mention is made of reducing uncertainties, it is doubtful if not impossible as to whether one could completely identify and eliminate these uncertainties.

Site Characterization Program (p. 5-10)

This program, to be prepared by the licence applicant, is to provide information sufficient to support a general understanding of the site in its current state and how it is expected to evolve over extended time frames associated with the safety case.

The program is to "establish baseline conditions for the site and environment in its present condition; support the understanding of the normal evolution; identify any events and processes associated with the site that might disturb the normal evolution of the DGR system; and support the understanding of the effect on safety of any features, events and processes associated with the DGR system. Baseline data provide the initial information for safety assessments at the conceptual stage and during initial facility design. They will serve as the basis for the first iteration of the full safety case and any initial geoscience verification program at the site once it has been selected." [p.5]

As noted, the pre-closure period includes site preparation, construction, operation and decommissioning. The post-closure or long-term period follows the closure of a DGR facility, with a time frame of tens of thousands of years or more.

Geological Environment (Section 3.1)

Key characteristics include:

1. containment and isolation characteristics of the host rock: geological, hydrogeological, mineralogical, chemical and mechanical;
2. past and future geological stability of the site, including orogeny, seismicity, glaciation and volcanism;
3. sufficient extent of suitable host rock at the repository depth;
4. site characteristics that would allow the development of a robust safety case;
5. demonstrated isolation of groundwaters at selected repository depth from shallow groundwater systems;
6. characteristics favourable for sorption, precipitation or other mechanisms to limit contaminant release and transport away from a DGR;
7. Low potential for inadvertent future human intrusion.

Comments/questions

2- The "determination" of future geological stability is not or is unlikely, given the time frames, to be definitive.

3 - What does "sufficient" imply? This is too vague a term.

5- How can the "isolation of groundwaters" be demonstrated in the very long-term?

6 - It is essential to "avoid" any releases of contaminants, not merely "limit" them.

7 - The term "low potential" in the context of human intrusion is inappropriate. Clearly, the point is that human intrusion <u>must</u> be avoided.

Each of these sections highlight the use of qualitative, rather than quantitative data, as is required by the draft regulation.

The draft regulation notes that: [p.6]

> Quantitative data should be provided in addition to qualitative descriptions where possible.
>
> An iterative approach to gather and verify data would continue until closure of the DGR and possibly after closure, to verify and update the safety case and demonstrate that long-term safety is maintained.
>
> The geological characteristics, the engineered barriers and the design of the DGR must indicate that a DGR at a particular site would remain safe of "tens of thousands to millions of years.

Comments

It is absolutely essential to have quantitative data on characteristics of the geological environment, and not just “where possible”. In fact, if such data is not available or possible to obtain, then that would imply that the only information available would be descriptive in nature. This is not a scientific or robust process, especially considering the consequences if containment is breached **at any time**.

Much of the information is, of necessity, based on predictions. While it is acknowledged that not all factors can be determined with certainty, given the length of time that a DGR is intended to provide safe long-term storage of this waste with no release to the environment, the matter of the degree of uncertainty is the critical issue.

Geological Setting (Sections 3.1.1-3.1.5)

These sections list information to be included in the determination of the suitability of a specific DGR site with respect to geological and hydrogeological settings, geochemistry, geological suitability and geomechanical characteristics. As stated in the draft regulation:

1. Any process that can be shown to demonstrate the potential for radionuclide migration or retardation from the DGR engineered facility through the geological environment should be documented.
2. Geological Stability: The site should be located in a seismically stable region, with low potential for seismic or volcanic events. It should be demonstrated that any credible geological event that could occur during the assessment time frame would not impact the isolation and containment capability of a DGR.

Comments:

How is it possible to demonstrate that any geological event, be it seismic, volcanic, etc., would not or could not occur and result in failure to isolate the waste?

What is considered to be “low potential” for seismic or volcanic events? Can this be clarified or quantified?

If the potential for migration or retardation of this waste from the DGR is demonstrated and documented, will that result in exclusion of that site?

How would wastes already emplaced be retrieved if the waste packages themselves have not been designed to be retrievable at least to the pre-closure of the site?

Site Characteristics – Surface Environment – Climate Change (Section 3.1 p.8)

As stated in the draft guidance:

> Baseline environmental data is needed to ensure that the environment will be adequately protected and any potentially adverse effects mitigated.
>
> Surface processes at the site should be sufficiently characterized to ensure that natural hazard events such as flooding, landslides and erosion would not impact the ability of

the radioactive waste management system to function safely during the pre-closure of a DGR facility.

The site area climate should be characterized in such a way that the effect of unexpected extreme meteorological conditions can be adequately identified and considered in the design of the DGR facility.

Comments

It cannot be assumed that "natural hazardous events" or earthquakes, volcanoes, climate instability, etc., can be "adequately identified" and would not impact the function of the DGR or that adequate protection would be able to mitigate any potentially adverse effects.

Climate change will change ecosystems significantly, including drastic changes from aquatic to terrestrial systems and vice versa as water levels rise or fall at a particular location. None of the current models on climate change take into account all of the effects that that climate change could have throughout the ecosystem. These models are being continuously refined as more experimental data becomes available.

We now know that climate change is accelerating at rates that exceed predictions. How can one expect that the stability and safety of a DGR would not or could not be affected, and within a relatively short time compared to the projected life of a DGR?

Collecting information, geomorphology characterization, updating climate change models and predictions is of course necessary, but this information gathering exercise depends on assumptions that could well turn out to be faulty, potentially biased and thus seriously limited. Furthermore, it cannot be assumed that mitigation would abate any breach of containment.

These comments also apply to the aquatic and terrestrial environment as well as topography (hydrology and flooding). [3.3.2 - 3.3.5] All of these systems are interdependent, and must not be considered as single entities. Above all, chaotic events cannot necessarily be predicted or prevented.

Breach of Containment - additional factors

The following outlines specific items that could compromise the containment resulting in releases of radioactivity and other hazardous material to the environment that need to be considered in site characterization. For example;

Corrosion

Over time, the containers of this waste will corrode. Microbial activity within the repository could also have a number of adverse effects on the safety of a nuclear waste repository, including corrosion of waste containers. This could result in the release of gases into the repository (e.g., hydrogen gas, carbon dioxide or methane). The build-up of gas pressure in the repository and the degradation of organic material, could damage natural barriers, allowing radionuclides to escape through rock fractures or pores.

The chemical and physical disturbances due to corrosion, gas generation and bio-mineralization, along with heat generated by radioactive decay, could impair the ability of backfill material to contain some radionuclides.

Permeability and Rock Stability

Any degree of permeability of the rock formation within the repository cannot necessarily provide an impervious barrier that would block the migration of radionuclides in the very long term. Unidentified fractures and faults, or lack of understanding as to how water and gas will flow through fractures and faults, could lead to the release of radionuclides in groundwater much faster than expected. The excavation of the repository can damage adjacent zones of rock and thereby create fast routes for radionuclide escape. Rock bursts can occur due to the high pressure deep underground in the repository.

Glaciation

The effects of future glaciations pose one of the greatest long-term threats to the integrity of deep repositories. The next glaciation could occur 10,000 to 1,000,000 years in the future. This is the period where the greatest damage could occur to the repository. The long-term adverse effects could include faulting of the rock, rupture of containers, and penetration of surface waters or permafrost to the repository depth, which would, in turn, lead to failure of the barriers and faster dispersion of the waste.

Earthquakes

During the lifetime of the repository, inactive faults could be reactivated. An earthquake could severely damage the entire containment system, including the backfill and host rocks. Even if the site is located in an area of low seismic activity, and historical records of earthquakes in the area of the proposed DGR indicate this to have been so at least from the 1800s, the length of recorded earthquake data has little relevance to earthquake hazard assessment over periods of hundreds of thousands of years. It is not possible to assume that large earthquakes are very unlikely or will not occur.

Human Intrusion

As stated in the draft regulation, "Information on past, present and potential future human activities at or near the site should be collected, and the likelihood of whether these activities could have an impact should be assessed." (Activities and Land Use, p. 11)

This is very vague and extremely limited. While it is absolutely essential to be apprised of "current and historical mineral exploration and mining that could represent potential instabilities or radionuclide migration pathways", at the same time, there is no mention of the impact of the DGR on local communities, not only while under construction, but long afterwards. Mining for oil and gas by fracking, for example, could occur near the DGR, as is happening near the WIPP site in New Mexico. An analysis of the impact of such activities, among others, needs to be quantified beforehand and not left to be responded to afterwards.

Additionally, human error and/or deliberate intrusion in the future could adversely and unintentionally affect the safety of the repository. This is one of the most difficult, if not impossible factors to assess.

Facilities for Verification and Characteristic Activities - Underground Research Laboratory (URF) (Section 6 p.4; 14)

As the draft regulation indicates, many geoscientific characteristics cannot be obtained from above-ground activities. In light of the nature of the waste planned to be stored in a DGR, that is, high-level radioactive waste, an underground research facility (URF) could conduct verification and characterization activities which could purportedly reduce uncertainties.

"Setting up an underground research facility is a very time-consuming process, and there may be a significant time lapse between the selection of a potential site and the availability of such a facility at that site. Therefore, it is best practice to start planning for this facility as early as possible in the siting process, and build support and expertise by using available underground research facilities."(p.14)

Comments

While an underground research facility (URF) may provide additional information on characterizing the geology, conducting experiments, etc., which may not be obtainable from above-ground activities to assist with demonstrating the feasibility and safety of a DGR, there does not appear to be a requirement for such a facility, even though mention is made of such facilities in other countries. In fact, the draft states that:

"It is important for the licence applicant to discuss its plans with the CNSC early for verification of site characteristics, such as an underground research facility or similar facility, to clarify the regulatory approval process and to identify those site characterization activities. These consultations are also necessary to identify those site characterization activities that may not require a CNSC licence to prepare site and/or licence to construct."[p.12]

If a URF is seemingly important, why would it not be a requirement in constructing a DGR and subject to a CNSC licence?

Limitations to Models

Many of the complex processes and interactions that could take place in the repository over hundreds of thousands to millions of years are completely unknown. Computer models used to predict the safety of the repository for the timescale needed would have to take into account all the complex processes and interactions that could occur over this period. As these computer models are not complete or accurate, they have no predictive value.

In fact, the verification and validation of numerical models of natural systems is impossible because natural systems are never closed.[1] Computer models can only be validated by the

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[1] Oreskes, N., Schrader-Frechette, K., Belitz. K. 1994. Verification, validation and confirmation of numerical models in the Earth sciences. *Science* **263**: 641-646.

demonstration of agreement between observation and prediction. This is not possible when it depends on observations so far into the future.

As a result, computer models that would be used in the safety case involve numerous subjective, choices and assumptions which can lead to overconfidence in a particular computer model and its underlying assumptions, without verification or validation. Such models must be seen to be providing qualitative data rather than quantitative data.

Summary

While this draft guidance regulation deals with various types of technical studies to ascertain the safety the safety of containment of high-level radioactive waste, the very long-term safety is, of necessity, based on expectations and predictions of numerous variables.

The factors that one can anticipate now and/or predict far into the future that could result in a disturbance of the DGR resulting in the migration of radioactive waste to the biosphere are not or cannot be definitive at this stage or ironclad. That remains the unsolved dilemma and challenge of “isolating” radioactive waste, if that is even possible.

What would happen if containment fails, and radioactive contaminants are released to the biosphere? Who is in charge? Who is the “caretaker”?

Even if the DGR would isolate the waste for long periods, it would eventually be abandoned, no guardians, stewards, to watch over the site and pass that information on.

In conclusion, given the overriding issues of storing high-level radioactive waste in a DGR, this draft regulation fails to capture the essence of the problem of abandoning this waste, while anticipating it would be safely contained for at least tens of thousands of years.

The mindset that it is possible to safely isolate this waste in a DGR speaks to attempts to achieve an immediate solution to a current and future problem and removes responsibility from the generation emplacing the wastes, transferring any problems to future generations.

CNSC’s mandate is to protect the health and safety of Canadians, as well as our environment. Rather, as evidenced by this draft regulatory document, the issue of storing radioactive waste safely has not merited the necessary scrutiny warranted as this mandate would indicate.