MOBILITY MISSION REPORT

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MISSION TITLE

Attendance of the general update workshop of the IGD-TP project on Post-Closure Criticality Safety (PCCS).

DESCRIPTION

Concerned organisations

Waste management organisations and Technical support organisations

Concerned infrastructures or facilities

Geological disposal facilities

Concerned phases

Phase 5: Post-closure

Themes and topics

- Theme 3: Engineered barrier system (EBS) properties, function and long-term performance
    - Spent Fuel and high-level waste disposal canisters
    - Containers for long-lived intermediate and low level wastes

- Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution
    - Perturbations (gas, temperature and chemistry)
    - Aqueous pathways and radionuclide migration

Keywords

Fissile nuclide behaviour; Spent fuel disposal; Criticality safety assessment; Criticality consequences assessment; Post-closure

EXECUTIVE SUMMARY

This mobility action consisted of the travel of the applicant to participate in the IGD-TP's Post Closure Criticality Safety (PCCS) project workshop in September 2022. The PCCS project bring together Waste Management Organisations (WMOs) and supporting organisations from across Europe and North America with the primary goals of enabling the sharing and discussion of technical knowledge and results, fostering a mutual understanding of post closure criticality safety, and identifying areas for further collaboration and engagement.

The September 2022 PCCS workshop in Baden, Switzerland was the second official project workshop and the first to be held in-person. The workshop was focused primarily on issues concerning the criticality safety of spent fuel disposal in the post closure phase of the repository. Topics included the application of fuel burn-up, the adopted criticality safety criterion, degradation scenarios and timescales, validation, criticality consequences assessments and communication with stakeholders. Representatives were present from the respective WMOs of Belgium, Spain, Hungry, France, Germany, Sweden, Finland, the UK, Switzerland, the USA and Canada, plus supporting researchers. The workshop included a visit to the Grimsel underground rock laboratory.

The three-day workshop enabled participants to identify key potential areas for collaboration as well as to learn from each other and provide a level of peer review for existing work. The applicant was able to participate in all of the workshop sessions which were helpful for his professional development and for ensuring that his own work remains in-step with the generally agreed best-practice in the field. It also enabled the applicant to network with other practitioners and to develop a holistic understanding of the outstanding challenges in the field.

1. MISSION BACKGROUND

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1.1. R&D background

Criticality safety concerns the potential for critical systems of fissile material to form resulting in a critical excursion which, in the context of geological disposal, poses immediate risks to facility personel (in the transport and operational phases) and to the containment function of the engineered and natural barriers (in the post-closure phase).

Criticality Safety is Topic 5.4.4 of the EURAD roadmap and is part of the Strategic Research Agenda (SRA) of the Implementing Geological Disposal of radioactive waste Technology Platform (IGD-TP).

Many, if not all, Waste Management Organisation (WMO) programmes include criticality safety sub programmes. But, given the unique and specialised nature of the problem of post-closure criticality in particular, there is limited opportunity for sharing of experience between companies and WMOs.

To this end, the IGD-TP initiated the Post Closure Criticality Safety (PCCS) project with a goal of harmonising the approach to criticality safety across participating WMOs, addressing common technical issues and sharing learning and best practice between participants. An intial online workshop was held in February 2022, and the first in-person workshop was in September 2022 in Baden, Switzerland.

The primary focus of the first workshop is the post-closure criticality safety of spent nuclear fuel, and related topics including burn-up, validation, communication and consequences.

1.2. Mission objectives

The objective of the mission was for the applicant to participate in the September 2022 PCCS workshop with the outcomes of professional development in the field and learning about the wider international status, issues and approaches in the field.

1.3. Mission request

The request is for support to cover the travel expenses for participation in the September 2022 PCCS workshop. The requested scope of the costs to be covered by the EURAD mobility programme are travel to and from the conference, meals for five days (two days of travel and three days at the workshop) and four nights of accommodation near the conference venue (nights of the 4th, 5th, 6th and 7th).

1.4. Mission composition

Host organisation

Nagra

Host facility

Hotel Blume, Baden

Mission dates

5-7th September 2022

2. MAJOR PRACTICES, TECHNIQUES, METHODS, TOOLS OR SYSTEMS OPERATED OR STUDIED

2.1. Practice, technique, method, tool or system operated or studied during the mission

Post closure criticality safety assessment

Description

Post closure criticality safety assessment comprises a number of tools and techniques used to demonstrate the criticality safety of fissile material management and disposal.

One important aspect for the post-closure criticality safety of a repository is scenario development, which is concerned with how a critical configuration could form in the long term after disposal. This requires an understanding of the evolution of the repository post closure as well as the physics of criticality. An assessor must determine which processes and events could lead to a more reactive system.

Another important tool is computer modelling of neutron transport to determine the neutron multiplication factor (k-eff) and therefore reach a decision on whether the system is (or is close to) critical. Neutron transport codes can be deterministic codes (e.g. WIMS) or Monte Carlo codes (MCNP, MONK, etc). Hand methods are also sometimes used for very simple systems or for sanity checking the results of computer codes.

Both methods must be supported and validated by experiments and nuclear data, and ensuring that published experiments adequately cover the scenarios relevant to the post closure phase is of common interest to the disposal community.

The approach to post closure criticality safety assessment across WMOs in different countries has largely developed in parallel, building on best practice and techniques although with information sharing often limited to published reports and policies.

Usage

The workshop provided a forum for WMOs and supporting practitioners to provide an update to the community on their progress and priorities in this field. It also presented an opportunity to develop a common understanding of prevailing issues in post closure criticality safety and for peer learning from successes in the field.

Benefits

This mission helped me to develop my capability as a criticality practitioner and to align my work on post closure safety with the prevailing approach and best practice within Europe (as well as the US and Canada). I am involved with the development of post closure criticality safety cases for NWS (the UK WMO) and so my participation is consistant the goals of the PCCS project and the goals of EURAD.

Limitations

Understanding of the development of critical systems in the post closure phase involves knowledge of the movement and relocation of material in a GDF setting over extremely long timescales. The results of a criticality safety study in this context are strongly dependent on the starting assumptions and which scenarios are considered credible. Contributing to reducing uncertainty in this field and developing common and substantiated assumptions is a goal of this workshop.

Applicability

My organisation has been and continues to be intimately involved with the development of post closure criticality safety assessments for the UK's geological disposal programme and works with a number of other European WMOs including Nagra in the field. An outcome of this mission is the alignment of my understanding and practice as a supporting practitioner with the European consensus.

2.2. Practice, technique, method, tool or system operated or studied during the mission

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Description

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Usage

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Benefits

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Limitations

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Applicability

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2.3. Practice, technique, method, tool or system operated or studied during the mission

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Usage

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Benefits

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Limitations

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Applicability

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2.4. Practice, technique, method, tool or system operated or studied during the mission

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Description

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Usage

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Benefits

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Limitations

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Applicability

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3. MISSION FINDINGS AND CONCLUSIONS

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3.1. Lessons learned and conclusions

For me personally the PCCS workshop provided an opportunity to have a look across the field of repository post-closure criticality safety. It provided an overview of the approaches taken by different WMOs and the challenges faced by individual countries as well as by the field as a whole. Outside the formal workshop sessions, periods including lunch breaks, the conference dinner and the excursion allowed me to engage with experts in the field directly which enabled me to learn in a more qualitative way.

3.2. Relevant findings and conclusions for home organisation

See Section 3.4.

3.3. Relevant findings and conclusions for host organisation

See Section 3.4.

3.4. Relevant findings and conclusions for other organisations

The workshop enabled substantial information sharing between all participants, which spanned all of the addressed technical topics (see mission journal). Overall it was found there is substantial similarity in the approaches adopted, with deviations well founded on the differences between national programmes and their regulatory framework. This suggests that good practice is being followed in this field by participants and provides independent verification of key findings and assumptions. As an example, the findings by NWS in the UK of only minor consequences in the event of a post closure criticality was found to align with findings by the US DOE, as was the assessment that a steady state criticality was the most likely outcome. In some fields, work undertaken by participants proved useful for others in the development of their own programmes which is likely to save work.

4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

4.1. Generic potentials

The PCCS workshop enabled participants to collaboratively identify key potential areas for collaboration, including verification analyses. These will be developed along with the project and enable substantial labour saving across the participants.

4.2. Potentials for home organisation

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4.3. Potentials for host organisation

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APPENDICES

Mission journal

05/09/2022

The first day of the workshop consisted of a set of roundtable updates by the WMOs on their progress in the field of spent fuel criticality safety. Presentations were given by the IGDTP member organisations ONDRAF (Belgium), ENRESA (Spain), PURAM (Hungry), ANDRA (France), BGE (Germany), SKB (Sweden), Posiva (Finland), NWS (UK), Nagra (Switzerland) and affiliated partners DOE (US) and NWMO (Canada). Following the updates were the technical discussions which took the form of a number of guided discussions.

The first area of discussion was the differing regulatory environments between countries, in particular whether participants needed to meet a prescriptive criticality safety criterion (value of K-effective), whether post-closure criticality was absolutely excluded or if consequences-based arguments would be considered and whether Burn-Up Credit (BUC) arguments were permissible.

The following topic was the application of BUC, with key subtopics being which radionuclides are included in assessment, assumptions which can be made about the co-dissolution of fission products and actinides, cases for which BUC arguments do not need to be made (largely unenriched fuels). The approach to BUC was also discussed. Most participants reported adopting a loading curve-based approach for most spent fuel, the US adopts an as-loaded approach for the majority of their inventory due to their interest in disposing of already loaded Duel Purpose Canisters (DPCs). It was noted that BWR fuel has a much less homogeneous burn than PWR fuel necessitating either much more complex calculations or pessimistic assumptions to be made.

The final discussion topic was data validation and uncertainty, which is broadly split into uncertainty in the criticality calculations from nuclear data (requiring validation through further criticality experiments) and uncertainty in burn-up assumed in the fuels (requiring validation though Post Irradiation Examination of spent fuel (PIE)).

06/05/22

The first discussion topic for the second day was the treatment of misloading events. The prevailing view was that this can be neglected in situations where all fuel present is below the loading curve (the approach adopted by Posiva) or where irradiation examination to validate the expected burnup is carried out immediately prior to loading (SKB). Otherwise, analysis is needed to demonstrate that under a misload scenario, criticality will not occur (DOE). The end of the first day also had the conference dinner, which gave an opportunity for discussion with other criticality professionals in a less formal setting.

The second area for discussion was data record requirements with key issues being ownership of the records, maintaining and validating existing records and situations where the necessary records do not exist. It was broadly recognised that the challenges in this field are very similar and it would be beneficial to collaborate to develop the database infrastructure necessary to properly maintain the requisite records.

In the afternoon of the second day an excursion to the Grimsel test site (an underground rock laboratory) was organised by the hosts. This provided an opportunity to see prototype emplacement machinery, key features of the granite body, a scale mockup of a

spent fuel disposal container and a number of former and ongoing experiments at the test site.

07/05/2022

The third day opened with discussion on communication strategies regarding criticality safety. This can be split in to two primary domains; communications with regulatory and governmental bodies and communication with the public. Partners with more progressed programmes shared their learning on this topic and some of the related pitfalls. A key learning point was improving public messaging by folding post closure criticality safety into the larger messaging about the overall safety of a facility.

The meeting closed with discussion of potential further activities, which included interactions between the project and other bodies such as the NEA's WPNCS, the collaborative development of a reference case for spent nuclear fuel, an exercise to compare loading curves developed by different WMOs.

MISSION BENEFICIARY

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PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

N/A

Home organisation experts

Tim Hicks

Senior Criticality Safety Consultant

Criticality Team

Galson Sciences Limited

Other organisations experts

N/A

REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
Date of last signee	Callum Eldridge	Tim Hicks	Name
			Visa