EUROPEAN COMMISSION

Community research

safe solutions for radioactive waste

Implementing Geological Disposal of Radioactive Waste - Technology platform

IGD-TP Exchange Forum n°5

October 28-30th, 2014, Kalmar, Sweden

Presentations and outcomes

www.igdtp.eu

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

Forewords

After the IGD-TP 4th Exchange Forum (EF4) held in 2013 in Prague, the Implementing Geological Disposal of Radioactive Waste – Technology Platform (IGD-TP) proceeded with the definition of two proposals submitted to the first Horizon 2020 call, the first on Cement (Cebama) and the second on Monitoring (Modern2020). These two Topics were discussed in specific working groups during EF4.

In addition, proposals for new working groups on Cement-organics-radionuclides interactions, Microbiological issues and "SAFEROCK" were brought up during the EF4. The IGD TP Executive Group decided to launch these WGs and will evaluate the possibility to set up common projects consistent with the Strategic Research Agenda (SRA).

The Master Deployment Plan 2014 was issued in mid-2014. It takes into account the outcome of all the Joint Activities in 2013. The Joint Activity outlines have been updated with the latest inputs from the working groups. They will also serve as a roadmap for the new technical projects.

Furthermore, in the last EF4, the IGD-TP/SNETP Information Exchange Platform offered the opportunity for both platforms to present insights on new waste forms and their potential consequences on the design and safety assessment of a geological disposal facility.

Finally, the IGD-TP has held discussions with the SITEX project in order to develop synergies and increase coordination of national research programmes in the field of management of spent fuel and radioactive waste. This action is aimed at reviewing all strategic aspects linked to a stepwise move to joint programming in this field to address uncertainties about the safety of geological disposal with a special attention being paid to stakeholders' concerns regarding all radioactive waste materials to be disposed of.

The aims of the 5th Exchange Forum were to:

1. Provide a forum for informal exchanges between the participants around common interests in RD&D;
2. Inform on working groups activities and EC projects ;
3. Explore the main achievements of the IGD-TP since its inception and to discuss if the priorities presented in the SRA have been adequately covered by the joint activities and associated projects.
4. Express new ideas that could complement our SRA priorities and that could lead to new Research, Development and Demonstration (RD&D) topics over the next five years.
5. Continue the work with SITEX and SNETP started in 2013 in order to bring forward new subjects for collaboration and/or identify subjects of common interest.

To fulfil these objectives, the Exchange Forum lasted two days. Participants (about 130) took part in plenary sessions as well as four parallel Working Group sessions and a walkabout session organised by the Competence Maintenance, Education and Training (CMET) Working Group to address the prerequisites for a voluntary accreditation scheme for Geological Disposal. A separate report on this session will be produced early next year.

Finally, a visit of the Äspö laboratory was organised for the EF5 participants.

In this document you will find all the abstracts of presentations as well as the outcomes of the four working group sessions.

All presentations are available on the IGD-TP website www.igdtp.eu.

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Plenary session 1
Abstracts

Towards Joint Programming of EU Member States RD&D programmes for the management of radioactive waste in Euratom Horizon 2020

Christophe Davies, European Commission, DG Research and Innovation, Fission Energy

Research, development and demonstration (RD&D) on the management and disposal of high-level and other long-lived radioactive waste and spent nuclear fuel in deep geological repositories has been carried out for several decades in the EU Member States (MS) and as part of the Euratom Framework Programmes (FP) for Research and Training since 1975.

In FP7 , the objectives of the programme in the area management of ultimate radioactive waste were the continuing development of a common European understanding of the scientific/technical issues, the establishment of common research priorities, and support for joint implementation of related research and coordination activities. Euratom provided a total funding to this area of EUR 56.7 million.

In the Euratom Horizon 2020 FP (2014-2018), the EC is now fostering the development of Joint Programming and implementation of MS research programmes. The aim will be to establish and implement a coordinated programme of research activities of EU added-value. Such programme would need to fulfil the needs of the wider community including WMOs (vision 2025), Technical Support Organisations to regulatory authorities, other public programmes supporting basic research and longer-term oriented science; competence development of less-advanced national programmes with implementation perspectives well beyond 2025, engagement of citizens and civil society, competence maintenance and education and training, management and dissemination of knowledge and results, international cooperation as well as socio-economic activities.

The objective of this presentation is to elicit this EC policy.

Conclusions and recommendations out of the EURADWASTE'13 conference

Gunnar Buckau, JRC-ITU, European Commission, DG Joint Research Centre, Institute for Transuranium Elements

Euradwaste '13 was organised in Vilnius, Lithuania on 14 to 17th October, 2013. This was the eighth conference is the series, this time concluding the seventh Euratom Research and Training Framework FP7, covering the period 2007-2013.

The main objective of the event was to take stock of the results obtained in the activity area "Management of ultimate radioactive waste – geological disposal" of the programme, indirect actions. Other key objectives were to analyse socio-economic and political issues at EU and MS level and to discuss possible action plans for the future.

Five sessions were held to address policy, strategies, science and technologies in the field. Specific effort was placed in producing summaries of the conference, the sessions and panel reports. These together with the high level keynotes have brought out a number of key messages and outlined possible lines of R&D activities, which could be taken-up by the research community and addressed within IGD-TP.

The aim of this presentation is to present these key messages and recommendations.

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What does the public really want when engaging with the nuclear industry?

Laurel Boucher, The Laurel Co., USA

The nuclear industry has evolved in terms of how it engages the public, yet it still experiences many challenges. It can be useful to step back and inquire, "So what does the public really want when engaging with the nuclear industry?" This keynote speech offers multiple theories from the social sciences to help answer this question. At the core is application of the theory "Dominating Concepts" --- that ideas that dominate the general thinking in an industry exert a powerful influence on how people think and act. Dominating Concepts are sometimes obvious but are often in the background. By examining ideas that dominate the nuclear industry's thinking as to what the public really wants, it becomes possible to recognize why and how these often produce the opposite of what is desired.

In this speech, one Dominating Concept widely held in the nuclear industry is examined. Through this it becomes possible to understand why the public may not respond to scientific explanations, why the public may distrust the nuclear industry, or why the public may engage the political process.

An industry may seek to adopt new concepts or ideas to influence how people think and act. Three new concepts as to what the public really wants when engaging with the nuclear industry are proposed. Each is examined, and insights and practical suggestions are provided.

The ENEN Association and its missions: an update looking beyond its 10th Birthday

Walter Ambrosini and Pedro Porras Dieguez, ENEN Association

The European Nuclear Education Network (ENEN) was founded by 22 institutions in 2003 as a no-profit Association under the French law. From that time on, ENEN grew in size and breadth of scope, totalling at the time of writing more than 60 Members and organisations linked by a MoU, both in Europe and abroad.
In the last decade, several important targets were successfully achieved by ENEN, including the design and the implementation of the European Master of Science in Nuclear Engineering (EMSNE) certification, the organisation of PhD Events, the knowledge management actions and the numerous European projects that the Association was coordinated or took part in. This service to the citizens of Europe and abroad, in maintaining and developing the opportunities to access to knowledge, skills and attitudes in the nuclear fields, represents the main mission of the Association, having the ambition to be a bridge between academia and the relevant stakeholders.
The involvement of the Geological Disposal (GD) and the Radiation Protection (RP) communities in the actions of the Association has been one of the important aspects taken care by ENEN in developing its work. Common projects have been and are being run and a growing attention is mutually paid by these communities to each other. In fact, the many interfaces existing in the field of education and training among the Nuclear Engineering and the GD and RP related disciplines ask for a strict coordination of actions, to avoid replication of efforts and to mutually interact to share resources, as courses and infrastructures, in the common benefit.
While celebrating its 10th Birthday (22 September 2013), the Association was already engaged in a major effort for developing and share nuclear safety culture competence, in the frame of the NUSHARE Project. The Project is aimed at setting up Education, Training and Information (ETI) actions for three target groups, schematically described as: 1) decision / policy makers and journalists; 2) personnel of TSOs and NRAs; 3) personnel of industry. This action, directly required by the cabinets of two EU Commissioners after the Fukushima event, represents a considerable endeavour, owing to its importance and visibility. The ENEN Association is therefore aiming at catalysing the available resources in this field, in order to pay its service to the European Community. In this effort, an even better cooperation with the GD and RP communities will provide greater opportunities of success.

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Working Group 1: Safety Case: Handling of uncertainties

Rapporteurs: Ulrich Noseck, GRS and Dan Galson, GSL

Safety cases are based on understanding the intrinsic safety of a disposal system in terms of the safety functions provided by multiple barriers. This understanding is demonstrated by presenting a range of different safety arguments, e.g. information derived by analogue studies, and modelling results. Such modelling needs to take into account the inevitable uncertainties that arise over such long timescales. Proper handling of uncertainties in the safety case is an important topic that has been identified by a number of WMOs and stakeholders. Work on this has been published by the OECD/NEA and the IAEA, as well as carried out in the context of previous EC R&D projects (e.g. PAMINA).

The ultimate goal "to have confidence" in the long-term safety of geological repositories means "to have reached a positive judgment that a given set of conclusions are well supported". To reach this goal for a specific disposal concept and site under consideration, it is necessary to identify uncertainties and to assess their influences on the relevant Safety functions. Uncertainties need to be considered in the scenarios, models and data that underpin the safety case. The "Handling of uncertainties" comprises of the investigation, management and communication of these uncertainties, including analysis of the influence of quantifiable uncertainties on the results of post-closure performance assessment. Not all uncertainties are significant or detrimental to safety. There are different strategies available for handling uncertainties, and the IGD-TP technical working group on *Safety Case: Handling of uncertainties* is exploring and further developing these strategies.

The Working Group addresses three topics:

1) Management of uncertainties. This comprises general strategies for management of uncertainties, specific aspects of handling uncertainties in different time frames, regulatory decision-making under uncertainty, and communication aspects.

2) Uncertainty identification and quantification. This is focused on the use of expert judgement to quantify uncertainties, derivation of probability density functions for parameter value uncertainties, and consideration of the importance of correlated uncertainties.

3) Sensitivity analysis. This aims at providing a survey and assessment of sensitivity analysis methods in view of the requirements of post-closure performance assessment, a comparison of methods using numerical experiments, and consideration of the relationship between the results of sensitivity analysis and the identification of R&D needs.

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Abstracts

Uncertainties in safety case: How to move beyond PAMINA

Manuel Capouet, NIRAS/ONDRAF, Belgium

The three-years project, PAMINA, provided a comprehensive catalogue of methodological and analytical approaches to treat uncertainties. Some of them were developed and tested in the framework of this European project. This presentation proposes to revisit PAMINA outcomes and to identify possible pathways for future investigation to improve uncertainty management in safety cases.

Andra's Strategy and Approach for Management of Uncertainties in Post-Closure Safety of Geological Disposal

L. Griffault, S. Voinis and M. Burgio, Andra, France

The French National Radioactive Waste Management Agency, or Andra, has, among its roles in management of radioactive waste, to ensure the protection of man and the environment from all radioactive waste generated in France. In order to verify compliance to the safety objectives, radiological and chemical impact evaluations are to be assessed. Development of scenarios constitutes the fundamental basis for the quantitative assessment as well as the choice of data and models that underpin the safety case. Different types of scenarios are usually considered, including a 'base case scenario' and 'alternate evolution scenarios'. One key element to establishing scenarios is the handling of uncertainties.

The objective of the paper is to present the approach for managing uncertainties in the post-closure safety of Geological Disposal.

Andra has implemented a specific Qualitative Safety Analysis (QSA) methodology in the framework of the Dossier 2005 [1] that aims to link technology characteristics, functions and state of knowledge at each stage of the project development. The QSA aims at exploring possible dysfunctions of the repository components (waste package defects, seal failures, etc.). It proposes design measures to reduce their occurrence, and identifies scenarios to be assessed: Normal Evolution Scenario (NES) and Altered Evolution Scenarios (AES). The analysis studies each uncertainty that may either (i) affect a component ability to perform a safety function, or (ii) have an influence on another component's ability to perform a safety function. To master uncertainties or events of any type, "QSA" proposes either design measures or calculation cases through scenarios (NES or AES). A set of AES scenarios is then developed to provide a description of the calculation cases to be quantified in relation to the uncertainty(ies) or event(s) (internal or external) which affect the safety functions. The "AQS" offers an integrated and structured vision of all uncertainties, their impact on post-closure safety functions and how those uncertainties are managed.

Uncertainties are categorized into two types: (i) internal uncertainties which are associated with waste and site characteristics (including the inventory estimation), and the process governing the evolution of the repository (like as THMCR behaviour and the models used to represent them) and (ii) external uncertainties which are associated with events like earthquake, flooding, climate condition and inadvertent human intrusions. The QSA is performed component by component and relies on the functional analysis, on the phenomenological analysis (PARS) and FEP's database (international AEN database and Andra's data base).

REFERENCES:

[1] Andra (2005). Safety Evaluation of a Geological Repository – Dossier Argile 2005 ». Report Available in English on Andra's site www.andra.fr

Assessment Timescales and Complementary Safety Arguments

Daniel Galson, Galson Limited, UK

This presentation will describe some recent work considering quantifiable and unquantifiable uncertainties in post-closure safety assessments for higher activity wastes. In particular, the presentation will consider issues around the timeframes for which it may be appropriate to quantify uncertainty in post-closure assessments using a probabilistic approach. This will be set within the context of the wider approach to safety assessment based on a safety narrative and using complementary safety arguments.

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Sensitivity Analyses: Theoretical Background, Use in the Safety Case, and Related Research Activities

Klaus-Jürgen Röhlig, TU Clausthal, Germany

A wealth of – often very sophisticated – methods and approaches for sensitivity analyses is being proposed and investigated by theoreticians, several of them being subject to research performed by safety assessment specialists (e.g. in EU's PAMINA project as well as in current research projects run by GRS and TUC). However, practical application in safety cases for deep disposal is mostly limited to linear and rank-based regression approaches. Practitioners often claim that these latter methods sufficiently fulfil the needs of a safety case.
The presentation will address this apparent antagonism by (i) providing an overview of the capabilities of several methods, (ii) reporting about recent research activities concerning the use of sensitivity analyses in safety assessments, and (iii) addressing open questions.

Overview of advantages and drawbacks of different methods for sensitivity analysis in the context of performance assessment

Dirk-Alexander Becker, GRS, Germany

Sensitivity analysis is an important tool for analysing final repository performance assessment models, since it helps the modeller to understand the model behaviour and to identify research needs. A number of sophisticated numerical methods for probabilistic sensitivity analysis have been developed in recent years, which work differently well on typical performance assessment models. The talk gives an overview of different types of methods and their specific advantages and drawbacks when applied to such models.

Sensitivities of the long-term safety results in SKB's licence application for a spent fuel repository

A. Hedin, SKB, Sweden

This talk presents sensitivity analyses of the results of radionuclide transport calculations in the safety assessment SR-Site that formed part of the Swedish Nuclear Waste Management Co's (SKB's) license application for a KBS-3 final repository for spent nuclear fuel at the Swedish Forsmark Site. The application was submitted on March 16, 2011 and is currently subject to regulatory review.

Several scenarios were analyzed in the assessment, and the sensitivity analyses presented here concern the scenario that dominate the calculated risk for the repository, namely one where the protecting buffer surrounding the canisters in the KBS-3 repository concept is eroded such that advective conditions are established in the deposition hole leading to enhanced canister corrosion and eventually canister failure; the so called erosion/corrosion scenario. Some of the methods and results are presented in the SR-Site main report whereas others have been developed and applied after the completion of the SR-Site assessment.

Regarding sensitivities, it is of interest to determine i) the input parameters that correlate with the dose over the entire dose range and ii) the input parameter values that are related to high and low doses. Ra-226 dominates the dose in most of the realizations in the erosion/corrosion scenario and it is thus of particular interest to clarify sensitivities of the Ra-226 dose to input parameters.

The first purpose is achieved with a global sensitivity analysis and two methods are used: i) determination of standardized rank regression coefficients (SRRC) and ii) an analysis of variance based sensitivity indices according to Sobol'.

The second purpose is also achieved with two methods: i) the calculation of conditional mean values and ii) the application of so called cobweb plots, where input parameter ranges associated with a particular percentile of the dose result are shown graphically.

Finally, the results of all the above methods is corroborated by the use of i) a tailored regression model and ii) a partition plot that both demonstrate how the variability in the output can be explained with analytic expressions derived from the conceptual understanding of the transport processes involved in the dose calculations.

All methods point to the same few parameters being the most important for both the overall variance and the extreme outcomes.

Uncertainty and sensitivity analysis applied to performance assessment of a deep geological disposal in the French context

Jacques Wendling, Andra France

In the field of performance and safety assessment of radioactive waste disposal, Andra has been carrying out for many years specific studies in order to quantify propagation of uncertainties in the models, and consequences on PA/SA indicators. Studies on uncertainties have two main objectives:

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first one aims to quantify variability of the indicator (uncertainty analysis), taking into account all kinds of uncertainties, second one aims to identify and rank input data or model which manage variability of the indicator (sensitivity analysis).

To fulfill objectives by handling multiparametric sensitivity analysis, Andra has developed, implemented and used several relevant methods, according to the complexity of the problem (depending on number of input data, non-linear phenomena, size of the problem …). These methods, such as local ones (partial derivate of an output) or global ones (probabilistic Monte-Carlo with correlation/regression or variance-based methods, which need to build metamodels) enable to provide many useful information about the behaviour of the system.

The aim of the presentation is, through several examples applied to performance assessment of french radioactive waste disposal, to describe the methodology (uncertainty of parameter/model according to the level of knowledge, definition of correlations between input data, sampling methods, calculation tools, statistical indicators), and relevant results given by each method.

Simplified approach to elicitation of expert judgement in quantification of uncertainty

M. Poole, RWM and D. Galson, GSL

Probabilistic approaches to performance assessments for radioactive waste disposal facilities require experts to quantify their uncertainty in various parameters. When people quantify uncertainty and estimate probabilities, they tend to make use of mental 'heuristics' that can be applied quickly and which have served us well in the environment in which we evolved. However, studies have shown that these heuristics lead to biases, usually overconfidence. These biases can be overcome using formal, facilitated elicitation methods that employ a structured approach to the quantification of experts' uncertainty in the form of a probability density function (PDF). These methods can be time and resource intensive, and we wish to propose a multi-level approach to elicitation, where the resources used are commensurate with the amount of information available and the importance of the parameter to assessment outcomes. At the least resource intensive end, we would like to evaluate the extent to which an 'intelligent' software tool can lead to efficient, but unbiased elicitation of PDFs representing the uncertainty in a parameter.

Comparison of probabilistic and alternative evidence theoretical methods for the handling of parameter uncertainties resulting from variability and/or partial ignorance in safety cases

Rainer Barthel, Brenk Systemplanung, Germany

Models of radionuclide release and transport in a deep geological repository of radioactive waste contain uncertain parameters. The treatment of such uncertainties, which result from variability and/or partial ignorance, is an essential issue of performance assessments. Bayesian methods are frequently used for the description of both aleatory and epistemic uncertainties, taking the probability density functions (PDFs) of epistemic uncertain parameters as subjective degrees of belief. Bayesian methods are well suited for the specification of epistemic uncertainties of PDF parameters resulting from the limited sampling of variable physical model parameters. For expressing epistemic uncertainties concerning physical parameters due to partial ignorance, alternative methods of the Evidence Theory developed by Dempster and Shafer, including the Probability Theory and the Possibility Theory as special cases, seem to be more appropriate. This is demonstrated by means of a few examples concerning epistemic uncertainties of PDF parameters, compartment model parameters and the description of statistical dependencies between model parameters by means of Copulas.

Fast Computational Methods for Handling Large Scale Data Uncertainty Problems

Gabriel Wittum, Steinbeis GmbH, Univ. Frankfurt

Models To model data uncertainty, we use high-dimensional Fokker-Planck equations to determine the probability density functions for the relevant quantities. Due to the high dimensionality, Monte Carlo methods are widely used for the solution of this kind of problems despite their poor convergence behaviour. Solving these high dimensional equations demands special highly efficient numerical methods. Several methods for the solution of PDEs arising in the mentioned context have been developed.

It is widely recognized that high-dimensional problems often posess an underlying structure commonly called effective dimension [1], which explains the good performance of Quasi-Monte Carlo methods for such problems. Up to now, such methods have been mainly developed for applications from Computational Finance, where handling data uncertainties are considered a

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crucial and central problem since a long time. Analysis of variance (ANOVA) decompositions can exploit the low superposition dimension of the problems, and the corresponding expansion can often be truncated up to second order terms. Reisinger and Wittum [2] however, developed an asymptotic expansion of the problem using the eigenvalues of the covariance matrix.

In the talk, we present the basic model and a numerical reduction approach based on the asympototic expansion by Reisinger and Wittum. We expand the methodology to an asypmtotic expansion of second order and show accuracy and performance of the expansion through several examples from computational finance, i.e. geometric and arithmetric basket options on a hypothetical fivedimensional basket, a 30-dimensional basket on the german main equity index (DAX) and benchmark problems with even higher dimension. Transfering this approach to groundwater modeling and handling saftey cases will be the objective of a future project.

References

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Journal of Complexity, 19(2):101–124, 2003.

[2] C. Reisinger and G. Wittum. Efficient hierarchical approximation of highdimensional option pricing problems. SIAM Journal on Scientific Computing, 29(1):440, 2008.

The use of natural analogues in the Finnish safety case

Barbara Pastina Posiva, Finland

At the end of 2012, Posiva submitted the construction license application for its spent fuel geologic repository. Posiva discussed natural analogues in the Complementary Considerations report (POSIVA 2012-11), which is part of the safety case supporting the license application. According to the Finnish regulations, the significance of scenarios that cannot be assessed by means of quantitative safety analyses can be examined by means of complementary considerations, such as comparisons with natural analogues or observations of the geological history of the disposal site. The significance of such considerations grows as the assessment period increases, and safety evaluations extending beyond the time horizon of one million years can mainly be based on complementary considerations. Complementary considerations are used in parallel to the actual safety assessment to enhance the confidence in the results of the analysis or certain part of it.

Information exchange: the role of NAWG in the past and the way forward tomorrow R.

Alexander, Bedrock Geoscience

One of the significant challenges for repository safety assessment is how to handle the uncertainties inevitably related to the very long time frames to be considered. One particular task is to extrapolate the likely long-term (i.e. 105 to 106 a) behaviour of the repository from the necessarily short-term laboratory and medium-term rock laboratory data currently available. There has been a recognition that natural analogues (NA) can positively contribute to multiple lines of reasoning in a Safety Case, along with other forms of study and the application of complementary safety indicators (e.g. NEA, 2012), which is reflected in their frequent use in recent safety cases (Ref.).

The NA approach, in common with the fields of philosophy, biology, linguistics and law, utilises the analogue argumentation methodology. Here natural (along with archaeological, anthropogenic, industrial, operational, social and self) analogues – systems which have similar properties to components of repositories have an unique role to play in supporting the Safety Case.

In 1985, owing to the considerable upsurge of interest on the topic of NAs at that time, a group of individuals working for or in national waste disposal programmes, took the initiative of establishing NAWG, the Natural Analogue Working Group. This was carried out to offer an international forum for:

- The discussion of NA programmes from around the world.
- Assessing the relevance of NAs to radioactive waste disposal
- Defining ways to apply NA data to safety assessment
- Examining appropriate ways to support the Safety Case with NA information

We propose the integration of NA into TP´s research area portfolio and recommend interaction with the international Natural Analogue Working Group as their experience and networks will be of use for members´ purposes, application and use in other areas, including support of less advanced programmes.

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Outcomes
Working Group 1: Safety Case: Handling of uncertainties

Presented in Plenary Session 2 on October 29th

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TWG 1 – Safety Case: Handling of uncertainties

Dan Galson (GSL)
Ulrich Noseck and Dirk Becker (GRS)

IGD-TP Exchange Forum n°5, October 28-30th 2014, Kalmar, Sweden

Safety assessment for disposal of higher-activity waste: background

25 years since initial European collaborative projects (EC PAGIS)

- Calculations demonstrated feasibility of meeting safety criteria for clay, salt, crystalline host rock

EC Pamina (2006-2009) and recent NEA IGSC and IAEA projects are part of ongoing dialogue on good practice

WHAT'S CHANGED: Site-specific licensing assessments underway (Finland, Sweden), based on methods developed over 30 years

- Safety case being prepared for a GDF in France (2016)
- Site-specific work underway in Switzerland and other countries

Changing needs and interests

Need to combine needs and interests of:

- Advanced programmes with specific sites
- Less advanced programmes in generic or research phase

A Programmes at site-specific licensing stage

- Data rich
- Sufficient research for current licensing stage
- Methodology refinement and optimisation

B Programmes without specific sites

- Data hungry
- Focus on research / safety case methods / trial calculations

Integrating themes

Previous EC collaborative work focused on the detail of PA calculations and treating uncertainties in PA

- …there are wider issues in managing uncertainty in a safety case

Main areas of need

- Integrating PA and wider use of the safety case in national programmes
- Refinements to PA approaches in selected areas
- Building experience of working with site-specific data for those countries without a site

Can integrate the interests of A and B in these areas

Collaboration themes IGD-TP JA8 Managing uncertainties in the safety case

- Review learning from recent safety cases
- Holistic approach to treating uncertainty in a safety case
  - Propagation of uncertainties through different parts of a safety case
  - Linking analysis of uncertainty between detailed sub-system performance models or research models and integrated total system models
- Structured approaches to presenting how uncertainties are treated in a safety case
  - Communicating about treatment of uncertainty in a safety case to kinds of stakeholder (internal, external)
  - Different kinds of uncertainty (quantifiable, unquantifiable)
  - Treatment of uncertainties at different assessment timescales (e.g. glaciation)
- "Complementary arguments" in support of safety
  - Different types of argument needed for different assessment timeframes
    - Complementary indicators to dose and risk
    - Natural system studies / natural analogues
  - Information in different projects and national programmes – would be useful to review and assemble

Collaboration themes IGD-TP JA8 Uncertainty identification & quantification

- Review of learning from recent safety cases
- Different approaches for formal use of expert judgement to quantify uncertainty
  - PDF derivation
  - treatment of parameter dependencies
- Adaption of advanced approaches to improve calculational efficiency and application to safety assessment modelling
- Testing of existing guidance on sensitivity analysis and development of improved guidance
- Improved understanding of value of sensitivity analysis in a safety case (e.g. meaning of SA in a conservative calculation? Use in confidence building)

Continued international collaboration

Approach
- Review application in national programmes
- Methodological thinking
- Worked examples
- Synthesis

Aim is to compare viewpoints…
- *for different disposal concepts and environments*
- *for programmes at different stages of development*

…and integrate to build confidence in current approaches, to advance the state of the art where useful, and to build competency

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The right forum - Benefits of a dedicated project

A good time (2016-) to stand back and look collectively in some detail at application of methods to handle uncertainties in recent safety cases (France, Finland, Sweden, UK), across a wide range of areas
…but review is only a first step

Areas where improvements are possible have been identified
…a project will help bring these to fruition so they are ready for use in next update to safety cases in ~2020…
…leading to a significant contribution to achieving IGD-TP vision for first repositories by 2025
….and better safety cases (when produced) by the countries with less advanced disposal programmes (still in generic or early siting phases)

A dedicated project will allow for more intensive collaboration and co-ordinated, hands-on learning from experience and methodology refinement….
…. much more powerful means of learning and improving than a simple talking shop

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Natural Analogue Working Group

Running continuously for 30 years

Increasing interest
- In the beginning oversold....
- Where can natural analogues build confidence in different kinds of safety argument? – top-down approach
- Natural (along with archaeological, anthropogenic, industrial, operational, social and self) analogues
- Now being increasingly factored into complementary arguments in support of safety (e.g. Finland, UK)

Interest in integration of NA into TP´s research area portfolio and recommend interaction with the international Natural Analogue Working Group

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Working Group 2: Microbiological Studies

Rapporteurs: Klas Källström, SKB and Karsten Pedersen, Microbial Analytics Sweden AB

The focus of the WG2 session will be on performance assessment and safety analysis issues. What is the state of art regarding the scientific microbiological knowledge data base in repository context: processes, modelling, parameters; treatment in design and performance assessment and safety analysis (PA/SA), remaining uncertainties on the scientific microbiological knowledge data base in PA/SA field and priorities for R&D to improve design and PA/SA.

Regulations concerning an assessment of long-term safety in final disposal of radioactive waste imply the following requirements.

- A safety analysis shall take into account features, events and processes (FEPs) that can lead to the dispersion of radioactive substances after closure.
- A safety analysis shall cover as long a period as barrier functions are required, but at least ten thousand years.

The WG2 session will identify microbial processes that can make a difference to existing safety analysis results. The outcome of our session will consist of a list of FEPs in which microbiological processes are important to include. Here are some examples for Scandinavian repositories, and we, the rapporteurs, are convinced that the session will identify similar topics for other European repository concepts.

- The processes that control microbial sulphide production in repository environments require more attention. Examples: Posiva report 2014-01 (available on www.posiva.fi), SKB-P-10-18 and SKB-TR-13-12 (available on www.skb.se).
- It is assumed that oxygen infiltrating the underground will react with minerals and microbial processes are mostly ignored. Glacial melt water is thought to be sterile. However, there are rapidly growing evidences in the scientific literature that glaciers and their meltwater are densely populated with microorganisms. How does this new information influence safety analysis? Example SKB-TR-10-57.
- Microbial influence on radionuclides and their migration is ignored in most repository concepts. The main question remains, to what extent can microbial processes influence migration related FEPs and the concomitant safety analysis regarding radionuclide migration?
- In repositories for low- and intermediate level waste, methanogenes may change the speciation of loosley bound C-14 and alter the dispersion. Breakdown of complexing agents might reduce the risk of dispersion due to formation of stable soluable complexes.

To make the purpose of the WG2 session short: Can we identify microbial processes that can lead to larger (or smaller) dispersion of radioactive substances after closure than what present day assessment models suggest? Can we put the processes we identified on the IGD-TP exchange forum in Prague in a safety analysis perspective? How much difference can a specific microbial process do? Should a factor of 2, 10 or more be added to the dispersal calculations, will the time frame for dispersal and transport change, will radionuclides take new ways to the surface?

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Abstracts

Improving realism and reducing pessimisms in the safety case for geological disposal of ILW

Joe Small, National Nuclear Laboratory,UK

Safety cases for geological disposal of intermediate level waste (ILW) recognise that microbial processes may occur in the waste and the barrier systems, but mostly no explicit account is taken of the effects of microbes in performance assessment (PA). In some instances, such in considering the speciation of redox sensitive radionuclides (e.g. Se, Tc, U) it is assumed that microbial processes may mediate processes governed by thermodynamics and so may not require specific representation. In other cases such as in considering gas generation PA calculations take a conservative and pessimistic approach that only consider gas generation processes (e.g. H2 by corrosion and radiolysis and microbial generation of CH4), but neglects processes such as sulphate reduction which may consume H2 and CH4 electron donors or may outcompete with methanogenesis. Similarly, PA studies include factors that enhance the mobility of radionuclides due to the effects of organic complexants, such as formed by alkaline degradation of cellulose, but they do not consider the complete process that includes microbial degradation to thermodynamically stable CO2.
There is a growing body of literature concerning the above microbial effects (FEPs) that could be incorporated into safety case documentation and included in PA calculations. Such an approach may have a direct effect on reducing the estimates of radionuclide migration through gas and groundwater and may have secondary effects on understanding the coupled physical effects on the barrier system. There are remaining uncertainties that will need to be considered such as concerning the combined effects of biodegradation and radiolysis under higher pH ILW conditions and the range of microbial processes that may operate under the physical and chemical conditions of an ILW repository. However, it should be possible at this stage to improve the realism and communicate the issues and remaining uncertainties concerning microbial processes in the safety case and PA for geological disposal of ILW.

Microbially induced corrosion under repository environments

Pauliina Rajala
VTT Technical Research Centre of Finland

In Finland the corrosion studies of metallic waste were started in 1998. First studies concentrated on metallic low and intermediate level nuclear waste that is produced during operation, maintenance and decommissioning of nuclear power plants. A long-term field exposure study showed high corrosion rates, which indicated that microorganisms play a role in the corrosion process. Subsequently, we have verified that a vast community of microbes, both archaea and bacteria, are inducing corrosion of steels under repository conditions. The studies targeting microbially induced corrosion in the low and intermediate level nuclear waste repository environment are still ongoing. During the last few years we have initiated studies on microbially induced corrosion as this process could compromise the integrity of the copper canisters in the high-level nuclear waste repository environment.

Potential impact of alkaliphilic bacteria on ILW-geodisposal scenarios: reducing unwarranted conservatism is safety assessments

Jon Lloyd, University of Manchester, UK

Microbial metabolism is under-represented in many safety assessments, or considered in worse case scenarios which are often unrealistic. In the case of ILW, it has largely been assumed that microbial metabolism will be minimal in the harsh cementitious near field environment. However, recent laboratory studies are suggesting that this is not the case. This presentation will give an overview of recent work that has quantified anaerobic microbrobial metabolism using samples from an analogue site for an evolved cementitious ILW-GDF, focusing on gas metabolism, complexant biodegradation, biomineral evolution and radionuclide biotransformations. By comparion with esablished models, collectively these studies suggest that current ILW safety cases are unduly conservative in some key areas,

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and suggest new areas of reserarch that should be considered.

Role of Microbes in Features, Events and Processes (FEPs) relevant for geodisposal of radioactive waste in argillaceous host rocks

Natalie Leys, SCK•CEN, Belgium

Wouters K.[1], Moors H.[1], Weetjens E.[2], Leys N.[1]
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The demonstration of long-term safety of a geological disposal system for intermediate (ILW) and high level (HLW) radioactive waste generally involves the identification and description of a series of **Features, Events and Processes (FEPs)** which may occur during the operation of the facilities and during the post-closure period, and which will have to be taken into account for **Performance Assessment** (PA). The FEPs strongly depend, however, on the host rock and the disposal system selected. For the Belgian case, focusing on disposal in deep subsurface clay layers, a number of FEPs were selected which are specifically relevant for argillaceous host rock (1) or which are specific for the Belgian supercontainer disposal concept (2)(3).
Some of these FEPs might be influenced by microbial activity, and might on the other hand also affect microbial processes.
In general it is assumed that, **Features and Events, and Processes** of a **thermal**, **hydraulic** or **mechanical** nature, are not themselves affected by microbial activity, but are likely to impact the boundary conditions that define microbial survival and activity in a repository environment. They can either inhibit microbial activity (e.g. hot temperature by high heat release from waste, swelling of clay reducing porosity, etc.) or enhance it (e.g. tectonic uplift causing increase in clay porosity, warm temperature by slow heat release from waste). Therefore, experiments are ongoing or foreseen, to estimate boundary conditions for microbial life in the frame of the most relevant FEP-derived parameters in the Belgian case, including **pore size** and **temperature** (e.g. COSMOS and µPRACLAY projects**)**.

Features, Events and Processes that are related to the **chemistry** of the waste, the engineered barrier system (EBS), the excavated damaged zone (EDZ) or the host rock, seem more likely to be influenced by microbial activity. The 'chemical' FEPs that were identified for the Belgian supercontainer EBS concept (2), include waste solubility, precipitation and dissolution, corrosion, mineralogical changes, redox reactions and changes, pH conditions and changes, sorption and retardation, complexation, gas generation, speciation and the existence of chemical gradients.

As described in the FEPCAT report, a selection of FEPs for argillaceous host rocks were classified by a panel of experts for their relevance for PA and for the adequacy of their corresponding knowledge base (1). For diffusion-dominated argillaceous host rocks like the Belgian Boom Clay, **20 FEPs** were evaluated by this panel as relevant for PA, but at that time not yet sufficiently well understood, thereby including a FEP on microbial processes (1). These 20 FEPs might not all be relevant for all disposal systems, but yet give an indication of possible knowledge gaps for disposal in argillaceous host rocks in general.

In our opinion, in at least **4 of these 20 FEPs**, the evaluation of the impact of microbial processes could help filling these knowledge gaps:

1. *Natural organic matter and RN complexation (FEP no. 15)*:
   a. Microbial degradation of natural occurring organic matter, coupled to the enhanced bioavailability of the organics via thermal gradation due to heat release by HLW
2. *Redox buffering capacity of the host rock (FEP no. 27)*:
   a. Microbial consumption of electron acceptors
3. *Effects of repository components on pore-water chemistry in the host rock (FEP no.28)*
   a. Microbial induced carbonatation versus calcium leaching in cement
   b. Microbial consumption of $NaNO_3$ from bituminized waste
   c. Microbial gas consumption (H_2) and gas production (N-species, CH_4, CO_2,)
   d. Development of microbial biofilms on repository components (clogging, enhancing gradients)
4. *Organics from waste and their effect on RN transport properties of the host rock (FEP no.30)*
   a. Microbial activity inside ILW, potentially altering radionuclide speciation or release mechanisms
   b. Microbial consumption of organics in EBS and host rock
   c. Microbial release of radioactive C-compounds (e.g. CO_2, CH_4)

At present, the expected impact of microbial processes listed above are not or poorly studied, while the boundary conditions for microbial processes are only addressed at lab scale so far. As suggested in the FEPCAT report (1), the role of microbial presence and activity in relevant EBS, EDZ and host rock conditions, would be a valid

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object of future lab scale studies and *in situ* explorations in candidate argillaceous host rocks

Understanding the microbial processes listed above, and their connection to known FEPs, might prove useful for assessing their relevance at the temporal and/or spatial scale considered in **Performance Assessment** (PA) for different argillaceous host rocks. The significance of these suggested microbial processes for a given disposal system, and the validity of their abstraction and contextualization towards PA is however yet to be determined. If found relevant, estimating microbial processes inside the waste, the EBS and the EDZ during the first phases of geological disposal, could support the definition of the initial state of the disposal system at the start of the post-closure phase, while assessing microbial metabolic pathways in the host rock could add to the understanding of geochemical equilibria **over longer time spans**.

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Sulphide issue in Olkiluoto - hydrogeochemical considerations

Petteri Pitkänen and Tiina Lamminmäki Posiva, Finland

Dissolved sulphide concentrations in groundwater over several mg/L may be detrimental to long term safety of final disposal of spent nuclear fuel as such concentrations cause corrosion of copper canister during long term. Sulphide concentrations are generally less than few tenths of mg/L (<0.02 − 0.6 mg/L) in steady state groundwater conditions, however, up to 30 mg/L have been observed due to hydrological transients caused by investigations and construction of the ONKALO tunnel at Olkiluoto. These high values typically occur due to mixing of upper SO4-rich brackish groundwater with deep saline groundwater characterised by high dissolved CH4 concentrations. This mixing seems to activate sulphate reducing bacteria (SRB). As hydrogeological conditions have stabilised, for example by installing multipacker systems in drillholes, sulphide concentrations have decreased in process of time. The decrease may be due to one or more of several reasons: i) iron sulphide precipitation, ii) draining of energy source for SRB, iii) dilution of sulphide concentration due to groundwater flow.

Groundwater data and thermodynamic calculations show that sulphide and iron concentrations are strictly controlled by low solubility of iron sulphide phases. Black iron sulphide precipitate has also been observed during some groundwater samplings. However, once the conditions have evolved favorable, sulphide contents are able to increase due to relatively high rate of microbial SO4 reduction and slow iron release rate from silicate mineral phases. The depth distribution of SO4, CH4 and occasional elevated HS- on the mixing interface would indicate CH4 to be the main electron donor in microbial SO4 reduction, however, field investigations and experiments in the ONKALO do not support significant anaerobic oxidation of CH4. Relatively high δ13C values of DIC do not indicate very light carbon input in the carbonate pool, which is typical to CH4. Few elevated sulphide observations even suggest that the use of any carbon, DOC or hydrocarbons, as an energy source may be limited in this interface. Therefore hydrogen has recently been considered to be a potential energy source for SRB in saline groundwater at Olkiluoto. However, gas sampling normally indicates very low dissolved H2 concentrations (few tens of µL/L) in groundwaters and only few mL/L level hydrogen concentrations have been obtained over the sampling period of 15 years at Olkiluoto. Another possibility is that hydrogen is dissolved in matrix pore water close to water conducting fractures and is available for SRB from there. More information of the role of iron and hydrogen is essential to understand groundwater sulphur cycle at Olkiluoto.

Remaining uncertainties regarding sulphide production, fluxes and concentrations in radioactive waste repositories

Karsten Pedersen, Microbial Analytics Sweden

Sulphide in groundwater and in porewater in the buffer and backfill affects directly the estimates of canister corrosion when evaluating the long-term safety of a spent nuclear fuel repository. The long-term safety of repositories of long-lived low- and intermediate-level nuclear waste is also affected

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by sulphide, but to a lesser extent. The knowledge of system-dependent processes that affect sulphide production and fluxes is incomplete and present safety assessment adopt simplified bounding analysis for the different subsystems host rock, backfill and buffer. Simplified coupled hydro-chemical models based on thermodynamic equilibrium are applied for estimating the sulphide concentrations at repository level during the operational, temperate and glacial phases. However, the sulphide-producing microbiological systems are alive and cannot be in thermodynamic equilibrium because living organisms preserve their internal order by taking free energy from their surroundings in the form of nutrients, reduced inorganic compounds or sunlight, and returning to their surroundings an equal amount of energy as heat and entropy. Order is increased in the microorganisms and decreased in their surroundings, i.e. living systems strive to move away from thermodynamic equilibrium. A good example is the MINICAN experiment where the microbiologically induced sulphide corrosion of iron exceed the thermodynamically calculated inorganic rate with three orders of magnitude (Smart, Rance et al. 2014). There is an urgent need to increase our base of knowledge regarding microbial production of sulphide both the geosphere and the buffer-backfill systems. Modeling must adapt biological principles for the turnover of energy and matter and comprehend that biological systems per se are not in thermodynamic equilibrium.

Smart, N. R., et al. (2014). "In situ evaluation of model copper-cast iron canisters for spent nuclear fuel: a case of microbiologically influenced corrosion (MIC)." Corrosion Engineering, Science and Technology 49(6): 548-553.

Lithotrophic metabolism in the relation with microbiologically induced corrosion

Mikes Jiri, CHEMCOMEX, Czech Republic

Crystalline rocks represent perhaps the most hostile environment in which deep subsurface microorganisms exist. Due to the lack of organic materials in these crystalline rocks, the microbial communities had to adapt to use hydrogen, oxygen poor water, carbon dioxide, inorganic acceptors of electrons in metabolisms. Depp geological environment conditions are very interesting, concerning metabolic diversity of particular microbial groups. Their activity may be used for technological purposes, but the set of gained knowledge can be very valuable in the prevention of adverse microbial processes – e.g. biocorrosion. In this contribution, a special analytical set for the determination of the reducing equivalent source (sulphide, ammonia ions, ferrous ions, etc.) is presented. In the second part, an example how to supress biological corrosion of iron and copper by some managed induced changes in chemical composition of immediate surroundings close to the metal object installed in the subsurface will be described. Finally, further challenges in this research field will be noticed, showing transfer potential to DGR studies and solution (tracer methods of microorganisms in the rock, stress tests).

Microorganisms of radionuclides-contaminated soils of Chernobyl: in depth analysis of diversity and study of uranium-bacteria interactions

Virginie Chapon, CEA, France

We explored the microbial diversity of Bacteria and Archaea evolving since 25 years in a radioactive-waste repository trench located in the Chernobyl exclusion zone. To assess the effect of long-term RNs exposure on diversity, microbial assemblages of soil samples highly contaminated with radionuclides (RNs) such as 137Cs and uranium were compared with nearby controls using high throughput pyrosequencing of 16S rRNA genes. The analysis of 690,023 sequences evidenced high diversity in all samples with 34 bacterial and 2 archaeal phylum represented. Chloroflexi, Acidobacteria, Proteobacteria and Verrucomicrobia were the most consistently detected phyla, representing 90% of all sequences. This result demonstrates that a long term exposure did not lead to the decrease of microbial diversity. Furthermore, principal component analysis of pyrosequencing data showed that microbial communities of RNs contaminated samples differed significantly from that of controls, suggesting the presence of RNs adapted species in the contaminated samples.
Several heterotrophic aerobic bacteria have been cultured from the contaminated samples. Among them, the strain Microbacterium sp. A9 exhibited high uranium tolerance. The interaction between this strain and uranium was investigated by a combination of spectroscopic (FTIR and TRLFS) and microscopic (TEM/EDX) approaches2. Comparison of data obtained at 4 and 25°C evidenced active and passive mecanisms of uranium uptake and release. We demonstrated that after a first step of uranium and phosphate release via an active efflux mechanism, Microbacterium sp. A9 accumulates U(VI) as intracellular needle-like structures composed of autunite. The functional groups involved in the interactions with uranium were identified.

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Outcomes
Working Group 2: Microbiological Studies

Presented in Plenary Session 2 on October 29th

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MICROBIOLOGICAL STUDIES OR HOW MICROBIOLOGISTS CAN INCREASE SAFETY CASE ROBUSTNESS

WG2
Karsten Pedersen (MICANS, SE)
Klas Källström (SKB, SE)
Joe Small (NNL, UK)
Natalie Leys (SCK•CEN, BE)
Katinka Wouters (SCK•CEN, BE)

Communication barriers
A common language misssing?

Homogeneous systems

- High pH >12.5
- Low water activity < 0.9
- Pore size > 1 µm

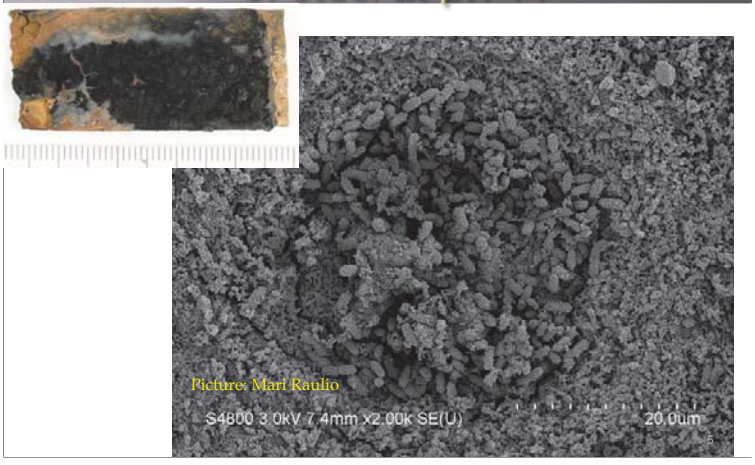
- inhibits microbial activity

Natural and most engineered systems are heterogeneous

- pH varies on the microscopic scale
- Water activity varies over time
- Pore size varies on the microscopic scale

- Local microbial activity is possible in cements, buffers, wastes and interfaces

Example: Local microbial corrosion of steel at pH 11



The FEPs language

- Features
- Events
- Processes
- =
- **Factors relevant to the assessment of long-term safety of nuclear waste repositories.**

Updated NEA FEPs list

- NEA/RWM/R(2013)8
- Updating the International FEP List:
- Repository Processes (*2.1*)
- 3.2.01 Thermal processes (repository) (*2.1.11*)
- 3.2.02 Hydraulic processes (repository) (*2.1.08*)
- 3.2.03 Mechanical processes (repository) (*2.1.07*)
- 3.2.04 Chemical processes (repository) (*2.1.09*)
- **3.2.05 Biological processes (repository) (*2.1.10*)**
- 3.2.06 Radiological processes (repository) (*2.1.13*)

- Biological processes are on the same level as hydrology, chemistry, mechanics and radiochemistry

  A multi-disciplinary approach to the safety evaluation/assessment

Microbiology in FEPs catalogues

FEPs on microbiological processes:

→ Often vague or crowded wording

- → Difficult to evaluate as isolated processes
- → Relevance for PA unclear

EXAMPLE : "Its complicated……."

2.3.5.2 Microbially/biologically mediated processes (waste package)
Microbiological/biological processes can affect the form or related properties of the waste form. For example, microbial processes can lead to the formation of acidic and oxidizing species that can participate in corrosion of the metals and generation of reducing conditions. Bacteria and microbes may also result in the generation of gases (see FEP 2.3.7.2), and anaerobic bacteria may form biofilms on or around the waste package.

Microbiology in FEPs catalogues

Actions:

- Identify cross links of 'Microbiology FEPs' with other FEPs
- Identify which interactions are important in the safety case

1) Microbial FEPs that are insignificant for performance assessment
2) FEPs that might define the boundary conditions for microbial processes.
3) FEPs that might be influenced by microbial processes

Site specific considerations:
- ➢host rock
- ➢disposal system
- ➢waste form
- ➢time

The lifeless scenario

Safety issue

Anaerobic corrosion of metals

H_2 Gas pressure build up

Geological sources e.g. serpentinization or radiolysis

The living scenario

Safety issues

Anaerobic corrosion of metals

H_2

Geological sources e.g. serpentinization or radiolysis

Microorganisms

$SO_4 \rightarrow H_2S \rightarrow$ corrosion

$CO_2 \rightarrow CH_4 \rightarrow$ pressure change

$CO_2 \rightarrow$ acetate $\rightarrow$ Cu stress corrosion

$Fe(III) \rightarrow Fe^{2+} \rightarrow$ illitization

E_h, denitrification…..and more

Effects on engineered barrier systems and radionuclide mobility

Conclusions

- Microbial processes are in FEP catalogues but rather **outdated**
- Need for closer **link and integration** between the existing FEPs and 'Microbial FEPs'
- Relevance of microbial processes for PA is **poorly understood**
- Assuming **total inhibition** of microbial processes may erode confidence and bias the performance assessment
- Need to update and highlight key FEPs
- Provide guidance for assessments at **relevant scales** and **site specific conditions** such as host rock, disposal system, waste form and time

Working Group 3: Information Exchange Platform with SNETP

Rapporteurs: Dominique Warin SNETP/CEA and Lena Zetterström Evins IGD-TP/SKB

Expected changes in waste forms may have implications for geological disposal and the required RD&D. The changes expected in waste forms that will need to be disposed of in geological repositories are of primary concern for WMOs. Indeed, the confirmation that this waste will be compatible with the current engineered barrier systems and host rocks may require intensive and decade long RD&D. In line with its vision, the IGD-TP deals with primary changes expected in the upcoming two decades (e.g. higher burnups, change of cladding materials, use of fuel form other than UO2, increased separation and recycling, change in the reprocessing end-product, GenIII reactors…). This also includes the primary and secondary waste that will be generated from the R&D facilities dealing with GenIV and other facilities.

A particular point of interest in this WG will be the presentation and the discussion of the draft position paper on “Nuclear developments and radioactive waste management” (provisional title) which has been drafted by SNETP and IGD-TP.

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Abstracts

The IGD-TP/SNE-TP Information Exchange Platform – an introduction

Lena Z. Evins, SKB, Sweden

The communication and information exchange between the two Technology Platforms handling nuclear development and waste disposal is important. Both sides should be informed of the recent developments and how these developments may impact the activities of the platform participants. Of particular interest is information exchange concerning expected waste forms. Therefore, both platforms initiated a Joint Activity in order to strengthen the information exchange. As a result this Joint Activity is classified as an Information Exchange Platform. In this introduction the discussions and decisions from the previous Exchange Forum will be recalled, and a short presentation will be given of the common fact sheet on nuclear waste.

The SKB requirements of the HLW waste intended for the KBS-3 repository

Lena Morén, SKB, Sweden

In Sweden, an application for a system to manage and finally dispose spent nuclear fuel was submitted by SKB in 2011. The system is intended for direct disposal of encapsulated spent nuclear fuel assemblies in a crystalline bedrock repository. Requirements on the spent fuel and its handling concern radiation safety during operation as well as post closure safety of the repository. Examples of properties of the spent fuel that impact radiation safety are solubility, material composition, intactness of fuel cladding and construction parts, enrichment, burnup and decay time. These and other properties constitute input to the design of the management system and final repository and contribute to, or may affect, radiation safety. Thus development of nuclear fuel and fuel usage that impact these properties are crucial for both the design of management systems and their radiation safety

Fuel data needs in Posiva's safety case

Barbara Pastina, Posiva, Finland

In 2012, Posiva has submitted the construction license application for the direct disposal of spent nuclear fuel in a geologic repository. The Finnish regulations require a new safety case for the operational license application, due in 2020. Based on the regulatory requirements on the safety case and on the knowledge acquired during previous assessments, specific fuel data are needed for two key parts of Posiva's safety case: the performance assessment and the assessment of radionuclide release and transport scenarios. The performance assessment's role is to assess the performance of the barriers during the expected long-term evolution of the disposal system and to identify uncertainties. On the basis of such uncertainties, radionuclide release scenarios are formulated and their radiological consequences assessed through a radionuclide release and transport model spanning from the spent fuel up till the surface environment. Fuel data for the performance assessment are linked to the long-term performance of the canister with respect to criticality safety. In case of identified uncertainties, long-term criticality scenarios have to be formulated and potential consequences of a criticality event in the repository have to be assessed. Fuel data for the radionuclide release and transport model are linked to the definition of the source term: radionuclide inventory, its partitioning among the different components of the fuel assembly (UO2 matrix, gaps/cracks/grain boundaries, cladding, other metal parts) and radionuclide release rates from these components. If new fuel or waste types are introduced, sufficient data have to be provided by the utilities or gathered through an ad-hoc research programme to enable radioactive waste management companies to assess the fuel's long-term criticality safety as well as its radionuclide release and transport properties in repository conditions.

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Evolution of the waste forms in the future: an overview of the French approach

Christelle Martin, Andra, France

The "Cigéo" project of geological disposal is designed for a waste inventory resulting from an iterative work between Andra and the waste producers. This inventory includes the existing and future HL and ILL waste generated by the current nuclear facilities (nuclear power reactors, reprocessing facilities, R&D facilities). It also includes HL and ILL waste that will be generated by future facilities (Gen III EPR Flamanville, experimental reactor Jules Horowitz, ITER reactor) whose licencing decree has already been accepted. A first key step of the approach developed by Andra is to get a detailed knowledge of the different types of waste and their characteristics, including long-term behavior, in order to evaluate their compatibility with the main requirements for the geological repository. An iterative analysis of the available data allows then to identify specific R&D needs (additional characterization, progress in conditioning …). The same approach is retained for waste that could be produced in a longer term perspective, for example those generated from future R&D facilities (GEN IV) and that are not included today in the "Cigéo" inventory. In the framework of the French strategy, spent fuel is not considered as waste. However, Andra is also conducting studies for the direct disposal of spent fuel, in accordance with the PNGMDR* recommendation.

**National Plan Management for Radioactive Materials and Waste*

Progress and R&D needs for radioactive waste conditioning and disposal for future fuel cycles: a UK perspective

Neil Hyatt, University of Sheffield, UK

Current nuclear decommissioning operations and future nuclear fuel cycles will produce a spectrum of new advanced wasteform materials, for which there is limited fundamental understanding concerning long term stability and compatibility with engineered barriers. Such wasteform materials may include: new phosphate and geopolymer binders, glass-ceramics tailored for advanced aqueous and pyrochemical reprocessing of nuclear fuels, ceramics for (minor) actinide disposition, and slag / meta wasteforms for variable decommissioning wastes. Recent progress in the design, processing, and performance assessment of these new waste forms will be described in the context of the UK R&D programme, and the future research needs required to underpin timely and publically acceptable geological disposal will be discussed. The opportunity to tailor future waste forms and geological disposal concepts to the radiological risk of the waste packages will be explored, with reference to optimising the foot print and heat loading of future geological disposal facilities.

The Sustainable Nuclear Energy Technology Platform (SNETP), Fuel Cycles and Interfaces with Geological Disposal

Richard Stainsby, NNL, UK

The Sustainable Nuclear Energy Technology Platform (SNETP) was established to enable the development of nuclear energy systems within Europe to be a sustainable, low carbon source of electricity and other forms of energy. The sustainability aims of the platform are realised through the work of the industrial initiatives (IIs) that constitute its three pillars. These are; NUGENIA which supports the development and continued operation of Generation II/ Generation III light water reactors; ESNII which facilitates R&D leading to the establishment of demonstrators for fast reactors operating in closed fuel cycles and NC2I which supports the development of non-electrical applications of nuclear-generated process heat. In their own ways, and on different timescales, each of these industrial initiatives contributes to sustainability through NUGENIA supporting current and near term nuclear power plants thus avoiding the burning of some amount of fossil fuel and avoiding the consequent greenhouse gas emissions. ESNII looks at extending the lifetime of nuclear fission as a resource through breeding and recycling of fissile materials. NC2I aims to displace fossil fuels from their current role of providing the primary heat source for heat-intensive industrial processes, such as metal processing, glass and cement making and in the creation of synthetic hydrocarbons. Radwaste streams are a common consequence of the differing reactor technologies within each of the pillars, but the characteristics of these streams are different with differing impacts on geological disposal. The recently-established fuel cycles sub-group within SNETP aims to assess the use of natural resources, the inter-dependence of the reactors on each other in realistic mixed-fleet fuel cycle scenarios and to examine the influence of decisions made in developing these scenarios on the quantities and characteristics of the radwastes which would potentially arise.

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Nugenia Research Topics in Spent Fuel Management (TA 5) and Potential Implications for Disposal

David Hambley, National Nuclear Laboratory, UK

There are active research programmes to assess the implications of steadily increased spent fuel storage times and the effects of increasing discharge irradiations. This work has identified some characteristics that may affect fuel integrity after long term storage. The status of current work and potential implications for disposal will be summarised. In addition there have been developments in fuel manufacturing, such as doping of fuel, that have been introduced to control reactivity and fuel microstructure. Whilst these are not new, their effects in behaviour in disposal systems has not been subject to much investigation. There are a number of lines of investigation into new LWR fuel designs. Although many are at an early stage of development it is timely to consider whether these could have implications for disposal.

SNETP-ESNII Gen IV reactors, related fuel cycle and disposal issues

Massimo Sepielli (SNETP Governing Board)

GIF, Generation IV International Forum, as known, is fostering six different concept models of Generation IV reactors, ranging from liquid metal and gas cooled fast reactors, to molten salt, hypercritical water and very high temperature gas ones.

The European fission platform, SNETP, through ESNII industrial initiative, is supporting development of three Gen IV reactor demonstrators, namely ASTRID, ALFRED, ALLEGRO and one ADS type research reactor infrastructure, MYRRHA, whose construction / operation are planned to be from 2025.

The nuclear fuel for these Gen IV reactor is so far supposed to be mainly MOx type, that's a mix of Pu and U oxides, fed in by recycling actinides returning from the reprocessed fuel.

Fuel reprocessing techniques for closed cycle are in turn based on moist or dry techniques which allow separate actinides and fission products almost completely. After many cycles of reprocessing, the actinides present in the exhaust fuel are reduced to minimum and fission products represent most part of it. It means more relaxed requirements for final radwaste disposal in geological on near- surface repository.

Another important issue from Gen IV reactors is the type material to be used for cladding, fuel element, internals, as these reactor structural material has to be proved against challenging requirements.

All the mentioned aspects: Gen IV fuel type, optimal reprocessing techniques (nonproliferation oriented), resulting new waste form and related repository features, according to European SRIA, represent current research issues to address in the SNETP and IGDTP road-maps.

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

Conditioning radioactive waste that cannot be accepted in surface facilities - Safety considerations and packaging basic principles

Grégory Nicaise, IRSN, France

Conditioning radioactive waste consist in a succession of transformation operations that aim at confining radionuclides and help to minimize the difficulties in designing and operating the storage and disposal facilities that are due to receive them. The nature and characteristics of the nuclear package chosen should be decided with a view of achieving a high level of intrinsic safety, therefore facilitating the risk management of all the operations required before its final elimination. In the case of waste that is not acceptable in surface disposal facilities due to their high content of long-lived isotopes, the technical options governing their placement in long-term storage facilities or their elimination in deep repositories are not yet definitely chosen. Today's absence of precise acceptance criteria being given, there is a strong added value for safety in designing waste packages enabling a high level of confinement to be reached and sustained over a long period and for a variety of storage and disposal conditions. The robust performances of the package enable the choice of different technical options for the future reception installations and provide safety margins against the uncertainties linked with the long-term evolutions Nevertheless, if a reliable demonstration of the robustness of the package cannot be a priori provided, the possibility of keeping some extent of reversibility of the conditioning has to be taken into account. One of the basic principles for the design of an intrinsically safe nuclear waste package is that it should be physically and chemically inert. This characteristic can be declined in terms of properties that should be reached "at best"

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

Outcomes
Working Group 3: Information Exchange Platform with SNETP

Presented in Plenary Session 2 on October 29th

This event is co-funded by the European Union under the 7th Euratom Framework Programme,
Grant agreement number 323260 - SecIGD2 project

Summary WG3

Information Exchange Platform (IEP) for SNETP and IGDTP
Rapporteurs: Lena Z Evins (SKB/IGDTP)& Richard Stainsby (NNL/SNETP)

Outline of the meeting:

* Information from IGD-TP to SNE-TP: How are changed waste forms considered by WMO?
* Information from SNE-TP to IGD-TP : What are the expected developments in waste forms?
* Other information Exchange and topics for discussions
 - Fact Sheet
 - Outlook: the next steps

What is this IEP?

- At the moment, a loosely defined group with representatives from both platforms
- Defined as Information Exchange Platform by the IGD-TP Executive Group
- Communication and Information Exchange
- Main focus: Waste forms
- Current and near future: Gen II/III
- Far future: Gen IV

Main messages

- We have successfully established a link between the platforms
- We have started information exchange!
- Change in fuel is happening right now.
- We a working on a common task: The Fact Sheet
- For continued work, it is desirable to formalise and structure this group further.
- Continued work could involve another couple of publications: position papers or discussion papers

Presentations

1 - The IGD-TP/SNE-TP Information Exchange Platform – an introduction: *Lena Z. Evins, SKB*,
2 - The SKB requirements of the HLW waste intended for the KBS-3 repository : *Lena Morén, SKB*
3 - Fuel data needs in Posiva's safety case : *Barbara Pastina, Posiva*
4 - Evolution of the waste forms in the future : an overview of the French approach :*Christelle Martin, Andra*
5 - Progress and R&D needs for radioactive waste conditioning and disposal for future fuel cycles: a UK perspective : *Neil Hyatt, University of Sheffield*
6 - The Sustainable Nuclear Energy Technology Platform (SNETP), Fuel Cycles and Interfaces with Geological Disposal: *Richard Stainsby, NNL*
7 - Nugenia Research Topics in Spent Fuel Management (TA 5) and Potential Implications for Disposal: *David Hambley, NNL*
8 - SNETP-ESNII Gen IV reactors, related fuel cycle and disposal issues: *Massimo Sepielli, ENEA*
9 - Conditioning radioactive waste that can not be accepted in surface facilities : *Gregory Nicaise, IRSN*

Some points from presentations (I)

- SKB & Posiva: requirements for waste (spent fuel) acceptance. Low solubility & knowledge of inventory in various parts. Fuel data needed for SA.
- Andra: a wider spectrum of long-lived waste types: HLW & ILW. Currently an iterative approach between Andra and the waste producers, takes evolution into account
- Discussion points: what is the optimum Burn-Up, due to the changes in minor actinides? Important to have the regulator involved in the iterative approach.

Some points from presentations (II)

- IRSN: How the producer has to design the waste package in absence of waste acceptance criteria? Basic principles, criticality,radioactivity, reactivity, mechanics... Example: plastic waste. Recommendation: development of dedicated thermal process to have an inert form

Some points from presentations (III)

- University of Sheffield: Two examples of ”non-standard waste”:Ion exchange resins & High fission product glass. How to optimise the waste form throughout the life cycle (off gas)
- SNE-TP: three pillars: Nugenia (Gen II/III), ESNII (Gen IV), NC2I (cogeneration).
  New Fuel Cycle Group.
- Nugenia: Change is happening! Burnup, improving fuel, advanced fuel types to existing reactors (pellet & cladding)

Some points frompresentations (IV)

- ESNII: Various types of fast reactors (SFR, LFR, GFR) and thermal (MSR, SCWR, VHTR). Reprocessing methods: hydrochemical/pyrochemical. Chloride salt wastes from pyroprocesses with different matrices
- Point of discussion: secondary waste, operational waste, activation waste? Current projects are now focusing on technology, so no project yet but relevant : for example exchange resins

Common Fact Sheet

- Purpose: To communicate that **we are working together** and have identified common ground. To establish the link.
- *Nuclear energy gives rise to radioactive waste that will need disposal
  *Good progress is being made in some countries on geological disposal
  *New reactor systems might simplify repository systems but will not eliminate needs for deep disposal.
  *Work on deep disposal should not be delayed waiting for new reactor systems
  *R&D concerning new reactor systems should include waste disposal from the start
- Second version now: Aim for final version in the spring, decison to publish by the Executive groups of both platforms.
- Dissemination being discussed. How to reach further than the platform web sites? ENEF (European Nuclear Energy Forum)?

Outlook: next steps

- More than a regular information exchange? How do we deepen the collaboration?
- Not ready for a common project proposal
- Suggestion: another ~2 common publications.
- Position papers/discussion papers
- Topics: 1) Advanced fuels, 2) Non-fuel waste /non-standard waste, 3) Utilities and fuel data, 4) Flexibility of repositories?
- Suggestions to be brought to the Executive groups of the platforms

Working Group 4: Priorities and lessons learned after 4 years of implementation of SRA

Rapporteurs: Frédéric Plas (Andra, France) and Peter Wikberg (SKB, Sweden)

This session is open to all EF participants willing to express what from their point of view are the main priorities and the major achievements of the platform after 4 years of implementation of the SRA. Starting from selected Key Topics and Topics presented in the SRA the participants are invited to make an analysis on the actual outcomes and progress in knowledge in a scientific and technical domain.

The participants may present/discuss how (far/ good/complete) the Topics have been covered by the Joint Activities and they are invited to bring forward new ideas for projects and collaboration within IGD-TP. All ideas fitting with the topics described in our SRA may lead to the establishment of a Working Group supported by the IGD-TP EG members. The main objective here is not to add priorities ("what") to the ones listed in the SRA but rather to propose practical ways forward to tackle a specific priority from a scientific/technical point of view ("how").

All other ideas will be considered and the discussion may emphasise on how these can complement our SRA and what could be the added value for all the members.
Finally, all participants are encouraged to make suggestions for the organisation and content of future Exchange Forums to our work programme with new areas of research.

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

Abstracts

Achievements and way forward for the IGD-TP since its inception

Jacques Delay, Andra, France

In the framework of the SecIGD2 project, it was proposed that by the end of 2015, the Strategic Research Agenda (SRA) could be updated. The EG proposed that each EG member, whatever the stage of development of their project, should provide a short analysis, from their point of view, on the major achievements of the platform. In addition, they should express their interest in participating in the activities and suggest improvements that could be carried out in the future (organisational and technical point of view).
The outcomes of the questionnaire have been summarized in a short document prepared in view of the preparation of the Exchange Forum. The main conclusions are that sharing experience, knowledge, first-hand information and good practice with sister organisations and working together are considered as key drivers for the involvement of EG members in the platform activities. Participating in the IGD-TP and in the EG gives a unique opportunity to closely follow (and to learn from) the development of the most advanced programmes.
In addition it was reaffirmed that participation to IGD-TP EG offers financial gearing on common research interests, especially where large expenditure or unique facilities are required. It helps to shape research programme on geological disposal with the limited resources available. This limited resource available limits also the possibility of the expansion of the activities.
As a conclusion EG members considered that major achievements were made in the setting up of research projects covering the SRA Key Topics and topics identified. In addition, EG members considered that cooperation has improved since the inception of the platform and not only between the more advanced programmes.
The questionnaire allowed to identifying existing topics to be discussed again and in particular their level of Urgency/Priority. In addition it was suggested to keep more attention to topics that may be of interest for the lesser advanced countries.

News topics were also brought forward and open for discussion (see below):

N° Key topic SRA	New proposed topics	Proposed by
3	Effects of long saturation times on bentonite buffer	Posiva
3	Microbiological assisted corrosion processes	Posiva
3	New forms of copper corrosion	Posiva
3	Shear strength of metal canisters	Posiva
2	Direct characterisation of spent fuel	SKB
2	ILW disposal, e.g. waste forms,	RWM
4	ILW disposal concepts, co-disposal	RWM
WMS1	Preservation of host rock materials	COVRA
WMS1	Use of non-destructive techniques for siting	COVRA
1	Gas issues in the performance assessment	Nagra
WMS4	Disposal facilities acceptance criteria (DFAC)	Andra
7	Social science	COVRA

TUS-Safety and Environmental Engineering Laboratory' cross sections considerations of one <Safety and SF&RAW matrix> and review of the SF&RAW management in Bulgaria

Ivan Ivanov, Technical University of Sofia, Bulgaria

A brief profile and expertise of Technical University of Sofia, in particular the Safety and Environmental Engineering Laboratory of Electrical Power Department will be present. On the basis of an overview of the status of the Spent Fuel and Radioactive Waste management in Bulgaria and of the safety requirements of the IAEA, European and national legislation and regulations will be defined and presented one <Safety and SF&RAW matrix>. Cross sections considerations of the matrix will be used for introducing of possible ways of disposal relevant to SF and the major categories of solid RAW, which could be part of subject and joint activities for realisation of new projects ideas and collaboration within IGD-TP.

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FIRST-Nuclides: Outcome, Open Questions and Steps Forward

Bernhard Kienzler, KIT-INE, Germany

FIRST-Nuclides is terminated end of 2014, resulting in a huge amount of new and important data to be used for repository Safety Case. One of the particularities of the project is the strong support and involvement of the End-Users. The presentation will summarize some results and will give an overview of the main comments and reflections of the End-Users.
The partners of the project as well as Associated Groups and End-Users identified a series of open questions to be resolved in future investigations. The set-up of experiments and getting the clearance by the utilities to publish the spent fuel data has been costly. Some of the experiments have run only for short time, which does not justify the level of investment to set up. For this reason, we believe that the definition of a long-term project allowing for the continuation of the experiments will maximize the outcome of the efforts invested. This will provide better basis of delineating instant release from long-term radionuclide release. Additional kind of samples (e.g. MOX) can be included.
To complete the evaluation of the results of FIRST-Nuclides, we propose the following schedule: A period of 2 years for final evaluation. During this time, the partners request support by the national Waste Management Organizations to keep the experiments running. Afterwards as second step, a new application of a European project will be prepared.

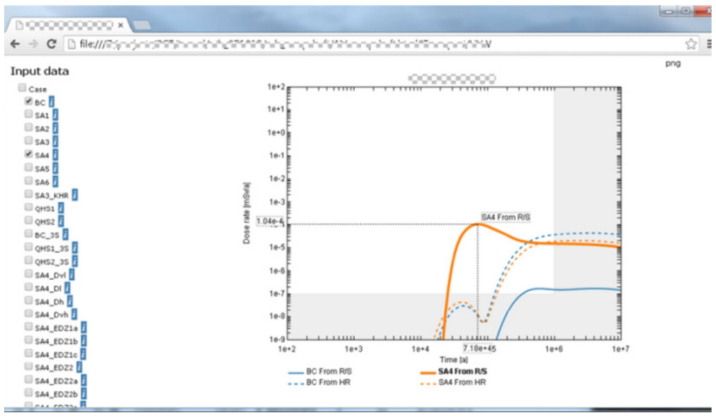
Quality assurance and communication between stakeholders of a geological disposal project facilitated by the Electronic input Data and Results application (EDR) for radionuclide transport calculations

Jean Croisé, AF-Consult, Switzerland

The custom-designed and web-based EDR is used to browse through the input data and results of radionuclide transport calculations performed in a geological disposal project. The application provides simple and immediate access to calculation cases, input data, input files and post-processed results. Stakeholders involved in a geological disposal project quickly recognize the tremendous potential of this tool for key tasks in their overall missions:

a) Modellers, for doing quality assurance of their calculations,
b) Implementers responsible for radioactive waste management, for carrying out post-closure safety assessments, and
c) Regulatory authorities responsible for nuclear safety, for evaluating the implementer's safety assessment calculations.

The application is programmed in JavaScript, runs in a web browser and may be supplied online or on a data carrier for offline use. It is based on the latest web standards HTML5 and SVG for interactive charts, which may be exported in high resolution graphics for insertion into technical reports.
A selection of handy features and advantages of the EDR will be presented and demonstrated live. Experience with its utilization in Switzerland allows for conclusions with respect to the EDR's applicability for the purposes of different stakeholders and its function as a common communication base among them.



Sample screen shot of the EDR showing the selection menu for calculation cases and the corresponding interactive results chart

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COMS-WD: A new proposal for cooperation between EU Member States responding to the EC Waste Directive

Erika Neeft, COVRA, Netherlands

All EU Member States (MS) should aim to have state-of-the-art radioactive waste management (RWM) programmes. This includes a strategy for implementing all RWM steps during pre-disposal and also disposal phases and ultimately for ensuring that facilities for safe and secure disposal of radioactive waste are available on appropriate timescales. A near-term challenge that affects Member States with both advanced and less advanced waste management programmes is meeting the requirements of the EC Waste Directive of 2011. This specifies that "Each Member State shall ensure the implementation of its national programme for the management of spent fuel and radioactive waste ('national programme'), covering all types of spent fuel and radioactive waste under its jurisdiction and all stages of spent fuel and radioactive waste management from generation to disposal" (Article 11). These Programmes are expected to be comprehensive and must document the following items: plans for the construction and the management of final disposal facilities; a concrete timetable for construction, with milestones and descriptions of all the activities that are needed to implement the disposal solutions; cost assessments; and the financing schemes chosen.

In the Council Regulation 1314 2013 Euratom Research and Training Programme of the Euratom 2014-2018 complementing the Horizon 2020, the activities to be supported in the field of waste include "research activities related to management of other radioactive waste streams for which industrially mature processes currently do not exist." The processes for safely managing LILW are not sufficiently mature for implementation in a number of smaller programmes of EU-MS since all of the technical, economical, human resource, and competence requirements are not fulfilled. COMS-WD will aim to improve the situation in these areas which are not directly covered by the large IGD-TP work focussing on geological disposal. The current proposal COMS-WD is designed to enhance safe waste management practices throughout all predisposal phases and potentially to enable safe disposal facilities to be available to all EU countries, however small their radioactive waste inventory and regardless of the existence, size or status of a present or past nuclear power programme.

The issues involved in moving ahead in this area are clearly not only technical but also societal. This aspect of COMS-WD also fits to the EC framework which includes a Science in Society activity which encourages mutually beneficial cross-fertilisation in areas such as "governance and stakeholder issues, especially those associated with the local acceptance of controversial facilities or technologies".

The key new data emerging from the Project will be the 4 reports that are planned. These will all be available on the website. These reports will be of direct use to the Participants when preparing their Waste Directive submissions. At a global level, the strategic objectives and the work products of the ERDO-WG have already attracted interest. International organisations such as the IAEA have recognised the potential for transferring the regional approaches developed in the EU to other parts of the world.

SITEX-II, for developing an international Expertise function network

Delphine Pellegrini, IRSN, France

The coordination action SITEX-II, submitted for the H2020 EURATOM Work Programme 2014-2015, aims at implementing in practice the activities along with the interaction modes issued by the FP7 program SITEX project (2012-2013), in view of developing an Expertise function network. This network is expected to ensure a sustainable capability of developing and coordinating joint and harmonized activities related to the independent technical expertise in the field of safety of deep geological disposal of radioactive waste. SITEX-II tasks include:

- **the definition of the Strategic Research Agenda (SRA)**, the definition of the ToR for the implementation of specific topics from the SRA, and the interaction with IGD-TP and other external entities mandated to implement research on radioactive waste disposal regarding **the potential setting up of an European Joint Programming on radioactive waste disposal**;
- **the production of a guidance on the technical review** of the safety case at its different phases of development, fostering a common understanding on the interpretation and proper implementation of safety requirements for developing, operating and closing a geological repository and on the verification of compliance with these requirements;
- **the development of a training module for generalist experts** involved in the safety case

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review process, including the implementation a pilot training session;
- **the commitment of CS in the definition of the SRA mentioned above**, considering the expectations and technical questions to be considered when developing R&D for the purpose of Expertise function. Close interactions between experts conducting the review work will allow enhancing the safety culture of CS and more globally, proposing governance patterns with CS in the framework of geological disposal;
- **the preparation of the "administrative" framework for a sustainable network**, by addressing the legal, organisational and management aspects

The JOPRAD Project: A step towards a Joint Programming on Radioactive Waste Disposal RD&D

Jacques Delay, Andra, France

The Directive 2011/70/EURATOM ("Waste Directive") establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, reaffirms the ultimate responsibility of Member States for management of the spent fuel and radioactive waste generated in their respective countries. This includes establishing and maintaining national policies and frameworks, and implementing the policies by establishing and implementing National Programmes. This includes assuring the necessary resources and the required transparency.

According to the Waste Directive, Member States are obliged to regularly review and update their National Programmes, taking into account technical and scientific progress as appropriate as well as recommendations, lessons learned and good practices from peer reviews.

Amongst others, the National Programmes shall include the research, development and demonstration activities (RD&D) that are needed in order to implement solutions for the management of spent fuel and radioactive waste, as well as associated financing schemes.

The main aims of "HORIZON 2020" are the integration of scientific programmes rather than support individual projects with an emphasis on those related to the ultimate management of radioactive waste.

Considering the "Waste Directive" statement on the need to study geological disposal options, the idea of Joint Programming is to bring together national research programmes to develop research activities of pan-European added-value. The immediate challenge is to address uncertainties about the safety of geological disposals, to build a sound safety case.

The goal of the JOPRAD project is to prepare the setting up of a "Joint Programming on Radioactive Waste Disposal" that would be established to coordinate at the European level, national research programmes and the associated research and development (R&D) activities on geological disposal for high activity long lived radioactive waste. This action includes reviewing of all strategic aspects linked to a stepwise move towards a Joint Programming in this field.

This project will involve organisations that are active in the safety, management and disposal of radioactive waste and research entities.

The first step of this project will be to engage in discussion with Member States representatives in order to clarify the organisation of their national R&D consistent with the implementation of the Council Directive. The second step will be to identify existing (or developing) research programmes that could contribute to the identification of common scientific objectives and activities as well as specific aspects that the organisations would like to develop in the Joint Programme. The third step will be to draft the joint "Programme Document" that should be the technical background of the Joint Programming.

The outcomes of the project will be
(i) a preliminary evaluation of a potential in-kind and financial commitment of organisations,
(ii) a "Programme Document" consisting of large programmes focused on key priorities of WMOs, TSOs side and Research Entities and
(iii) a "Summary report" comprising a proposal for the implementation of this Joint Programming.

This action will lead to the further integration of the interested research community and hence help to maintain and develop the EU leadership in knowledge and expertise for innovative radioactive waste management solutions that effectively matches public expectations. Moreover, it will further reinforce and make the interaction at EU level between WMOs, TSOs, industry, policy makers and the research community more effective.

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Outcomes
Working Group 4: Priorities and lessons learned after 4 years of implementation of SRA

Presented in Plenary Session 2 on October 29th

This event is co-funded by the European Union under the 7th Euratom Framework Programme,
Grant agreement number 323260 - SecIGD2 project

TWG4 Priorities and lessons learned after 4 years of implementation of SRA

- Roadmap for IGD-TP: implementation driven R&D priorities with cooperative added values for all programmes.

- Initial focus on supporting the most advanced programmes so that they are able to reach their goal of getting the licences to start operation of their repositories.

- Review of the SRA is on-going :
    - All EG members, whatever the stage of development of their programme, should provide a short analyses on the major achievements of the platform
    - All responses have been compiled into one group of on-going topics, with change of priorities (High/medium), and on group with new topics.
    - The Executive Group will use the outcome of the review to better handle the joint activities.

1. At this step,
    - We cluster a number of issues into:
    - Potential change of priorities: **Safety and risk, optimization, governance, source-terms, engineered barriers and monitoring**.
    - Potential new topics: **Long-term processes in the repository and ILW waste and repository acceptance criteria**.

    - We do not distinguish significant change. ***Obvious change is to include ILW (still as deep disposal)***.

2. Methodology for the further development of the SRA is discussed without conclusion (yet)
    - Representatives of EG indicate that this is to be decided by the executive group.

3. SRA must strive to cooperation between implementers and scientific and technical organisations (TSO).
    - Therefore two new project proposals to link TSO and WMOs (JOPRAD and SITEX-II)

4. SRA is mainly focussed on priorities of more advanced countries, but improvement of the integration of less advanced programmes into IGD-TP is questioning:
    - JA of IGD-TP…?
    - Promote EU waste directive related efforts, e.g. COMS-WD

CMET Walkabout session
on the feasibility of a voluntary accreditation scheme

Introduction to Accreditation - Orientation to the Walkabout

This event is co-funded by the European Union under the 7th Euratom Framework Programme,
Grant agreement number 323260 - SecIGD2 project

CMET session on the feasibility of a voluntary accreditation scheme

Introduction to Accreditation - Orientation to the Walkabout

Exchange Forum 5, Kalmar, October 2014

The research leading to these results has received funding from the European Union's European Atomic Energy Community's (Euratom) Seventh Framework programme FP7 (2007-2013) under grant agreements n°249396, SecIGD, and n°323260, SecIGD2.

Orientation to Walkabout work

Purpose of today's session:

- In the introduction to give a brief overview of voluntary accreditation and about ECVET - "a credit system for professionals"
- Orient and assist you in preparing for the walkabout and to speed up the walkabout process: what is expected from you and what to do with the given post-it notes and handout during the walkabout and also afterwards

The walkabout is aimed to:

- Collect your multiple perspectives and to
- Contribute to the feasibility study of the voluntary accreditation scheme and related work by the CMET working group
  - *by soliciting input of the IGD-TP participants and*
  - *ensuring that crucial expert views are not excluded from the study*
  - *assist in the on-going work of the current EFTS projects (European Fission Training Schemes)*

About Competence Maintenance, Education and Training Working Group (CMET)

- We are a permanent working group set by the IGD-TP in 2012 resulting from the SRA's Cross-cutting Activities (JA14).
- Our terms of reference (v.2)were revised at the end of 2013.
- We are ~ 30 geological disposal professionals from 13 different countries, 27 organisations, and representing 6 different type of stakeholder organisations.
- The activity is now lead by Posiva Oy and it is supported by the Euratom FP7 SecIGD2 project grant.
- One CMET action includes the feasibility study of a voluntary accreditation scheme – aiming to contribute to the **adoption of ECVET** as a tool **for improved borderless mobility**, **lifelong learning** and **quality of learning**.

What is Accreditation and ECVET?

Accreditation is defined E.g by IAEA (2014, NG-T-6.4)[1]: *"the formal process of approval against established standards by an independent body"*

Accreditation within the ECVET[2] context would be

- *about a third party recognising your knowledge, skills and competence (KSC) achieved non-formally or informally*
  - *vs. a formal qualification that a national body/-ies recognises*
- *includes inherently an element of **trust** about the **objectivity of the recognition** of the units of learning, learning outcomes, KSCs*

Such accreditation in geological disposal does not exist beyond:

- *agreement based accreditation in specific disciplines: E.g. basic radiation protection training, NDT, welding, shotcreting, work safety, ENEN Master's supplement*

[1] *IAEA 2014 no NG-T-6.4 Nuclear Engineering Education: A Competence Based Approach to Curricula Development*
[2] *ECVET = European Credit system for Vocational Education and Training*

Why ECVET? It's Part of European Policy

The recent 2nd situation report on E&T in the Nuclear Energy field in EU[3] highlights e.g.

- the challenge that **human resources in the nuclear field** could be **at risk**;
- therefore one main goal of Euratom actions to contribute to the sustainability of nuclear energy by three means and one of them is ***"developing the required competences (training)."***

To improve European competitiveness, these Euratom actions aim

- *"to continuously **improve knowledge transfer and competence building**, in particular by fostering lifelong learning and borderless mobility, thereby **improving the employability** in the nuclear sector across the EU." and*
- *"Euratom E&T actions are addressing primarily **research and industry workers with higher education, i.e. levels 6 to 8** of the European Qualifications Framework – **EQF** (= bachelor, master and doctorate levels or equivalent, resp.). The focus [] is on Continuous Professional Development (CPD), taking advantage of the **governance and best practices for E&T** that are **proposed in the EU higher education policy (DG EAC)**".*

[3] *EC 2014. Second Situation Report on Education and Training in the Nuclear Energy Field in the European Union. SWD(2014) 299 final, Commission Staff Working Document 3 October 2014.*

And further about the why!

Another recent European report

The SET Plan E&T roadmap (2014) (http://setis.ec.europa.eu/setis-deliverables/education-training-roadmap) *) that is a collective roadmap on E&T formulated by stakeholders, **puts forward a structural approach, calling for large-scale E&T actions** and is designed with the **following three main** guiding **objectives**:

1. *To **address knowledge, skills and competences needs and gaps** via building networks, pooling capacities and allowing quick and wide replication;*
2. *To **reinforce the E&T system's link with the business and research** environment;*
3. *To plan and enable skill **development and recognition**, at the same time facilitating the **dissemination** of new knowledge, techniques and tools.*

European ECVET pilot is ending in 2014 and will be evaluated:

The future can be a permanent system of ECVET.

Also for the professionals with nuclear sector being the flagship.

*) Extract from EC 2014. Second Situation Report on Education and Training in the Nuclear Energy Field in the European Union. SWD(2014) 299 final, Commission Staff Working Document 3 October 2014.

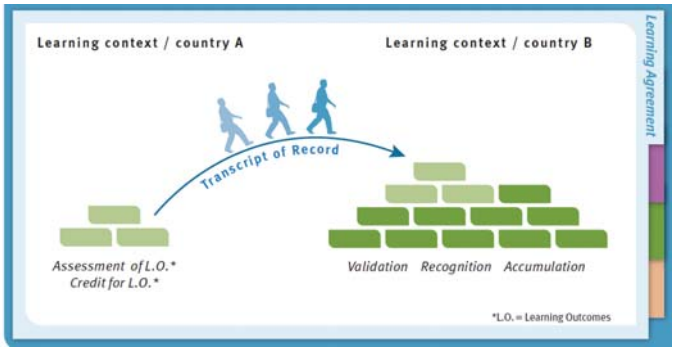
So what is ECVET?

ECVET – European Credit System for Vocational Training and Education is part of EU educational policy and **developed in the framework of the Copenhagen 2002 process** (vs. Bologna process for higher education)

- It starts from defining a **job**: a profile, function or task, which is
- is broken down to smaller **units of learning** and
- Each unit is defined by **learning outcomes (LO)** i.e. what is learned or mastered
- Each such unit of learning can then be recognised and exchanged between contexts
- The learning outcomes for each unit are targeted to **a specific level** of European qualification framework (**EQF**[4]), whose 8 levels act as a "translation tool " between different national qualifications, and
- Each LO is broken into **three types of components: KSC** i.e. Knowledge, Skills and Competence that are defined in a common language using a taxonomy (Bloom or sector specific) and
- The learning outcome/s and units can then be assessed and recognised irrespective of the way they have been acquired.

[4] complies with the ISCED 2011 levels (Unesco 2012)

Borderless Mobility and Accumulation of Learning Units/Outcomes



Source: ECVET brochure NC-80-09-607-EN-D, European Commission, DG EAC

Explaining Knowledge, Skills and Competence (KSC)

Knowledge, Skills and Competence for Learning Outcomes - Examples

Knowledge	**Cognitive Ability**	**Know what (conceptual, abstract)**
Example:	Mathematics/ Calculus	Calculate differential equations
Skill	**Technical or Functional ability**	**Know how (to do, procedural)**
Example:	Engineering/ Nuclear Safety	Produce a nuclear safety documentation
Competence	**Attitude, behavioural or interpersonal ability**	**Know (how) to be, how to relate**
Example:	Interpersonal	Capacity to mobilise people

Geological Disposal Example of Learning Outcomes

part of Unit	Coordination of safey analysis/case for geological disposal (some examples)	
LO	K	Understand and apply long-term safety requirements for achieving, demonstrating and presenting safety of geological disposal (including safety functions)
		Understand the concept of safety and the understand the impact of underlying physical and chemical processes.
		Understand probabilistic safety analysis principles and risk in the context of safety case
	S	Plan and structure a comprehensive safety case for a licensing stage
		Apply natural analogue information in a safety case in support of long-term safety arguments (complementarity)
	C	Able to steer and supervise the production of a safety case
		Able to coordinate interdisciplinary work in team

Source: Adopted from Petrus II (FP7) and ECVET seminar 2012

Why should this work be carried out for Geological Disposal?

Our state-of-the art of learning:

- Dedicated university education is available in some EU countries , but **most learning and accumulation of experience is informally acquired** (includes training, learning on projects, learning at work...).
- Informality is specific for learning in our community: either learning on the job and internal training. This includes professional development.
- Different learning outcome are needed at different stages of the repository development.
- The **learning outcomes already achieved,** they have **not been collected or documented** => Accreditation can act as a motivation to carry out such **memory keeping work**.
- With the long-timeframes of disposal – **knowledge preservation and transfer is needed** already **now** as the demographics change in Europe.
- Work on identifying the Knowledge, Skills and Competence has started, but the results are far from complete and have not been brought together yet.

This is were your views are now needed:
Do we need to proceed and how to proceed!

Some Implementation Need Examples

- KSC from the various stages of geological disposal need to be collected and documented => they will also form the assessment criteria or a standard for accreditation
- Standards/KSC defined need validation from the relevant stakeholders
- Accredited learning outcomes need recognitions from the relevant stakeholders/ the community . One needs a (broad) partnership/ partnerships (networks) like ENEN
- Transcripts are needed as a proof of recognition.

Recognition: Accreditation and ECVET Tool

Accreditation further requires for example

- an accreditation body/bodies – *professional, objective*
- agreed accreditation criteria – *a preset standard/s*
- target/object of accreditation – *unit of learning, learning outcomes – e.g. defined using ECVET*

ECVET is also tool for setting up the criteria

- A tool for setting the standards for what **an individual masters** or e.g. what **a training programme delivers**, if implemented according to the standards leading to the validated and accepted learning outcomes
- ECVET enables assessment **independently of the way** the learning outcomes are acquired
- In this way it contributes to lifelong learning and efficiency directly by **eliminating the need for overlapping training or education** when the assessment standard is met.

ECVET Framework: Objectives, Contribution and its Technical Components

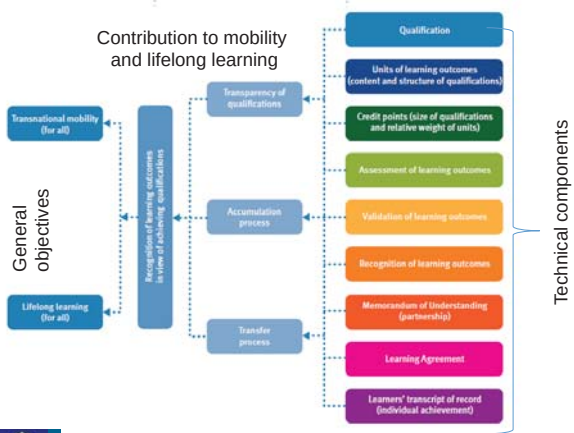


Figure from ECVET User's Group. 2011. Using ECVET to Support Lifelong Learning.

Assessment of Learning Outcomes within Geological Disposal for Individuals and Training Providers/Programmes

ECVET TECHNICAL COMPONENTS need for:	Voluntary Accreditation of an individual's LOs	Voluntary Accreditation of an ECVET training provider
Assessment of LOs	Yes. Assessment criteria and demonstration of LOs needed. See also validation.	Yes. Assessment criteria and demonstration of LOs needed.
Validation of LOs	Yes. An accreditation body needs to be set up or approved by the partners.	Yes. Done by an internal process, by MoU partners, or by an accreditation body.
Recognition of LOs	Yes. By the industry and institutions in the community and/or by training providers by signing an MoU.	Yes (see MoU).
Partnerships (MoU)	Yes. Wide coverage of partners to engage themselves in a MoU for voluntary approval of the recognised LOs.	Yes. Basis for transfer of the recognized LOs between various providers (a criteria for voluntary accreditation, too).
Learning Agreement	No	Yes, needed for exchange in the formal exchange between training providers or between a provider and a workplace.
Learner's transcript of record (e.g. Europass)	Yes. A certificate needs to be provided of recognition of LO/s resulting from assessment =>: e.g. inclusion into Europass.	Yes, provided by the training provider to the home institute and later into the Learner's transcript (achievements). One example, the ENEN supplement to a diploma.

Your Input During the Walkabout

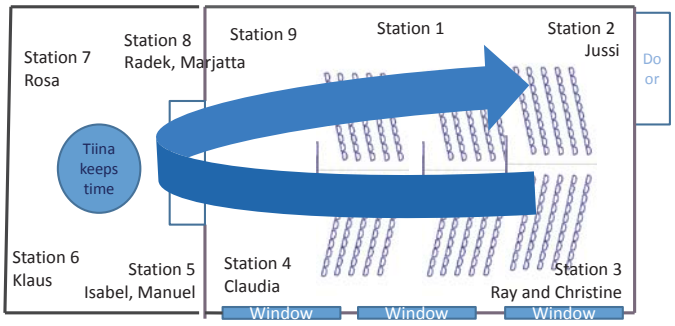
Reflecting on **a potential for accreditation** in geological disposal based on what has been presented and based on the questions

- write down your opinions and ideas related to 8 set of questions on the hand-out – write **each idea on an individual post-it with print letters.**
- identify where you **consider benefits and constraints** and identify **what has** already **been implemented** in your organisation/ country in geological disposal in the area of accreditation.
- identify **what would still be needed or not** needed?

After the reflection, start by taking your station related post-its to the station closest to you

- submit your post-it note for the relevant station (questions) on the flip chart and discuss your views with the station host and other participants on that station;
- after ~10-15 minutes **move clock-wise to the next station** and repeat until you have covered all stations – **a clock/bell will ring** an alarm as a sign.

Direction of Walkabout - Clockwise



Time to Start the Walkabout

- All views and inputs are most welcome, your own, your company, your neighbours, … ☺
- Now please take your post-its and move to the flipchart station closest to you.
- A bell will signal for you to change the station.
- A coffee break will be at 10:30-11:00 hrs, please come back on time for the remaining stations.
- We will conclude the session for the lunch and come back with the session report in the afternoon.

Report on CMET Walkabout session

This event is co-funded by the European Union under the 7th Euratom Framework Programme,
Grant agreement number 323260 - SecIGD2 project

Exchange Forum 5
CMET Session – Quick Report on the Outcomes of the Walkabout

Recap of the CMET session objective

Purpose of today's session was:

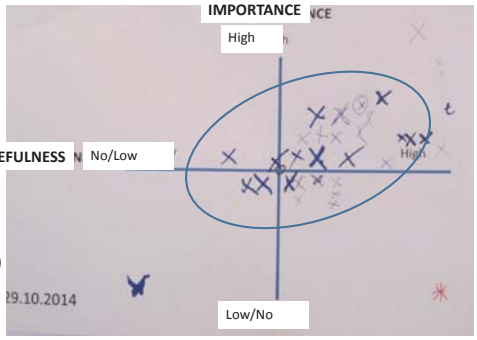
- To give a brief overview of voluntary accreditation and about ECVET and foremost
- To collect multiple perspectives that would contribute to the feasibility study of the voluntary accreditation scheme and related work by the CMET working group

The main outcomes from each walkabout station are presented in the following:

Station 1 (1)
Do we need an accreditation system?

Usefulness and importance of an accreditation scheme/system
-in general?
-to you?

- Considered more useful (80%) than important (70%)



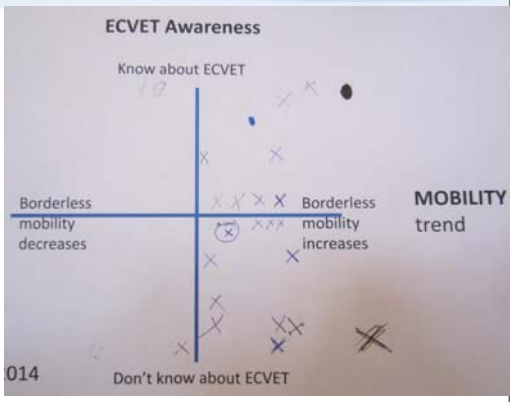
Station 1 (2)

What would motivate you to apply such a system?

- *Motivations*
  - *of a company to get staff to learn (+)*
  - *is it worth it? cost vs. benefit*
- *Credibility*
  - *favorable to public acceptance*
  - *regulator acceptance*
- *Mobility*
  - *favorable for early career professionals*
  - *+/- it is already happening*
- *View that it is very implementation dependant – the time/effort needed could be the constraint*

Station 2 (1)

- **Do you understand what ECVET is?**
- Mostly not well known!
- Borderless mobility increases



Views about Human Mobility and Life Long Learning

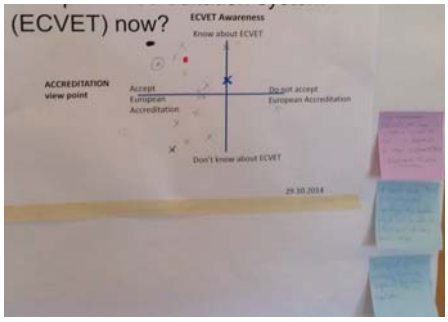
- *12 positive notes*
  - *"good concept"*
  - *Enables maintenance of critical mass and knowledge*
  - *Both in a perspective of individual and organization*
- *3 doubtful*
  - *Does it really work*
  - *How country specific items concerned*
- *2 concerned*
  - *How it effects individual workers*
  - *Brings stress, (unhealthy) competition, problems to personal life*

Station 2 (3)

Would you be willing to accept a European accreditation system (based on ECVET) now? 16 positive, 1 neutral, 1 negative

ACCREDITATION view point in the sticker notes: does it work, needs time to be introduced to the practice. Problems if adopted too fast by the regulators

ECVET Awareness



Station 2 (4)

Those aware of the ECVET system to respond on:

What are your views about the proposed EU instrument ECVET (European Credit System for Vocational Education and Training)?

- *Those who are aware about ECVET willing to accept an European accreditation system?*
- *Also most of those who do not know about ECVET willing to accept it. " a good concept"*

Does your organisation currently collaborate with others in setting up a system using the ECVET tool?

- **Posiva and Petrus III-consortium**
- **Not adopted by organizations: 12 "No" responses**

Station 3 (1)

What is the current competence maintenance approach used in your organisation? Do you have one?

- *YES n=19; NO n= 2 ; Unsure n = 1*
- *Two groups identified: A: current professionals in the organisation and B: new entrants to the organisation*
- *Several approaches (> 25) – major approaches are*

A –current professionals	B – new entrants
Internal courses (N =7)	Choose students (PhD) (N = 8)
Seminars related to the dev. of competence (N = 2)	Training/supports to achieving educational goals (N = 7)
Chartership with professional bodies/ professional progression (N = 2) PhD (sponsoring, sabbaticals)	University degrees in science (N = 5) TSO training education (experts to starters) (N =2)

Station 3 (2)

To what extent would you/your organisation apply a competence assessment (accreditation) system, if a widely accepted scheme was available?

Number in favor: N = 12; NO N = 4, Do not know: N = 6

Where in the job hierarchy of your organisation does accreditation fit? *(identify the 2-3 most frequent levels here)*

- *levels: Experts a top level*

Would you prefer/require/push your staff to be accredited? Would you require accreditation from new staff on entry, if accreditation was available?

How many would require accreditation? N = 16

How many would make it voluntary for the staff? N = 7

How many would require as an entry requirement? N = 7

Station 3 (3)

Would you be willing to integrate or do you see benefits in integrating your current system into a European accreditation system?

How many would integrate? (N = 12)

Benefits identified:

- *none identified*

Station 4 (1)

What are the appropriate approaches to find out/to measure/ to distinguish (objectively?) if someone has achieved a required standard of mastering certain KSC (Knowledge, Skills and/or Competence)?

- **CV (12)**
- **Interview (12)**
- **Work Portfolio (7)**
- **References (publications, recommendation letters, ...) (7)**
- **Discussion on practical examples (case solving, ...) (6)**
- **Education (3)**
- **Probation period (3)**
- **Independent expert body (Accreditation, professional institutions) (3)**
- **Continuous appraisal (on the job) (1)**
- **Public presentation of previous works (1)**

Station 4 (2)

In which areas is the definition of learning outcomes most urgently needed, and why?	N= for each learning outcome
Safety Case Knowledge	7
Environmental areas / issues	5
Safety areas	3
Independent learning ability	3
Applied sciences	2
Interdisciplinary thinking	2
Modelling / numerical competences	2
Material sciences / design	2
Safety case understanding	1

Station 4 (3)

In which areas is the definition of learning outcomes most urgently needed, and why?	N= for each learning outcome
International framework	1
English language knowledge	1
Mathematics	1
Quantification of uncertainty	1
Hydraulics / Fluid mechanics	1
Performance Assessment	1
Quality assurance	1
Monitoring	1
Geography	1
Hydraulics / Fluid mechanics	1
Relationship between safety case/ repository concept	1

Station 4 (4)

In which areas is the definition of learning outcomes most urgently needed, and why?	N= for each learning outcome
Team work ability	1
Quantification of uncertainty	1
Chemistry	1
Geosciences	1
Performance Assessment	1
Basic Nuclear engineering sciences (reactor techniques, nuclear physics, ...)	1
Basic knowledge of fuel and fuel cycle	1
Project management	1
Public awareness / societal questions	1
Construction / operation	1

Station 5 (1)

What is your interest in having a voluntary accreditation for the geological disposal community?

POSITIVE

- *Ease exchange and mobility of experts in Europe*
- *Allow to learn about different methods, education styles, regulations and standards*
- *Preserve, maintain and train newly hired people.*
- *Promotes confidence building.*

Station 5 (2)

What is your interest in having a voluntary accreditation for the geological disposal community?

LIMITED:

- *What is the added value with regards to existing education systems and mobility tools (e.g. training courses in the framework EC funded research programs (matter of cost and dedicated subjects) ? -strongest comment-*
- *Preference for academic profiles*
- *Preference for mobility promoted by financial benefits*
- *Might restrict availability of experts*
- *Intercultural difficulties*
- *Language barriers*
- *Acquired skills are only fit for their specific program (country).*

What constraints do you see for such an accreditation system? What type of risks do you see related to an accreditation system, if such a system existed?

Station 5 (3)

What constraints do you see for such an accreditation system? What type of risks do you see related to an accreditation system, if such a system existed?

CONSTRAINTS

- *Should be a complement to existing accreditation systems in some countries*
- *Requires times and resources to implement and maintain.*
- *Might be difficult to apply because the geological disposal program is a very specific and narrow field.*
- *Should take into account the national regulations.*

Station 5 (4)

Would you see the implementation of such a European system as a risk of decreasing the flexibility of your existing (staff qualification) system? (E.g. administrative burden?)

No impact N = 7 ,

What suggestions do you have to overcome the constraints and/or the risks (including resource constraints)?

to be addressed later

Station 6 (1)

I II III IV V VI

RAD. WASTE TYPES	CARRY OUT GENERIC STUDIES AND	SELECT HOST ROCK AND	DEVELOP TECHNOLOGY AND		PRODUCE IN INDUSTRIAL SCALE AND
	DEVELOP CONCEPT	SELECT SITE	DESIGN REPOSITORY	CONSTRUCT REPOSITORY	OPERATE REPOSITORY

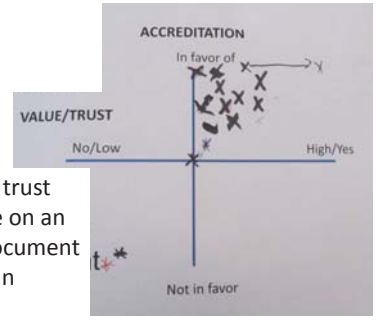
Stage (I-VI)	Specific action area	Replies N=

Several comments on having too little time to reflect on this

Many topics picked from the Deployment plan especially under Key Topics 3 and 7

Station 7 (1)
Are you in favour of accreditation?

Favor N =17
Not in favor N = 3
Not sure N = 1



What value and trust would you place on an accreditation document issued by such an accred. body?

- Fear of the process becoming bureaucratic.

Station 7 (2)

Trust and value of an accreditation document?

- *depends strongly on the type of accreditation system implemented and who accredits (e.g. in IAEA high trust)*
- *difficult to answer due to the difficulties to measure learning outcomes*

Who should make up the accreditation body [so that you would trust their decisions]?

- *Expert groups, end-users; IAEA, an independent agency*
- *combination of universities (incl. ENEN, IAEA) and end-users; universities*
- *WMOs*

Station 7 (3)

What type of credentials should the members possess, who make up such a body?

- *interdisciplinary scientific competences, with expertise in waste management (like professors coming from university) and related*
- *experts for the IGD-TP or WMOs*
- *higher education institutions*
- *lot of replies saying don't know, need to think about it*

Where should this body reside in order to be trusted by your organisation?

- *an international and independent organisation*
- *IGD-TP organisation*
- *IAEA*
- *EU*
- *In a nuclear country*
  - » *No idea*

Station 7 (4)

What type of organisational form should the body have?

- *independent – most important, recognised by all relevant institutions*
- *an informal network*
- *part of EU (Energy division)*
- *Public and transparent*

Station 8 (1)

How should an accreditation scheme/system be financed?

- *European level funding (EU) i.e. our taxes N = 10*
- *ENEN special account*
- *By cost sharing – WMOs, industry, individuals (N = 5-10)*
- *Public private scheme*

And by whom?

- *WMOs; Government; Member states;, Nuclear fund…*
- *individuals themselves (N = 7)*

- Risks:
  - *should be affordable to the participants*
  - *time consuming*
- Constrain:
  - *keep at national level*

Station 8 (2)

What would be your willingness to invest into getting an accreditation?

For you N=	For your staff/organisation member N =	For a training programme N =	For something else:
9	5		1

Station 9

Other thoughts and views related to the voluntary accreditation scheme and competence maintenance in geological disposal from the participants:

- *Timing / timetable of such a scheme*
- *Lower level of EQF (attention to specific areas like RP, social sciences…)*
- *Lead organisations to get the other WMOs on board*
- *Advertise this*
- *Pilot and lessons learned*
- *Equally available for everyone*
- *Risks: Lack of flexibility, lack of heterogeneity (like in training); danger of narrow specialisation*

Quick conclusions

- to be determined at a later stage, not totally against – more cautious due to lack of information and awareness
- for several participants a new topic
- hopeful the awareness has increased now

Where you able to provide all your input?

The station questions will remain open until 6 November 2014 at the link

https://www.webropolsurveys.com/S/30FAA4B6C4285645.par

The link is also accessible from the JA 14 page on http://www.idgtp.eu.

More inputs are most welcome.

The way forward after today

- Your detailed views will be now recorded, then
- Analysed and the final results handled at CMET no 4 on 26 Nov. in Paris (registration by 19 November 2014)
- Further discussions will take place in CMET no 5 in April 2015 in Lisbon back-to-back with Petrus III (either week starting 13 April or 20 April 2015);
- The report on the feasibility study on the voluntary accreditation schem will ready by end of 2015 with recommendations
- After that the decision will be much depending on you – the IGD-TP how to proceed.

Conclusions and way forward by Monica Hammarström

This event is co-funded by the European Union under the 7th Euratom Framework Programme,
Grant agreement number 323260 - SecIGD2 project

Implementing Geological Disposal of Radioactive Waste
Technology Platform

Conclusions and way forward for IGD-TP in 2014-2016

Monica Hammarström, IGD-TP Chair

The research leading to these results has received funding from the European Union's European Atomic Energy Community's (Euratom) Seventh Framework programme FP7 (2007-2013) under grant agreements n°249396, SecIGD, and n°323260, SecIGD2.

Summary

- EF no 5 2nd EF with "working-group" approach
  - ✓ 5 working groups
- 18 countries
- 130 participants including representatives from SNETP, ENEN, Sitex and guests from Oskarshamn and USA

Summary

- We realize question marks regarding the Euratom programme after the licensing of first repository
- Decision on outcome of last call will be presented in the coming weeks
  - ✓ Three project proposals were prepared through discussions at EF 4 (Prague) (Cebama, Modern2020 and MIND)
  - ✓ More money requested than available
  - ✓ EG needs to look alternative solutions
- Looking forward to the conclusions and recommendations from the Euradwaste´ 13

Summary

- Through ENEN it is clear that long-term stategies to maintain and develop competences are needed
- Public involvement puts requirements on
  - ✓ Listening
  - ✓ Open process
  - ✓ Time

Summary of Working groups

- WG 1
  - ✓ Different needs in different programmes, transfer of experiences and knowledge
- WG 2
  - ✓ Need for closer link and integration between the existing FEPs and 'Microbial FEPs. Increase understanding of microbial processes
- WG 3 IGD-TP/SNETP
  - ✓ Valuable network has been established
- WG 4
  - ✓ No need to revise the SRA, ILW (deep geological disposal) should be added

Main Challenges for 2015-2016 (1)

- Keeping the Joint Activities alive (backbone of the IGD-TP)
  - ❑ Limited human resources
  - ❑ Efforts mainly borne by EG in priority…But all can contribute
  - ❑ EG to think about how to develop ways of contributions especially for less advanced programmes
  - ❑ EG to ensure continuous follow-up of EC-projects and JA i.e via dedicated "end-user" groups
  - ❑ Don´t forget to use the Website and Project-place

Main Challenges for 2015-2016 (2)

- Setting the conditions for the Joint programming
  - ❑ Keeping the condition for success (Independency WMOs/TSOs/research groups)
  - ❑ Engaging the scientific community
  - ❑ Ensure a fair contribution from all partners whatever the level of development of their programmes
- Increasing the coordination between other groups and actors
  - ❑ Strengthening the links between IGD-TP and SNE-TP
  - ❑ Integrating public concerns remains an open issue (any follow-up on the contacts with EESC?)

Events in 2015

Set Plan Conference 2014
"Driving the energy transition together"
Dec 10-11
www.setplan2014.it

"Repository programmes for SF/HLW in Crystalline hard rock and Clay formations-State of the art in full-scale demonstration tests for repository technology development
Oskarshamn, June 2-4 (prel)

Visit at Äspö HRL

Participants to the visit need to present a valid photo ID.

PROGRAMME 30th October

08.00	Departure from the hotel by bus
09.30	Arrival, coffee and registration
10.00	Presentation Äspö HRL
10.15	Visit to the tunnel/Deepened presentation
11.45	Changing of groups
13.00	Lunch
14.00	Departure to Kalmar airport and the hotel

Don't forget to bring your luggage !

See you at the next EF6 in London !

EF6 November 3-4, 2015 organised by RWM

Poster Session

IGD-TP working group on RD&D dissemination

Raymond Kowe, RWM, UK

The Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP) SecIGD2 project has set up a working group specifically to investigate the needs of new member states and to organise two international conferences (2014, 2015) for disseminating the scientific and technical information and results derived from the IGD-TP's Joint Activities and other RD&D efforts in the field of geological disposal.
The working group has produced a questionnaire and collated responses to identify needs from less advanced programmes. The working group will produce a 'mini-roadmap' that is aimed at helping a first response to the RD&D related aspects of the EC Directive. The roadmap will set out the key steps in developing a geological disposal facility programme and strategy based on advanced waste management organisations experience. The roadmap will signpost open documentation and guidelines for specific technical areas.

IGD-TP CMET Working Group Activities

Marjatta Palmu, Posiva, Finland

This poster will present the activities of the IGD-TP CMET working group.

A Czech contribution to microbiology of deep geological environment

Spacek Pavel, CHEMCOMEX, Czech Republic

CHEMCOMEX has been collecting some new results and methodical approaches during last years, which are focused on lithotrophic microorganisms involved in geological processes of contaminated subsurface and groundwater systems (iron reducing bacteria, immobilization of metals by biological precipitation, methods for reducing equivalent source estimation - iron , manganese, sulphides, ammonia ions etc.). There is a fast developing cooperation with Czech Technical University – Faculty of Civic Engineering operating the Underground Research Centre Josef, a unique research infrastructure for crystalline rock underground studies, research projects and education. The second potential site that has been considered for research is Bukov underground laboratory (operated by SURAO), nowadays under construction. ÚJV Řež (a research institute with long term history of nuclear sciences) provides experience with use of radionuclides in different areas of energy production, their identification and quantification. All partners, their infrastructures, and main ideas of this cooperation creates content of this contribution.

Long term behavior of Waste Forms from Gen IV Reactors towards Geological Disposal

Massimo Sepielli, ENEA, Italy

SNETP Gen IV fast reactors prototypes (sodium, lead, gas - cooled) produce downstream reprocessing a spent fuel "new" waste type, which will require in the long-term proper geological disposal repositories for fission products and minor actinides storage. Geological disposal requirements can be relaxed by adopting particular processes for spent fuel treatment, in terms of stability, durability, environmental impact, loading and volume reduction of the final waste inventory. The present work is related to a very promising research activity about conditioning of chloride wastes coming from spent fuel treatment by pyro-processes, including the characterization of the final waste forms. At present Pyrochemistry appears as a promising alternative for the separation of uranium from fission products, which is ordinarily carried out in eutectic molten chloride salts, such as LiCl-KCl. This method is expected to be very suitable for advanced nuclear engineering, due to its advantages compared with the hydrometallurgy process currently used for the extraction of lanthanides: radiation stability of molten salts (allowing processing of spent fuels of high radioactivity), absence of neutron moderator such as water, low waste production, non-proliferation requirements. Furthermore, it represents an excellent alternative for treatment of UO2 and MOX fuel, and the only possibility for fuels like nitride and carbide fuel, to which hydrometallurgy cannot be applied. Since many years ENEA is involved in research programmes concerning separation of actinides from other fission products and treatment of related wastes. The latter are chloride salts, for which different materials have been proposed as conditioning matrices. They include sodalite, a mineral phase that contains chlorine, SAP, a formulation recently proposed by Korean Atomic Energy Research Institute (KAERI), and murataite, an isometric-hextetrahedral black mineral containing many metal cations. Several tests and analyses are envisaged in order to characterize the final products: density measurements;

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

thermogravimetric analysis; SEM-EDS; optical microscopy; FTIR; XRD. Leach tests under static conditions will be carried out in demineralized water at both 23° and 90°C, up to 150 days. For the tests, in addition, the most suitable radiological characterization techniques will be investigated in order to verify their applicability to New Waste Types arising from Gen IV reactors fuel cycles. Financial support from the Nuclear Fission Safety Program of the European Union (projects ACSEPT, contract FP7-CP-2007-211 267, and SACSESS, Collaborative Project 323282), is gratefully acknowledged.

Preliminary assessment of the interactions between chloride salt wastes immobilized in a sodalite matrix and disposal site

Massimo Sepielli, ENEA, Italy

The pyrometallurgical processing of spent nuclear fuel, conducted at 500°C in a molten salt medium (LiCl-KCl, 59-41 mol%), generates a chloride salt waste containing alkali-metal, alkaline-earth, and some rare-earth fission products. Sodalite, a naturally occurring mineral containing chlorine, has been investigated as an immobilization matrix for this salt waste. The general aim of the present work is the assessment of the interactions which take place between solidified chloride wastes and soil, through the evaluation of a series of leach tests made at three different pH (acid, neutral and alkaline), in order to understand the effects that such important parameter can have about the release of fission products present in the chloride wastes immobilized by a sodalite matrix. The role played by a borosilicate glass added to the final waste form has also been taken into account. It is shown that an acidic pH increases the leach rate of each element, while the latter is reduced at elevated pH values, and, as expected, it increases at increasing temperature, especially at 90°C. Furthermore, the behaviour of the various ions is perfectly in agreement with their nature: in particular, monovalent alkaline elements (rubidium and cesium), difficult to retain in the matrix, show a higher mobility; bivalent alkaline-earth elements (strontium and barium) are less released into the environment; finally, trivalent rare earth metals, like neodymium, show a low release, while lanthanum is unexpectedly more released at acid pH. Based on the results obtained, the general conclusion can be drawn that disposal sites with a high acidity degree should absolutely be avoided. Financial support from Italian Ministry for Economic Development (Accordo di Programma: Piano Annuale di Realizzazione 2011) is gratefully acknowledged.

DOPAS "Plug and Seal" Project: Achievements from transfering the information from real to lab scale, supporting EPSP (CZ) experiment.

Václava Havlová, ÚJV Řež, a.s., Czech Republic

The DOPAS FP7 project had been derived from the IGD-TP's Strategic Research Agenda that pointed s out the topic of "plug and seals" as one of the first priority issues. DOPAS project addresses the design basis, reference designs and strategies to demonstrate the compliance of the reference designs to the design basis, for plugs and seals in geological disposal facilities. The Czech contribution to the DOPAS project (Demonstration of Plugs and Seals) has been based on the EPSP experiment – Experimental Pressure and Sealing Plug. The experiment has being realised at the Josef Regional Underground Research Centre (URC Josef).
However, due to the fact that the EPSP experiment is not going to be dismantled during the course of DOPAS project, some of the material properties and performance has to be verified in laboratory scale. Physical models of plug constituents have been constructed in UJV Rez, a. s. laboratories, using Czech Ca-Mg bentonite as a sealing material and low-pH concrete, the same as used in-situ. Water saturation with water has been studied in the first type of experiments, using the simulated conditions (water inflow through cocrete plug under pressure up to 20MPa). The data gained will be used for calibration of bentonite saturation calibration models. Furthermore, bentonite – concrete interaction will be identified and quantified after long term interaction under similar conditions as in Josef Gallery. However, lab experiments here can only simulate processes that would be present under real rock massive conditions. DOPAS project does not enable to dismantle the plug during the course of the project. Therefore long-term research activities (5 – 10 years), enabling to spent enough time on studying all the aspect of processes, concerning plugging and sealing or any other DGR related task, are here envisaged for future projects.

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

Addressing total cost management when planning and implementing a radioactive waste management programme for deep geological disposal

Claudia Vivalda, Nidia - Scientific Services, France

The poster addresses the issue of Total Cost Management (TCM) during the life-cycle of a radioactive waste management programme for deep geological disposal.
According to the Authority for Total Cost Management, the AACE International, "Total Cost Management is the effective application of professional and technical expertise to plan and control resources, costs, profitability and risks. Simply stated, it is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product, or service. This is accomplished through the application of cost engineering and cost management principles, proven methodologies and the latest technology in support of the management process."
Based on the above definition, the poster will present how the principles of TCM can be applied when planning and implementing a programme for deep geological disposal of radioactive waste. It will address the different phases of the programme and highlight how the cost dimension represents a relevant information to support decisions related to the site implementation strategy, the research and development activities, the engineering and construction processes.
The poster will also tackle the problem of cost estimates' uncertainties of reference systems, i.e. storage sites, in their feasibility stage and planning to implement technologies not fully developed or customized. It will discuss how to find more reliable estimations that support the decision making process at a certain level of confidence, based on probabilistic calculations of costs.
In doing that, the poster will introduce the use of probabilistically distributed values for uncertain relevant costs and the propagation of these distributed values through the cost model by mean of Monte Carlo simulations to obtain probabilistic outcomes and their statistical parameters, e.g. mean, median, confidence intervals.

TSWG JA6a: Cement-organics-radionuclide interactions

KIT-INE, Germany

Organics are present in cement based materials as: (1) Waste components, (2) Organic cement additives, partly in significant concentrations especially in low pH cements.
The organic components as well as their degradation products may interact with radionuclides forming soluble complexes affecting the radionuclide source term. Investigations on cement-organics-radionuclide interactions are not included in Cebama. A working group could discuss following topics among others:

- Impact of organics on radionuclide retention in cement systems
- Impact of organics on redox conditions in alkaline environments
- Organic degradation by different processes (including microbial processes)

A WG meeting discussing these topics is proposed in March 2015 at KIT.
Please communicate your interest in participating in the WG by January 31, 2015 to:
Bernhard.kienzler@kit.edu;
Marcus.altmaier@kit.edu;
Vanessa.montoya@kit.edu

TSWG J6c: Safety of Spent Nuclear Fuel Disposal in Crystalline Rock (SafeRock)

Vanessa Montoya, KIT-INE, Germany

The collaborative project SafeRock responds to the call of the European Commission C(2013)8563 of 10 December 2013 (H2020-NFRP-2014/2015), section B - Contribute to the Development of Solutions for the Management of Ultimate Radioactive Waste, Topic NFRP 6 – 2014: Supporting the implementation of the first-of-the-kind geological repositories.
The overall objectives of the SafeRock project support the implementation of geological disposal of spent nuclear fuel in crystalline rock by investigating key remaining issues for the Crystalline Rock Safety Case. The project includes the coupling of near-field radionuclide mobilization with far-field transport processes by performing spent fuel corrosion experiments under repository-like conditions using materials from underground laboratories and providing input for relevant sorption / transport studies. The project is implemented by a consortium of 19 Beneficiaries consisting of 9 large Research Institutions, 3 SMEs, 6 universities, and the EC Institute for Transuranium Elements.

This event is co-funded by the European Union under the 7th Euratom Framework Programme, Grant agreement number 323260 - SecIGD2 project

Working towards a reference framework for environmental monitoring, IGD-TP Joint Activity 4

Catherine Galy, Andra, France

Establishing the environmental characteristics of a proposed site for geological disposal of radioactive waste is an essential, early activity for any implementation program. This information is necessary to define a reference state (or baseline) against which future change can be evaluated. It is an important input for environmental impact assessments (EIAs) and for the development of an environmental safety case. It is also required to address stakeholder concerns and expectations, helping to build confidence in geological disposal as a safe and effective solution for the long term management of radioactive waste.

IGD-TP Joint Activity 4 will explore how environmental monitoring around a proposed site should be defined, structured, organized and managed. The focus of JA4 is the period before construction begins, although it is recognized that environmental monitoring set up to establish an initial reference state will be to a certain level required during subsequent construction and operational phases. JA4 is also focused on EIA requirements, although there are clear overlaps with safety case requirements and it may be that in these areas duplication of effort can be avoided by developing a common approach to monitoring.

Because the environment is a highly dynamic system made up of multiple components (biosphere, hydrosphere, atmosphere, lithosphere, geosphere) interacting at different scales (spatial and temporal), a comprehensive monitoring program, up and running prior to the construction of the geological disposal , is required to establish a good, representative view of the initial reference state. In term, the aim of the monitoring is to enable the understanding of “natural” variations and/or any other anthropogenic impact affecting the site (prior to the planned activities) in order to be able to differentiate those from the potential impacts, direct or indirect, induced by the planned geological disposal. Collecting, organising and interpreting monitoring data in order to meet EIA (and safety case) requirements, and to address stakeholder expectations is a real challenge. Different monitoring strategies have been adopted or are currently being developed by waste management organisations across Europe. By comparing these strategies and exchanging ideas on approaches to environmental monitoring, JA4 will help to ensure that good practice is shared and common areas for research and development are identified.

JA4 aims to deliver a reference framework for waste management organisations, which will support development of their environmental monitoring strategies and detailed monitoring programs. This work is likely to include information on the spatial, temporal and technical scope of monitoring; sampling and analysis techniques for key environmental parameters; managing large data sets; data interpretation and accounting for environmental trends as well as the involvement of stakeholders in the design and implementation of monitoring programs.

A Method to Induce Correlations between Distributions of Input Variables for Monte Carlo Simulations.

António De Campos Pereira, Stockholm University, Dept. of Physics, Sweden

A heuristic method for introducing correlations between input variables used in probabilistic simulations for risk assessments is presented in this work. This method is an improvement on previous solutions as it not only allows one to include correlations between ranks of variates sampled from probability density functions, but also between the raw values of those variables.
The method is based on the entropy concept, is a general method and is extremely simple. It lets the user choose the types of correlations to be introduced between arbitrary probability distributions. The method is particularly useful to construct empirical distributions based upon limited sets of experimental data.

A Monte Carlo study applicable to nuclear waste assessment is used to illustrate an environmental application of this approach. In this case, a discrepancy of half an order of magnitude is observed between the results of a random Monte Carlo simulation and a simulation where two parameters were weakly correlated.
Keywords: Correlations; entropy; radionuclide migration

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Cebama: Cement-based materials, properties, evolution, barrier functions

Vanessa Montoya, KIT-INE, Germany

The HORIZON 2020 EURATOM Collaborative Project Cebama is developed with the overall objective to support implementation of geological disposal of nuclear waste by improving the knowledge base for the Safety Case.
The project includes (i) experimental studies of interface processes between cement based materials and host rocks or bentonite, and assessment of the specific impact on transport properties, (ii) quantification of radionuclide retention under high pH cement conditions, and (iii) development of comprehensive modeling approaches supporting the interpretation of the results. Further objectives cover dissemination of results to scientific and non-scientific stakeholders as well as training and education of young professionals. The 4 years project is implemented by a consortium of 27 partners consisting of large Research Institutions, Universities, one TSO and one SME from 9 EURATOM Signatory States, Switzerland and Japan. National Waste Management Organizations support Cebama by co-developing the work plan, participation in the End-User Group, granting co-funding to some beneficiaries, and providing for knowledge and information transfer.

Research activities in the field of deep geological disposal in Research centre Rez

Lucie KARÁSKOVÁ NENADÁLOVÁ, Research centre Rez, Czech Republic

On the poster will be described information about research activities and equipment in Research centre Rez.

The Research Centre Rez – its position in the radioactive waste management system in the Czech Republic

Jitka Miksova, Research centre Rez, Czech Republic

With regard to the increasing demands on the supervisory authority of nuclear safety related to the development of nuclear energy, the need of an independent technical support has arisen. This support has to be ensured not only in relation to the nuclear reactors operation but also with respect to the radioactive waste management. The position of the Research Centre Rez as a technical support organization in the RWM system of the Czech Republic will be presented in this contribution. What function within the Czech radioactive waste management should be ensured by Research Centre Rez, resp. TSO; what is a current stage and a potential development in this field with respect to the international activities, will be also discussed.

Variations in microbial community composition in piezometer installations

Katinka Wouters, SCK•CEN, Mol, Belgium

Introduction
The Boom Clay layer is presently investigated as a potential host rock for geodisposal of nuclear waste in Belgium. The HADES underground research facility (EIG Euridice c/o SCK•CEN), located at 230 m depth under the site of SCK•CEN (Mol, Belgium), provides access to this clay layer for in situ geological, geochemical and geomicrobiological testing. In order to predict how microbiology will affect the biogeochemical processes in a disposal scenario, the resident microbial communities of Boom Clay and the man-made structures within this clay are being characterised.

Objectives and Methods
In this study, water samples were collected from Boom Clay via various existing HADES piezometers (diverse in depth, orientation, location, age, materials used, etc.), including some of the PRACLAY piezometers used for geochemical follow-up along the large scale heater test. Microbial cells from these samples were concentrated on a 0.45 µm filter membrane, followed by DNA extraction, PCR amplification of the V1-V3 region of bacterial 16S rDNA, automated sequencing and an in-house developed bio-informatics pipeline.
The aim was to assess differences or shared features of the microbial communities residing in piezometer boreholes, supplementary to the previous screening of a single, vertical piezometer [1], and to correlate variations to geochemical analyses.

Results
Along the five piezometers, bacterial communities of the filters within one piezometer seem more similar to each other compared to those in other piezometers, despite a variety of filter materials or Boom Clay layers sampled within one piezometer. While the boreholes of two piezometers seem highly enriched in one family of Betaproteobacteria (Rhodocyclaceae), the other piezometers, seem to balance dominance between members of the Chloroflexi, Proteobacteria, Actinobacteria, Firmicutes, Bacteroidetes and Chlorobi, although

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in different ratios and with variations in overall diversity.

Conclusion
The observed variability in bacterial community composition suggests enrichment of certain members of the community according to the engineering properties of the piezometer installation. Although such local enriched microbial community might not be representative for the total (engineered) clay environment, it shows that technical installations (such as piezometers) can introduce and promote local variations in the clay environment and the associated bioprocesses. Further studies of other piezometers and of clay samples are needed, to pinpoint the source bacterial community underlying in situ enrichment, to unravel the mechanism that shapes such microbial community in different repository conditions and to outline the relevance of the (dominant) microbial classes in defining borehole water (and gas) chemistry.

Reference

[1] Wouters K, Moors H, Boven P & Leys N (2013) Evidence and characteristics of a diverse and metabolically active microbial community in deep subsurface clay borehole water. FEMS Microbiol Ecol. 86: 458-473.

SecIGD2 RD&D Planning Guide for Geological Disposal

T. Beattie, MCM-Consulting, Switzerland

The SecIGD2 project of the Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP) has developed a guidance document on RD&D programme planning towards geological disposal of radioactive waste. The Guide considers the essential elements of RD&D planning and provides instructional questions that should be addressed to respond to EC Council Directive 2011/70/EURATOM Article 12 (1,F). It considers the activities that are typically undertaken and prioritised depending on the status of the national waste management programme in relation to the development of safety cases for early licensing phases. It also considers the management activities that need to be considered to successfully implement RD&D activities, such as competency management, civil society involvement, different contractual mechanisms for completing RD&D, and the potential benefits of technology transfer of RD&D knowledge from more advanced radioactive waste programmes.

Users of the guide are identified as Decision Makers, National Disposal Programme Owners and Implementers, National Waste Management Organizations, National Technical Safety Organizations, representatives of Civil Society and experts knowledgeable in Governance and involvement of Civil Society.

Interest from potential users of the guide is now sought to (i) provide initial review comments to guide authors on potential improvements and/or missing information; and (ii) to attend a 1-day dissemination event (PLANDIS, 26th May 2015, Romania) which will communicate and road test the guide in an interactive workshop format, prior to final publication. Interested users of the guide are encouraged to visit the www.igdtp.eu for further information.

Monitoring of copper corrosion in bentonite by means of coupled multi-electrode array

Tadeja Kosec*a, Bo Rosborg, Andraž Legat, Slovenian National Building and Civil Engineering Institute, Slovenia

The majority of our previous research on copper corrosion under oxic conditions has been performed by means of the electrical-resistance (ER) sensors, in combination with the electrochemical impedance spectroscopy (EIS). Although the results of these techniques provided the average corrosion rate of copper in bentonite, additional analysis of the exposed surface indicated uneven corrosion attack. The present work focuses in the spatio-temporal characteristics of the corrosion process, where the dynamic processes and localization of corrosion is assessed. For this reason, coupled multi-electrode arrays (CMEA) were implemented under similar conditions as in our previous study - in a bentonite, saturated with saline water. Using this technique, single corrosion events on individual, galvanically connected multiple electrodes can be monitored. With such detection of coupled anodic and cathodic events, corrosion pattern in time can be determined. At the end of exposure, different spectroscopic techniques are applied to identify modes of corrosion and type of corrosion products. The general corrosion rate and localized corrosion rates were compared.

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Assessment of Bentonite Characteristics in KB3 Method

Markus Olin, VTT Technical Research Centre of Finland

In the KBS-3 method, the reliable estimation of functioning of buffer and backfilling materials protecting the copper canister and spent fuel therein is a bottom line issue for safety. Both the regulator and scientific community must have enough know-how about the behaviour and long-term functioning of these materials. We are aiming to produce that data and knowledge, the work being divided into three major topics. First, in the Thermal-Hydrological-Mechanical (THM) topic, the goal is to gain more understanding about coupled THM processes by applying both experimental methods and modelling; the experimental work is planned to be carried out on all levels from nano-scale (SAXS) via meso-scale (tomography, mineralogy) up to full scale (shear block). Second, in the Thermal-Hydrological-Chemical (THC) topic, the goal is to gain more understanding of these processes by applying both experimental methods and modelling; the experimental work is planned to be carried out on cation exchange, colloids, solubility of montmorillonite, and microbes in bentonite. Third, in the Thermal-Hydrological-Mechanical-Chemical-Biological (THMCB) topic, the goal is to gain more understanding of the full THMCB coupled processes, mainly by applying suitable modelling tools, especially Numerrin and COMSOL Multiphysics. The work is carried out in a coordinated research project BOA of Finnish Research Programme on Nuclear Waste Management (KYT2014). The collaborating research institutes are: Aalto University shear phenomena between different backfill material interfaces), the Geological Survey of Finland (GTK, mineralogical methods for characterization of bentonite), the University of Jyväskylä (3D X-ray tomography and modelling to study wetting of montmorillonite), the University of Helsinki (radiochemistry: methods for bentonite colloid measurements and sorption of radionuclides onto those colloids), the University of Helsinki (Physics: modern X-ray diffraction methods to study the nano-level structure of bentonite), Numerola Oy (own mathematical methods, Numerrin, both to analyze 3D tomography data and to solve transport models based on that data), and VTT Technical Research Centre of Finland (measuring the solubility of montmorillonite, applying chemical sensors in aqueous concentration measurements and studying microbial activity in bentonite). All these methods are directly applicable in studies of the bentonite buffer in a large application area, such as from dry to saturated bentonite, from initial state to post glacial conditions, and from compacted bentonite to dilute colloidal solutions.

Continental deep biosphere of the Fennoscandian Shield

Merja Itävaara, VTT, Finland

The continental earth crust contains regions of very different age and composition including crystalline rocks, metamorphic systems, sedimentary basins and organic deposits, and magmatic intrusions. Throughout the crust, fluids are the principal agents in transporting and focusing Earth's energy and mineral resources. In Finland the earth crust is around 50km deep and the bedrock is very stable crystalline bedrock which is also supposed to be safe for long term storage of nuclear wastes. Deep terrestrial subsurface microbial populations are still highly unexplored, and their origin and interactions with surface populations are not known. In Finland we have access to several deep sampling sites and have developed microbiological sampling techniques. Our studies based on metagenomics have revealed several ongoing processes such as deep nitrogen fixation, carbon cycling and other geobiological processes occurring in deep terrestrial habitats.

Simplified concepts in modelling nuclide transport and doses from spent fuel disposal system using probabilistic methods

Pekka Kupiainen, Fortum, Finland

In Finland, the disposal system for spent nuclear fuel is based on the KBS-3V concept and Posiva is assigned to take care the disposal. An initial defect in a copper canister is assumed in the reference scenario of Posiva's TURVA-2012 safety case. The radionuclide migration is depicted by using a simplified solute transport model that is an alternative approach compared to numerical methods used largely in the performance assessments. In the simplified model, the radionuclide migration in geo- and biosphere is calculated by using analogy to a branching radioactive decay chain. The time constants of the model are solute half-times and delay times in the release barriers and biosphere compartments. Using a probabilistic Monte Carlo method, the effect of uncertainty related to initial data can be quantified by estimating confidence levels for the release rates and dose rates.

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A simulation with seven key nuclides (C-14, Cl-36, Se-79, Mo-93, Nb-94, Ag 108m, I-129) using the simplified model and chosen parameter distributions and correlations between them reveals that the distributions for results (time constants, dose rates, release rates) are roughly log-normal or log-uniform. The total dose rate at 50 % confidence level and at cautious 95 % confidence level have about two orders of magnitude difference at most during the 10 millennia time scope used for dose assessment, indicating that the uncertainty is rather large. The parameters causing the uncertainty of the final results are the ones related to canister and buffer. The simplified model performs well for the geosphere transport but overestimates the results of the biosphere analysis compared to the results of performance assessment of TURVA-2012 with similar parameters.

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Appendix I - Useful links

IGD-TP Strategic Documentation:

Vision Report (2009)
Strategic Research Agenda (2011)
Deployment Plan 2011-2016 (2012)
Master Deployment Plan (2014)

Websites:

IGD-TP: www.igdtp.eu
DOPAS: www.posiva.fi/dopas
SNETP: www.snetp.eu
SITEX: www.sitexproject.eu
EC DG Research & Innovation: http://ec.europa.eu/research/

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Appendix II - Agenda

IGD-TP
5th Exchange Forum
October 28-30th 2014, Kalmar, Sweden

Tuesday 28th October 2014

Plenary Session 1

8:30 - 9:00	Registration
9:00 - 9:30	**Opening Session** *Chair Johan Andersson, SKB* **EF5 meeting objectives** Monica Hammarström, IGD-TP Chair
9:30 - 10:00	**Key Note: Views of the Municipality of Oskarshamn** Rolf Persson, Municipality of Oskarshamn
10:00 - 10:20	**Key Note: Towards Joint Programming of EU Member States RD&D programmes for the management of radioactive waste in Euratom Horizon 2020** Christophe Davies, European Commission, DG/RTD
10:20 - 10:40	**Key Note : Conclusions and recommendations out of the EURADWASTE'13 conference** Gunnar Buckau, JRC-ITU
10:40 - 11:10	*Coffee Break*
11:10 - 11:40	**Key Note: What does the public really want when engaging with the nuclear industry?** Laurel Boucher, The Laurel Co., USA
11:40 - 12:10	**Key Note: The ENEN Association and its missions: an update looking beyond its 10th Birthday** Walter Ambrosini and Pedro Porras Dieguez, ENEN Association
12:10 - 12:20	**Organisation of the parallel Working Groups** Jacques Delay, IGD-TP Secretariat
12:20	*Lunch*

Parallel Sessions – Technical Working Groups Session

14:00 - 15:40	**Technical Working Groups - presentations and discussions** Rapporteurs WG TWG1 Safety Case "handling of uncertainties" Room: Kvarnholmen TWG2 Microbiological Studies Room: Lilla Festsalen TWG3 Information Exchange Platform IGD-TP/ SNETP Room: Blå Salongen TWG4 Priorities and lessons learned after 4 years of implementation of SRA Room: Ängö *Detailed agenda of the WG session below*
15:40 - 16:00	*Coffee Break*
16:00 - 17:30	**Cont. Working Groups' presentations and discussions** Rapporteurs WG
17:30	**Closing of the Working Groups' Session** Rapporteurs WG

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Wednesday 29th October 2014

Parallel Session 1

PS 1	**Chairman's and rapporteurs' meeting** (Chairman and rapporteurs only)
09:00	Rapporteurs' meeting - Summary of discussion, draft of WG conclusions
10:30	*Coffee break*
11:00	Chair and Rapporteurs' commission session for drafting the conclusions
12:20	*Lunch*

Parallel Session 2

PS2 ORWG CMET	**IGD-TP's input for the development of a voluntary accreditation scheme for geological disposal** Marjatta Palmu, Posiva Oy
09:00	**Introduction to the voluntary accreditation scheme and guidance for the walkabout** Marjatta Palmu, Posiva Oy
09:30	**Walkabout for the input for the development of a voluntary accreditation scheme in the IGD-TP** all organisations present at the EF supported by the CMET working group member
10:30	*Coffee break*
11:00	Cont. Walkabout for the input for the development of a voluntary accreditation scheme in the IGD-TP Marjatta Palmu, Posiva Oy
12:20	*Lunch*

Plenary Session 2

14:00	**The IGD-TP Knowledge Management Search Portal - Practical information, service description and agreements** Tiina Jalonen., Posiva Oy Terho Laakso, Documill
14:15	**Report of the 4 Working Groups** Rapporteurs WG
15:15	*Coffee break*
15:45	**Overview on the outcomes of the walkabout related to a voluntary accreditation scheme and next steps** Marjatta Palmu, Posiva Oy, CMET chair
16:00	**Conclusion and way forward for IGD-TP in 2013- 2016** Monica Hammarström, IGD-TP Chair
16:30	**Closing IGD-TP 5th Exchange Forum** Monica Hammarström, IGD-TP Chair

Thurday 30th October 2014

Visit of the Äspö Laboratory Organised by SKB

Participants need to present a valid photo ID.

08.00 Departure from the hotel by bus
09.30 Arrival, coffee and registration
10.00 Presentation Äspö HRL
10.30 Visit to the tunnel / Deepened presentation
11.45 Changing of groups
13.00 Lunch

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Parallel sessions – Technical Working Groups (TWGs)

TWG1 - Safety Case "handling of uncertainties "

Rapporteurs: Ulrich Noseck, GRS; Dan Galson, Galson Sciences Inc.

Room: Kvarnholmen

Agenda

14:00	**Introduction** U. Noseck, GRS and D. Galson, GSL
Management of uncertainties in the safety case	
14:10	**Uncertainties in the safety case: How to move beyond PAMINA** M. Capouet, ONDRAF/NIRAS
14:20	**Andra's strategy and approach for management of uncertainties in post-closure safety of geological disposal** L. Griffault, Andra
14:30	**Timescales for probabilistic safety assessment** D. Galson, GSL
14:40	Discussion
Methodological development and site-specific application of sensitivity analyses	
14:50	**Sensitivity analyses: theoretical background, use in the safety case, and related research activities** K. Röhlig, TUC
15:00	**Overview of advantages and drawbacks of different methods for sensitivity analysis in the context of performance assessment** D. Becker, GRS
15:10	**Sensitivities of the long-term safety results in SKB's licence application for a spent fuel repository** A. Hedin, SKB
15:20	**Uncertainty and sensitivity analysis applied to performance assessment of a deep geological disposal in the French context** J. Wendling, Andra
15:30	Discussion
15:40 - 16:00	*Coffee break*
Uncertainty identification and quantification	
16:00	**Simplified approach to elicitation of expert judgement in quantification of uncertainty** M. Poole, RWM and D. Galson, GSL
16:10	**Comparison of probabilistic and alternative evidence theoretical methods for the handling of parameter uncertainties resulting from variability and/or partial ignorance in safety cases** R. Bartel, Brenk
16:20	**Fast computational methods for handling large scale data uncertainty problems** G. Wittum, Steinbeis/GUF
16:30	Discussion
Natural analogues in support of the safety case	
16:40	**The use of natural analogues in the Finnish safety case** B. Pastina, Posiva
16:50	**Information exchange: the role of NAWG in the past and the way forward tomorrow** R. Alexander, Bedrock Geoscience
17:00	Discussion
Future international collaborative work	
17:10	Discussion
17:30	Close

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TWG2 - Microbiological Studies

Rapporteurs: Klas Källström, SKB ; Karsten Pedersen, Microbial Analytics Sweden AB

Room: Lilla Festsalen

Agenda

Intermediate level wastes (ILW)	
14:00	**Improving realism and reducing pessimisms in the safety case for geological disposal of ILW** Joe Small, National Nuclear Laboratory, UK
14:15	**Microbially induced corrosion under repository environments** Pauliina Rajala, VTT Technical Research Centre of Finland
14:30	**Potential impact of alkaliphilic bacteria on ILW-geodisposal scenarios: reducing unwarranted conservatism is safety analysis** Jon Lloyd, University of Manchester, UK
14:45	**Discussion ILW FEPs where microbial issues must be considered** All
High level wastes (HLW)	
15:10	**Role of microbes in Features, Events and Processes (FEPs) relevant for geodisposal of radioactive waste in argillaceous host rocks** Natalie Leys SCK-CEN, Belgium
15:25	**Sulphide issue in Olkiluoto - hydrogeochemical considerations** Petteri Pitkänen and Tiina Lamminmäki, Posiva Oy Finland
15:40 – 16:00	*Coffee Break*
16:00	**Remaining uncertainties regarding sulphide production, fluxes and concentrations in radioactive waste repositories** Karsten Pedersen, Microbial Analytics, Sweden
16:15	**Lithotrophic metabolism in the relation with microbiologically induced corrosion** Mikes Jiri, CHEMCOMEX, Czech Republic
16:30	**Microorganisms of radionuclides-contaminated soils of Chernobyl: in depth analysis of diversity and study of uranium-bacteria interactions** Virginie Chapon, CEA, France
16:45	**Discussion HLW FEPs where microbial issues must be considered** All
17:10	**Sum up and drafting of conclusions** Rapporteurs
17:30	**Close**

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TWG3 - IEP IGD-TP/ SNETP

Rapporteurs: Richard Stainsby SNETP/NNL; Lena Zetterström Evins IGD-TP/SKB

Room: Blå Salongen

Agenda

14:00	**The IGD-TP/SNE-TP Information Exchange Platform – an introduction** Lena Z. Evins, SKB, Sweden
Part I	**Information from IGD-TP to SNE-TP: How are changed waste forms considered by WMO?**
14:10	**The SKB requirements of the HLW waste intended for the KBS-3 repository** Lena Morén, SKB, Sweden
14:25	**Fuel data needs in Posiva's safety case** Barbara Pastina, Posiva
14:40	**Evolution of the waste forms in the future : an overview of the French approach** Christelle Martin, Andra
14:55	**Progress and R&D needs for radioactive waste conditioning and disposal for future fuel cycles: a UK perspective** Neil Hyatt, University of Sheffield, UK
Part II	**Information from SNE-TP to IGD-TP : What are the expected developments in waste forms?**
15:10	**The Sustainable Nuclear Energy Technology Platform (SNETP), Fuel Cycles and Interfaces with Geological Disposal** Richard Stainsby, NNL
15:25	**Nugenia Research Topics in Spent Fuel Management (TA 5) and Potential Implications for Disposal.** David Hambley, NNL
15:40 – 16:00	*Coffee Break*
16:00	**SNETP-ESNII Gen IV reactors, related fuel cycle and disposal issues** Massimo Sepielli (SNETP Governing Board)
Part III	**Other information exchange and topics for discussion**
16:15	**Conditioning radioactive waste that cannot be accepted in surface facilities - Safety considerations and packaging basic principles** Gregory Nicaise, IRSN
16:30	Common Fact Sheet: Status and discussion on dissemination
17:15	Outlook: the next steps
17:45	*Close*

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TWG4 Priorities and lessons learned after 4 years of implementation of SRA

Rapporteurs: Frédéric Plas (Andra) and Peter Wikberg (SKB)

Room: Ängö

Agenda

14:00	**Achievements and way forward for the IGD-TP since its inception** Jacques Delay, Andra, France
14:20	**Discussion** on: - importance/urgency of the existing SRA topics - proposal for new topics Discussion will be based on the report entitled SRA main achievements and way forward V1.1sent to all participants before the meeting
15:00	**TUS-Safety and Environmental Engineering Laboratory' cross sections considerations of one <Safety and SF&RAW matrix> and review of the SF&RAW management in Bulgaria** Ivan Ivanov, Technical University of Sofia, Bulgaria
15:20	**FIRST-Nuclides: Outcome, Open Questions and Steps Forward** Bernhard Kienzler, KIT-INE, Germany
15:40	*Coffee break*
16:00	**Quality assurance and communication between stakeholders of a geological disposal project facilitated by the Electronic input Data and Results application (EDR) for radionuclide transport calculations** Jean Croisé, AF-Consult, Switzerland
16:20	**COMS-WD: A new proposal for cooperation between EU Member States responding to the EC Waste Directive** Erika Neeft COVRA, Netherlands
16:40	**SITEX-II, for developing an international Expertise function network** Delphine Pellegrini, IRSN, France
17:00	**The JOPRAD Project: A step towards a Joint Programming on Radioactive Waste Disposal RD&D** Jacques Delay, Andra, France
17:20	**Conclusions** - All
17:30	Close

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Appendix III - List of Participants

IGD-TP 5th Exchange Forum

28-30 October 2014 Kalmar, Sweden

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Appendix IV - Handout for the EF5 CMET Session

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Nine (9) question sets about the feasibility of a voluntary accreditation scheme

The CMET working group has identified in its Terms of Reference as the target of the accreditation either training programmes (outside the institutional setting) or individuals. Please comment also on the target of the accreditation in your replies.

Please **write your replies in print letters on the post-its for each station** separately and post them at the relevant station's flip chart.

Station no.	Station specific questions	Room for notes
1	Do we need an accreditation system for geological disposal? If we need it, why? If we do not need it, why not? For whom, for what purpose would we need such a system? What would motivate you to apply such a system?	
2	Do you understand what ECVET is? Y/N What are your views about the (increasing) need for borderless mobility and lifelong learning in geological disposal and nuclear waste management? *If you replied "yes" to the first question:* What are your views about the proposed EU instrument ECVET (European Credit System for Vocational Education and Training)? Would you be willing to accept a European accreditation system (based on ECVET) now? Does your organisation currently collaborate with others in setting up a system using the ECVET tool?	
3	What is the current competence maintenance approach used in your organisation? Do you have one? How competence is currently assessed in your organisation? What procedures are used to assess the staff's competence? To what extent would you/your organisation apply a competence assessment (accreditation) system, if a widely accepted scheme was available? Where in the job hierarchy of your organisation does accreditation fit? Would you prefer/require/push your staff to be accredited? Would you require accreditation from new staff on entry, if accreditation was available? Would you be willing to integrate or do you see benefits in integrating your current system into a European accreditation system?	
4	What are the appropriate approaches to find out/to measure/ to distinguish (objectively?) if someone has achieved a required standard of mastering certain KSC (Knowledge, Skills and/or Competence)? In which areas is the definition of learning outcomes most urgently needed, and why?	

Station no.	Station specific questions	Room for notes
5	What is your interest in having a voluntary accreditation for the geological disposal community? What constraints do you see for such an accreditation system? What type of risks do you see related to an accreditation system, if such a system existed? Would you see the implementation of such a European system as a risk of decreasing the flexibility of your existing (staff qualification) system? (E.g. administrative burden?) What suggestions do you have to overcome the constraints and/or the risks (including resource constraints)?	
6	Identify/What are the specific areas in relation to SRA (Strategic Research Agenda) and to all stages of the repository development (see CMET poster/ SRA p. 16) that would benefit from specific CMET action/s?	
7	Who should make up the accreditation body [so that you would trust their decisions]? What type of credentials should the members possess, who make up such a body? Where should this body reside in order to be trusted by your organisation? What value and trust would you place on an accreditation document issued by such a body? What type of organisational form should the body have?	
8	How should an accreditation scheme/system be financed? And by whom? What would be your willingness to invest into getting an accreditation? For yourself? For a member of your organisation? For a training programme?	
9	Other thoughts and views you wish to share related to the questions above or to the voluntary accreditations scheme and competence maintenance in geological disposal?	

You are welcome to complement your inputs to the Competence Maintenance, Education and Training (CMET) working group's session on the feasibility of a voluntary accreditation system for geological disposal by responding also to the questions on-line.

These open ended questions will be **available for your comments until the 6th November 2014** via the following link: https://www.webropolsurveys.com/S/30FAA4B6C4285645.par . Also available on http://www.igdtp.eu and the ProjectPlace post.

Thank you in advance for your contribution to the feasibility study. The feasibility study will be published on the IGD-TP webpage by the end of 2015.

Appendix V - Summary of keynote speech given by Laurel Boucher

What does the public really want when engaging with the nuclear industry?

Summary of keynote speech given by Laurel Boucher
at the IGD-TP 5th Exchange Forum Kalmar, Sweden (27 Oct 2014)

This keynote speech provides new or expanded ways of thinking about what the pubic really wants when engaging with the nuclear industry --- specifically in the area of geological disposal of radioactive waste. The speech provides insight into why the public may not respond to scientific explanations, why the public may distrust the nuclear industry, and why the public may engage the political process. It offers multiple theories from the social sciences to help answer the question, "So what does the public really want when engaging with the nuclear industry?"

At the core is application of the theory "Dominating Concepts" --- the theory originated by Dr. Edward de Bono and extended here, the theory that --- Ideas that dominate the general thinking in an industry exert a powerful influence on how people think and act. The value of examining a fundamental idea (a Dominating Concept) is that in doing so, it may become obvious that the idea itself is flawed and leads to unintended or undesirable consequences. If this is the case, it then becomes prudent to adopt a new and more useful idea or Dominating Concept.

To illustrate, there was a time when it was widely believed that being left-handed is a disadvantage and should be discouraged. This is an example of a Dominating Concept held at the societal level. This idea led many well-meaning people to attempt to force those naturally left-handed to use their right hand. This in turn led to many undesirable consequences, for example: problems with reading and writing, disturbances in speech, disturbances in concentration, and a difficulty recalling learned material. Fortunately, the social prejudice against left-handedness changed to the point that society has now largely adopted a new Dominating Concept, "Being left-handed is acceptable."

A current Dominating Concept in the nuclear industry is, "The public wants scientific explanations." To examine this concept, it is useful to consider "Who is the public?" "What are the needs and values of the public?" and "How is the nuclear industry, in general, similar to or different from the public?"

For the past 25 centuries, humankind has attempted to define patterns of human behavior through the theory of Temperaments. Late in the 20th century, Temperaments has been re-defined by David Keirsey. Temperament is the pattern of needs, values, and behaviors that underlie how people act. It answers the question, "Why do people do what they do?" While Temperament theory does not explain everything about patterns of human behavior, it does have a scientific basis, and it does provide insight into what motivates people. So it can be useful to help understand "Who is the public, and what are the public's needs and values?"

There are four Temperament types, three which are presented here. Two types --- the Guardian and the Artisan --- added together comprise approximately 70 – 80% of the general population (the public). They value/trust information that is concrete, practical, and straightforward. They are irritated by the vague or impractical. In addition, the Guardian Temperament attempts to conserve things as they are.

In comparison, the Rational Temperament type comprises approximately 5 – 10% of the general population (the public). The Rational values/trusts information that is intuitive, conceptual, abstract, and logical. They are irritated by being asked to do the illogical. The Rational Temperament, although a small percentage of the general population, is highly represented within the nuclear industry.

When the key characteristics of these three Temperament types are compared it becomes easier to understand why the public may not respond to scientific explanations. If statistically the public is comprised primarily of the Guardian and Artisan types as Temperament theory suggests, then scientific explanations regarding geological disposal of radioactive waste --- explanations which are by their nature conceptual and theoretical --- are difficult to value/trust. They are not "real" and solid and practical. And they represent change, not conservation. In addition, scientific explanations, as will be illustrated, typically do not deal with the emotional (illogical) component.

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What more useful Dominating Concepts might be adopted?

One suggested new Dominating Concept is, “The public wants the nuclear industry to listen in an expanded way.” What is meant by “an expanded way?” One distinction is that listening can occur at three levels: for content, for emotions, and for values. A scientific explanation is typically listening (and responding) at the level of content. Listening at the level of emotions is discussed first.

Dr. Thomas Gordon, an American psychologist and pioneer in the field of collaborative communication, has suggested people unknowingly block or prevent genuine communication by using one or more of the following in situations in which emotions are strong: ordering, warning, moralizing, advising, logic, judging, praising, name-calling, analyzing, reassuring, questioning, and diverting.

Three responses in particular --- logic, analyzing, and reassuring --- are commonly used in scientific and technical areas. This is one example scenario: The public expresses concern that the geological repository presents a risk to the quality of their water source. A logical response is - “We have analyzed the scientific data, and we find no evidence to indicate that water quality will be at risk.” In contrast, a response that acknowledges emotions (does not prevent communication) is - “We recognize the public is afraid there is a risk to the quality of their water.” This is another example scenario: The public expresses concern that the nuclear industry has withheld important and relevant information. A reassuring response is - “We reassure you this oversight was not intentional.” In contrast, a response that acknowledges emotions (does not prevent communication) is - “We recognize the public is concerned and irritated that important information had not been earlier disclosed.”

Listening for and acknowledging emotions will not necessarily solve a problem. However, it does meet a psychological need --- the public feels heard and respected. It helps emotions to dissipate. And it presents the nuclear industry as being more caring. In contrast, when the nuclear industry responds with logic, analysis, or reassurance to emotional appeals by the public, the public feels its interests are being ignored or marginalized. Feeling marginalized, the public may appeal to the political system. And when the political system engages, the emphasis shifts away from science and technology.

A second new suggested Dominating Concept is, “The public wants its values acknowledged and factored into the decision-making process.”

Decision-making often occurs in a backwards manner. It often begins first by the identification of alternatives (“how” problems will be solved) rather than considering “what” or “why,” for example:

- What are the important criteria?
- What are the fundamental values?
- Why are we doing what we are doing?
- What do we hope to accomplish?

More holistic and sustainable decisions are built when these questions being answered first and solutions are identified next. It is useful to determine the underlying values being expressed. These are often not stated outright and must be intuited (guessed) and verified. For the scenario: The public expresses concern that the nuclear industry has withheld important and relevant information, it could be intuited that the public is expressing the values of honesty and expediency. In contrast, the nuclear industry in its actions may be expressing the values of accuracy and being vetted (information first passes the approval of multiple levels within the organization before being shared with the public).

Underlying values, once known, can be factored into decision-making. They can also be translated into what can be measured. This can occur through an elicitation process. Such a process helps members of the public, with the assistance of a moderator, to engage in a structured dialogue through which their key values and means of measurement are identified and clarified.

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A third new suggested Dominating Concept is, "The public wants to develop its own truths." Fritz Perls is quoted as saying, "Truth can be tolerated only if you discover it yourself." The public wants to be empowered to develop its own conclusions. It is prudent that the nuclear industry, being the scientific and technical experts, provide opportunity for the public to engage, to work with information, and to arrive at its own conclusions. This can be done through an illumination process. Such a process helps members of the public and the nuclear industry to sit down together, eye-to-eye, to conduct a joint "thinking task," for example to create an exhibit through having a dialogue that illustrates:

- The roles and responsibilities in the process of siting a geological repository, or
- The various views on a particular topic area, or
- The process of distributing and receiving information.

A joint "thinking task" helps illuminate the thinking of both the public and the nuclear industry. It helps bridge differences in cultural, educational, and technical backgrounds. It allows members of the public and nuclear industry to better know one another personally. And it provides an opportunity for the public to develop its own truths through direct experience.

This speech began by examining the Dominating Concept, "The public wants scientific explanations."

Of course, the public DOES want scientific explanations, but more so the public wants the nuclear industry to listen in an expanded way. The public wants its values acknowledged and factored into the decision-making process. And the public wants to develop its own truths.

The American author Henry David Thoreau once wrote, "If you have built castles in the air, your work need not be lost; that is where they should be. Now put the foundations under them." The IGD-TP has "built its castles in the air" by stating a vision that by 2025 the first geological disposal for spent fuel, high-level waste, and other long-lived radioactive waste will be operating safely in Europe.

A strong foundation is necessary. The Strategic Research Agenda, the Deployment Plan, and the ongoing work of the IGD-TP governing body and its member states provide the basis of this foundation. This foundation must also include the "human dimension." This speech has presented several facets of the human dimension --- the adoption of new Dominating Concepts, the expansion of listening for and acknowledging the emotions, the factoring of values into the decision-making process, and the engagement with the public in joint thinking tasks. A solid foundation contains and weaves together sound business practices with the natural and social sciences. This is do-able.

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