WG4
Spent fuel dissolution and chemistry in a high-level waste container

Lena Zetterström Evins
## Agenda Tuesday 3rd November

### WG 4 Spent fuel dissolution & chemistry in container

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IGD-TP’s Founding Documents

Vision
Strategic Research Agenda (SRA)
Deployment Plan (DP)

IGD-TP’s Executive Group
Initiates, decides, steers, funds and directs IGD-TP and its collaboration and its strategic documentation (updates of SRA, DP), establishes Working groups and, organizes information exchange

IGD-TP’s Exchange forum
Exchange of information, advice, questions discussion and proposals

IGD-TP Secretariat
Support and catalyses the IGD-TP’s activities and organisational evolution
Acts as a communication and information centre
Follow up the deployment of joint activities and updates the Master Deployment Plan
Organizes Exchange Forums and maintains web site and extranet
Reports to the EG

Joint Activity Types for Deployment
ORWG, TSWG
IEP, TEP, TT according to Master Deployment Plan

Terms of Reference (ToR) of IGD-TP

IGD-TP’s Working Group
SRA
DP
IWG
CMET

Coordination with EC
Euratom Framework programme
3.2 Key Topic 2: Waste forms and their behaviour

3.2.1 Definition, scope and rationale

Definition – This Key Topic deals in particular with understanding the behaviour of various wastes in geological repositories. The waste types include spent uranium oxide (UO₂) and mixed oxide (MOX) fuels, vitrified high level waste and long-lived intermediate level wastes. The various waste types represent the potential source terms for release of radionuclides after the waste canisters are breached.

Objectives – The purpose of work is to understand safety-relevant processes, in particular the contribution of the waste form to radionuclide retention in the repository. It is important to define the total inventory of various radionuclides and their time-dependent release in mathematical models in order to assess radionuclide release from a repository.

Rationale and benefits – The studies will better quantify the processes controlling radionuclide, chemicals and gas release from waste forms, thus contributing to the quality of models used in safety assessment and adequately defining the types and magnitudes of uncertainties associated with various processes. It is expected that, because experimental facilities and specialised equipment for work with highly radioactive materials are available in only a few countries, benefits for other countries could become available through use of these facilities in such studies under international co-operation arrangements. All knowledge related to each of the waste forms is gathered in specific files for each waste form. WMOs that are at an earlier stage of implementation in their programmes would benefit through participating at the appropriate stage and having access to information from the studies performed.
Setting the stage

This introduction aims to highlight the needs identified in IGD-TP SRA, Euratom call as well as from research groups.
- Improved understanding of behaviour of the expected waste form in expected repository conditions.
- Test dissolution rate of the waste form in direct relation to expected chemistry inside a corroding waste container.

Expected fuel evolution in Sweden (pers. comm. Vattenfall 2011):
2011: doped pellets in one reactor
2016: doped pellets in 50% of reactors
2021: doped pellets in all reactors
NB: doped pellets, made by different manufacturers do not have uniform properties.
Fuel evolution (Nugenia, 2014)

David Hambley, NNL, EF5 2014: Technology Readiness Level / Irradiation Performance Maturity

9 Multiple assemblies/core loads
8 Multiple assemblies/core loads
7 Few assemblies

Availability of doped fuel pellets for dissolution experiments?

Licensing facilities for existing SNF as well as future SNF, but so far based on standard fuel data...
Requirements to formulate clear waste acceptance criteria
Some issues highlighted from ITU summary

- the consensus to move from leaching of spent fuel in oxidising to reducing conditions as these are more representative for conditions
- a relatively small number of modelling attempts to describe the spent fuel corrosion mechanism
- to identify critical operational fuel characteristics controlling the radionuclide release.
- include spent (U,Pu)O₂ fuels and spent fuels with additives such as Cr or Al in the future experimental programmes.
- Single-parameter experiment using SIMFUEL should be applied complementary

*Next SFW in Stockholm 3-4 May 2016! I will soon send more info…*
Background to this WG

• SRA Key Topic:
  • “Waste forms and their behaviour”

• Overarching goal:
  • improve understanding of fuel behaviour in realistic repository conditions
  • Handle development of modern fuel characteristics

• Specific goal – activities
  • Effect of dopants (Cr, Al, Si…) on matrix dissolution rate.
    • In First-Nuclides ADOPT fuel was studied for the Rapidly released fraction of the inventory. We also need data for the matrix dissolution and IRF for a wider range of fuels.
  • Influence of real groundwater chemistry inside waste package on matrix dissolution rate.
    • critique from reviewer of Saferock: “But a real "coupling" should take into account realistic time and space scales, and a pertinent description of the nearfield, with all its components, which is not the case. Degraded canisters and overpacks or engineered barriers will play an important role, as most RN, and especially actinides and highly charged fission product cations will react in the "degraded" nearfield.”
      [interpreted as, in short] “water chemistry inside waste container will depend on natural groundwater buffering with degradation products”
  • "SIMFUEL” experiments: varying age and burnup,
This action will address key R&I issues in view of the construction and operation in the EU of the first DGRs, notably with respect to validating data and performance. The focus should be on topics of high priority and European added value that were raised in safety reviews and identified in the SRA of IGD-TP. These concern notably the disposal of **new and unconventional fuels**, the validation of the properties of engineered barrier materials and the confirmation of the integrated performance of engineered barrier systems. A further goal is to identify the aspects of these first EU DGR projects that could be amenable to the transfer of knowledge and technology to other countries or regions with less mature programmes, and therefore the action should also involve a mechanism of communicating results to these countries in the most effective way. The Commission considers that proposals requesting a contribution from Euratom of between EUR 2 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts. Proposals for topics NFRP 6 to 8 will be ranked in a single ranking list.
Guidelines for selecting proposals

Purpose: limit the risk of unnecessary effort and rejection of proposals.

- At EG18, November 5, 2015
  Each coordinator asking for official support should provide to the EG a summary of the proposal for information (1 page/partner/indicative budget).  *Is this doable? At least overall project budget…*

  A first selection of projects according the SRA priorities

- In EG19, February 24-25, 2016
  Each coordinator should submit two page project description and the estimated required budget,

  After presentation by an EG members of the final scope, participants and budget of the proposals, the formal decision for supporting or not supporting a project should be taken by EG.

- After EG19, March 2016
  The formal letters for IGD-TP support will be sent to the proposals’ coordinators.

- October 2016
  Submission of the proposals.
Send required summary to EG 5th November!

Bulk of this discussion tomorrow morning. We should aim for:

• Defining the working group in terms of participating organisations
• Preliminary structure: work packages, background and motivation based on today’s presentations
• List of beneficiaries, estimation of contribution in Person months
• List tasks connected to other direct costs
• Attach a very preliminary budget to each participant considering the 2-4 million Euro target.
### Agenda Tuesday 3rd November

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| 17:00 | General Discussion (All) |
| 17:30 | END day 1 |
Wednesday 4th November- Discussion

Working group /participating organisations …

Coordinator: SKB  - any thoughts/comments?

Research performed by …
Studsvik, JRC-ITU, KIT-INE, PSI, Univ Cambridge, VTT, FZ Jülich, Andra (?), CEA(?), CTM (?), Ciemat(?), Amphos 21(?), SCK*CEN (?)
- see next slide

End-User Group, WMO organisations:
SKB, Posiva (?), Nagra, NDA/RWM, Andra, Enresa, Nirond/Ondraf(?)
=Sweden, Finland, Switzerland, UK, France, Spain, Germany, Belgium(?)

Other countries?? Hungary, Czech Republic, Netherlands?
*No response from Rawra (Cz), RHK (Hu) nor Covra (NL)
Participation – some notes

**French** Involvement: Andra participate in End User Group rather than in Work packages?

CEA (Christophe Jégou): “with our partner EDF. It seems agreed that we participate in the project. Nevertheless we have not converged to date on the content of our participation. We are both involved on studies around the IRF of MOX fuel and the spent fuel matrix behavior under environmental conditions (container, corrosion products, argilite…). We will get back to you shortly to specify our contribution.”

**German** involvement: KIT-INE performs experiments, who in EUG?

**Spanish** Involvement, Enresa (Miguel C) ”our spent nuclear fuel research groups at Ciemat and at CTM (in collaboration with ITU in Germany) are interested"

- CTM (Albert Martinez):
  “perform matrix dissolution studies and also some IRF studies on high burn-up UO2, doped fuels and MOX fuels. …possible experiments at ITU or in a cold lab using analogues at CTM, or also modelling part of the experimental data coming from the project.” “we agree on most of the topics that ITU will propose”

- Ciemat (Joaquin Cobos): “the possibilities to participate in the new Working Group”

- Amphos21 (Jordi Bruno): help with coordination and dissemination and of course modelling

**Finnish** involvement: Posiva participation, yes/no ?

**Belgian** involvement: (SCK*CEN, Karel L) “sent our ideas to KIT”
Wednesday 4th

Name? : **DISCO**: Modern Spent Fuel **D**I**S**solution and Chemistry in **C**O**N**tainer

or **DisCERN**: Dissolution and Chemical Environment in Repository Near-Field

(\textit{discern} = distinguish, perceive, detect, determine, discover …)

or **DiRRECt**: Dissolution of Spent Fuel in Realistic Repository Conditions

Preliminary structure: work packages…

- WP1 Management (pure Coordinator /EC contacts) (SKB?)
- WP2 Research coordination and dissemination (SKB+ Amphos21?)
- WP3 Sample preparation and characterisation (model/analogue materials: Jülich, Cambridge, fuel characterisation/irradiation history: Studsvik, JRC-ITU, KIT-INE)
- WP4 Analogue materials experiments (VTT, Cambridge, Jülich,)
- WP5 Fuel leaching experiments (Studsvik, JRC-ITU, KIT-INE, CEA?, SCK*CEN?)
- WP6 Modelling of the chemical systems (PSI, ANDRA/other?, Amphos21?)

CTM? Ciemat?
# Budget variables to consider

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<th>Organisation</th>
<th>Main contribution</th>
<th>#PM</th>
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<th>Other Direct Costs</th>
<th>ODC SUM 990000</th>
<th>SUM EUR 2072400</th>
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<td>79200</td>
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<td>89200</td>
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Wednesday 4th

- New project (Disco?) Modern spent fuel DIssolution in degraded COntainer.

- Hypothesis: Modern fuel (advanced fuel and mox) dissolution differs only insignificantly from standard fuel.

- Approach:
  
  A, Spent fuel leaching of modern fuels: Adopt (Cr&Al), only Cr-doped, and two different MOX. Direct test through comparison with previous results.

WP Leader: TBD Studvik /KIT, Contributors: Studvik, KIT, ITU, CTM, SCK*CEN, Rez, CEA, (Hungarian contribution?) Doped fuel or MOX, two participants UO2 to close issues from First Nuclides Rez res reactor fuels, more info coming. Reducing and oxidating conditions. Characterisation of samples, sample prep: limitations in labs. Try to be similar but difficult. Techniques for solid characterisation, sample size inside or outside of cells, solutions one similar to first nuclides. But additional solutions should be discussed.

- B, Effect of doping tested through model systems experiments, including model materials preparation and characterization. Test through compare to previous results, as well as illumination of important parameters, for a theoretical understanding

WP Leader Cambridge/Julich, Contributors: Julich, Cambridge, Sheffield, VTT, Ciemat Structure Mox, & instant release, Matrix release from doped fuel.? Model systems need to connected to the fuel matrix to less test conditions the experimental conditions. Tablets for transport with the
Before EG19, February 24-25, 2016,
Each coordinator should submit two page project description and the estimated required budget

End of January? SEND doodle and question about 2nd may

And again 2nd of May? Day before Spent fuel workshop.
WG 4 - Background, motivation

Spent fuel dissolution and chemistry in a high-level waste container
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WG 4 – Real spent fuel
WG 4 - Model systems
WG 4 Summary

**DISCO**: Modern Spent Fuel DISsolution and Chemistry in Container

Hypothesis: Modern fuel (advanced fuel and mox) dissolution differs only insignificantly from standard fuel.

General Hypothesis: Modern fuel (advanced fuel and mox) dissolution in real repository conditions differs only insignificantly from standard fuel. (zero-hypothesis)

Motivation: there are knowledge gaps and need for extended data base for the modern fuels and for the chemical system in a degraded HLW waste canister

3-4 year project. Preliminary work package structure

- **WP1** Management, Coordination and Dissemination/Knowledge Management
  SKB (Coord), Amphos21

- **WP2** Sample preparation and characterisation of the chemical systems (All)

- **WP3** Fuel leaching experiments WP Leader: (Studsvik/KIT-INE)
  Contributors: Studsvik, KIT, ITU, CTM, SCK*CEN, Rez, CEA, (Hungarian contribution?)

- **WP4** Model materials experiments WP Leader: (Univ. Cambridge/FZ Jülich), Contributors: FZ Julich, Univ. Cambridge, Univ. Sheffield, VTT, Ciemat

- **WP5** Chemical modelling WP Leader Amphos21/PSI, Contributors: Amphos PSI, NNL, Andra, Quintessa