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Innovative Disposal Container Materials: Improved Durability and Manufacturing Feasibility (InCoManD)

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safeND2025 – Session T5b

InCoManD participation and tasks



InCoManD

2024 - 2029

Work Package 9: **Innovative Disposal Container Materials - Improved Durability and Manufacturing Feasibility**

Task 1:
Management/Coordination

Task 2:
Knowledge Management

Task 3:
Innovative HLW Container Materials

Task 4:
Evaluation of Materials Durability

Task 5:
Experimental and Modeling Assessment of Degradation Mechanisms

26 Partners (9 countries)

Short name of participant	Andra (FR)	BAM (DE)	BASE (DE)	CIEMAT (SP)	Gaitecho (FR)	GNS (DE)	GRS (DE)	HZDR (DE)	EMSE (FR)
Short name of participant	IRCCER (FR)	KIT (DE)	NSC KIPT (UA)	ONDRAF (BE)	Posiva (FI)	SIIEG NASU (UA)	IMT Atlantique (FR)	SÚRAO (CZ)	TUL (CZ)
Short name of participant	UGR (SP)	UJV (CZ)	UJV (PL)	LUH (DE)	UPM (SP)	VŠCHT (CZ)	VTT (FI)	ZAG (SI)	

6 Associated Partners (3 countries)

Short name of participant	EPFL (CH)	UBERN (CH)	PSI (CH)	Nagra (CH)	UNIMAN (UK)	Sandia / LBNL (USA)
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+ Expert Review Group (ERG)
+ End-users

Project Goals: Impact and Added Value



- **Innovation and/or optimization of material solutions** (incl. assessment of the materials durability and analysis of the economical implications)
- **Better description and understanding of material degradation mechanisms** (improving state-of-the-art knowledge by implementing as realistic as possible conditions)
- **Building of comprehensive predictive models**
- **Synergy through a cooperative project** involving several countries across Europe sharing a common goal.
- **Capitalise on ConCorD results (EURAD-1)**, but also, develop common methodologies, encourage *Round Robin experiments and benchmarking to provide more confidence on the results* produced by each partner.
- Significant effort in attracting and training new scientists (lectures at the Master and Doctorate levels).



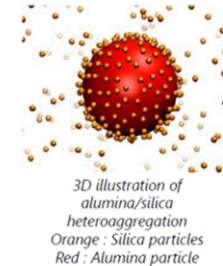
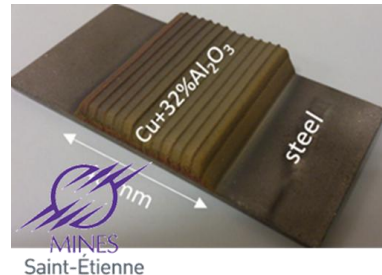
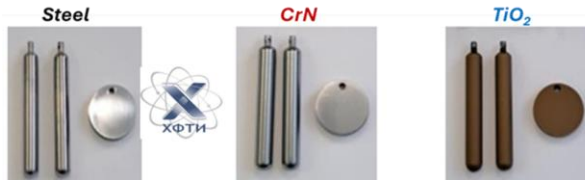
What's new?
Materials and processes to be tested, improved, optimized under more realistic (field) conditions never done so far.

Task 3:

Innovative HLW Container Materials



- Subtask 3.1: *Improve* recently selected innovative, bulk and coating materials, and seek for new options (e.g. multilayered materials, ceramic-metal composites)
- Subtask 3.2: For selected materials, *define and optimize* elaboration or fabrication processes
- Subtask 3.3: *Developing* first Life Cycle Calculation (LCC) / Life Cycle Assessment (LCA) approaches to *identify* critical points in the upscaling strategy



Task 4: Evaluation of Materials Durability



- Subtask 4.1: *Evaluate* materials durability (*i.e.*, corrosion resistance under transients), by implementing lab-scale experiments, systematic parametric studies (irradiation, pH, temperature,...), to *identify* the main degradation mechanisms and associated important parameters.
- Subtask 4.2: *Development* of dedicated complex (even *in situ*) experiments to mimic accelerated field conditions (necessity to build improved test devices for coupling stress factors)



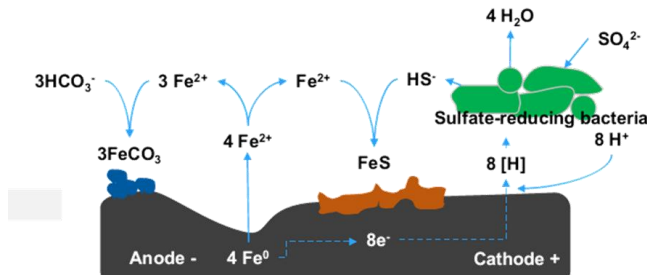
Copper tube

MX-80 bentonite

Ciemat

Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas

LOT: SKB TR-20-11



Scheme of iron corrosion by SRB based on reactions as suggested by the cathodic depolarization theory¹

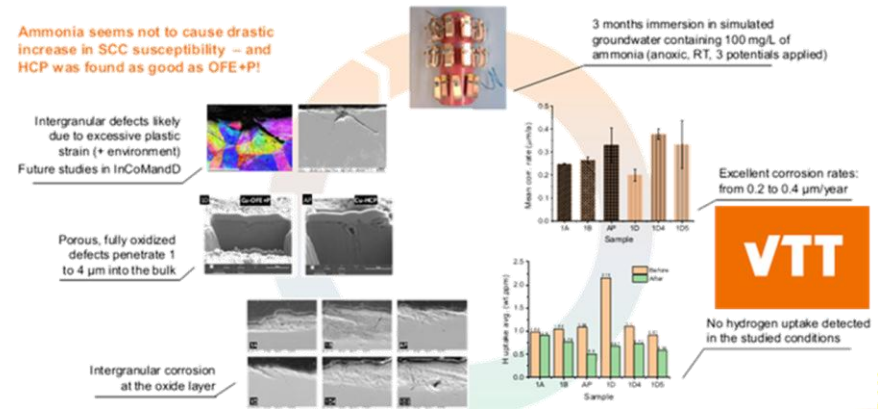
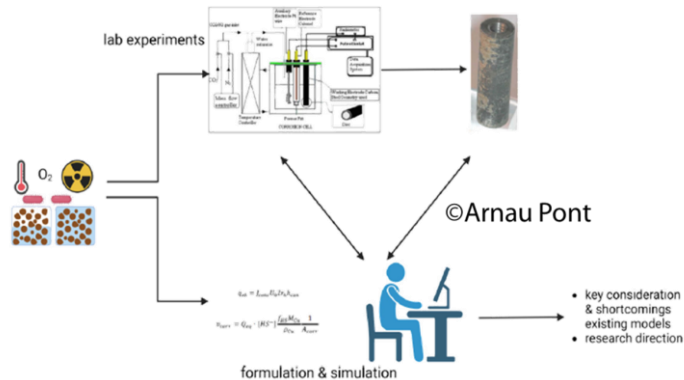
DRESDEN
concept HZDR



Task 5: Experimental and Modeling Assessment of Degradation Mechanisms



- Subtask 5.1: *Experimentally assess* joint mechanical-corrosion degradation in selected materials via threshold stress and intensity factor measurements under disposal conditions
- Subtask 5.2: *Develop* a modelling of geochemistry and time-dependent transients



Current Status of InCoManD



- Duration: 01.10.2024 – 30.09.2029
- **Kick-off meeting** (in person) in Paris in January 2025
- 1st Online-Workshop between experimentalists and modelers (May 2025)
- First Delivery - EURAD-2-D9.1 published in June 2025:
[EURAD-2 - D9.1 Durability of Traditional and Innovative Disposal Container Materials and Coatings: State-of-the-Art and further Research within InCoManD | Eurad](#)
- Work Program Year 2 confirmed in June 2025
- In October 2025, the **first Annual Event** takes place at



UNIVERSIDAD
DE GRANADA



Highlights of Work Program Year 2



Task 3 (Innovative HLW Container Materials)



Bulk ceramics:

- First steps of alumina gelcasting elaboration process by varying the slurry composition
- Testing sealing materials based on intimate blends of alumino-silicate powders
- Improving SiC-based materials containing Cr additive



InCoManD

Coatings:

- Preparation of CrN/CrON and Ti/TiO₂ multilayer coatings and Cu-Ni/Sn coatings using electrochemical deposition, both for further experimental investigation
- Improving cold spray deposited Cu/Al₂O₃ coatings performing thermal treatments

Sealing methods:

- Development of a microwave sealing device for ceramics focusing on an innovative approach combining an ad hoc sealing material and SiC fibres as a susceptor
- Testing of sealing process parameters (composition, temperature, time) for (bulk) SiC
- Studies on assessing the potential of arc-welding processes for sealing steel and copper containers

Highlights of Work Program Year 2



Task 4 (Evaluation of Materials Durability)

Implementation of corrosion tests of selected materials under conditions relevant for repository concepts:

- Various investigations on Cu-based materials (e.g. friction-stir welded coupons; Cu-coatings; composite Cu/Al₂O₃ cold spray coatings; electrochemically deposited Cu-Ni/Sn coatings)
- Corrosion resistance of non-copper coatings (Ti, Cr PVD) and multilayers of those in passive oxide and anoxic Opalinus Clay water and its slurry with Wyoming bentonite at 50 °C.
- Ceramics: Leaching experiments on Al₂O₃ (~90 °C, pH 12.5, + preliminary irradiation tests at 10 Gy/h)
- Fe-based materials: Cr-steel and Cr-Ni-steel (pH 7,5 – 8,5, aerobic and anaerobic conditions with porewater containing chloride, sulphate, hydrogen...)

Development of ad hoc experiments to mimic accelerated field conditions

- Various investigations on selected container materials in combination with bentonite, defining the near-field conditions, under environmental disposal conditions with and without microorganisms.



Highlights of Work Program Year 2



Task 5 (Experimental and Modeling Assessment of Degradation Mechanisms)

Experimental evaluation for the joint effects of deformation and corrosion

- Working at reducing the potential pH range in which stress corrosion cracking (SCC) agents (e.g., nitrates) can initiate cracking on Cu-OFE+P and Cu-HCP in the presence or not of chlorides
- Investigation of (i) microstructure, (ii) effect of cold work and (iii) hardness on the susceptibility to crack initiation and propagation of these materials
- Consideration of steels and role of residual stresses

Modelling for geochemistry and time-dependent transformations

- Improvement of current reactive transport modelling to gain higher accuracy regarding corrosion rates over time.
- Modelling of transport geochemical reactions, at the microscale, occurring at the carbon/stainless steel – clay or cement interfaces.



Summary



- InCoManD has been successfully launched
- Partners have coordinated their planned work
- The initial State-of-the-Art report has been published including an outlook on what is planned for InCoManD
- Selection of materials and test parameters is ongoing as planned
- Experimental setups and tests have been launched
- Year 2 work program is approved
- First results, experiences and further investigations will be discussed during the 1st annual event of InCoManD in Granada/Spain in October 2025.



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