EURAD-2 WP description Template #2

Please see Instructions for Work Package Preparation Team, public document for guidance (available on EURAD and PREDIS websites)

Short Acronym and full Title	Release of safety relevant radionuclides from spent nuclear fuel under deep disposal conditions		
Type of activity	☒R&D	☐Strategic Study	
Budget estimation (total budget in M€, i.e ~ 1.5 M€)	5 M€	Duration of the WP (in months): 60 months	
Links with EURAD SRA / Roadmap Themes (if multiple choices, indicate the primary link **in bold – maximum 3**)	☐Programme Management (Theme 1) ☐Pre-disposal (Theme 2) ☒Engineered Barrier Systems (Theme 3) ☐Geoscience (Theme 4) ☐Disposal facility design and optimisation (Theme 5) ☐Siting and Licensing (Theme 6) ☒Safety Case (Theme 7)		
Links with EURAD SRA topics (if multiple choices, indicate the primary link **in bold – maximum 3)**	**3.1.1 Spent Nuclear Fuel** 7.3.1 Performance assessment and system models		
SRA drivers **(maximum 3)**	☒Implementation Safety	☐Tailored Solutions	☒Scientific Insight
	☐Innovation for Optimisation	☐Societal Engagement	☒Knowledge Management
Objective (What) – **1 sentence**	Improved quantification and mechanistic understanding of the release of safety relevant radionuclides covering most representative types of spent nuclear fuel (SNF) and of the fuel evolution both prior and posterior to contact with ground water to better predict the radionuclide source term for post-closure safety assessment		

Justification: impact / innovation / added-value (Why) – bullet points or short paragraph **(maximum quarter of a page)**	The aim of this WP is to close knowledge gaps outlined in for example the EURAD State of Knowledge Report Spent Nuclear Fuel Domain 3.1.1 (K. Spahiu 2021) and is built on the experiences gained in the FIRST Nuclides and DisCo projects. The aim is to provide data that allows re-evaluation of the current approaches to release of safety relevant radionuclides in post closure safety assessments. This will clarify what approaches are overly pessimistic and what approaches need to be adjusted to better represent expected radionuclide release in the repository environment. In order to do this an improved mechanistic understanding is required, as well as quantification of the radionuclide source term for different fuel types. Carefully designed experiments with advanced experimental setups and improved analytical methods for activation and fission products will increase the system understanding and give confidence in the proposed release values and models. The studies shall be focused on representative fuel, operated at representative reactor conditions, relevant for WMOs at a European level. Efforts shall be made to adapt the experimental protocols to allow for comparison between studies performed at different laboratories whilst still utilizing the strengths at the individual laboratories. For Knowledge Management there is a need to synthesize information from past projects.
List of planned tasks / subtasks with % of effort per task (5% increments) **(Maximum 10 bullets)**	• **Task 1: Management/coordination of the WP, 10%** • **Task 2: Knowledge Management (incl. training materials development and State-of-the-Art for R&D WPs, etc.), 10%** o State-of-the-Art on radionuclide release (dissolution and leaching behaviour) of spent nuclear fuels in a deep geological repository.[1] o Completion and rationalization of database of SNF dissolution initially developed within First-Nuclides and Disco Projects for the development of machine learning model. • **Task 3: IRF/FGR Performance of Spent Nuclear Fuel, 40 %** o Spent Fuel Leaching (UOx, MOX, ATF)[2] (including sample preparation and characterization) under relevant reducing conditions to study the relationship between FGR, IRF and matrix dissolution, in particular the release of fission gases during leaching. Effect of water chemistry and secondary phase formation on radionuclide release. • **Task 4: Role of Grain Boundaries in Spent Fuel Corrosion, 20 %** o Leach tests with SNF (UOx)[1], Simfuel and doped-model materials (including sample preparation and characterization) using novel methods to discriminate RN contributions from

[1] Will be based on on the EURAD State of Knowledge Report Spent Nuclear Fuel Domain 3.1.1 (K. Spahiu 2021)

[2] For SNF studies it is required that irradiated material is available at the start of the project.

	open grain boundaries, closed porosity, rim grains during alteration, secondary phase formation. Including sample preparation and characterization.
	• **Task 5: Studies on Model Materials, 10 %**
	  o Studies using model materials such as MOX, UOx, Cr-UO_2, (Cr,Al)UO_2, FP-doped UO_2, UO_2-ZrO_2, Simfuel to better quantify and understand the mechanisms of specific processes related to radionuclide release, quantify the effect of surface area, secondary phase formation and water radiolysis. Sample preparation and characterization is included in the scope.
	• **Task 6: Mechanistic modelling, 10 %**
	  o Improvement and development of mechanistic models (including model comparison/benchmarking), for example; i) to account for the release of matrix, grain boundary and gap (at scale of SNF pellet) ii) to integrate the effect of different amount of epsilon particles on the release of AP, FP and matrix dissolution. iii) Interpretation or transposition at the DGR scale: which process(es) prevail in the different phases expected in repository conditions (e. g. Fe/H2 effect).

List of expected outcomes linked to the identified SRA drivers **(Maximum 6 bullets)**	• Implementing Safety: Radionuclide release data that allows the needed re-evaluation of the current approaches to release of safety relevant radionuclides in post closure safety assessments. • Scientific Insight: Data for deriving an updated and improved mechanistic understanding of radionuclide release processes. • Knowledge management: Completion of SNF dissolution database, thus enhancing knowledge management and transfer between the participating organisations (and beyond).
Deliverables **(Maximum 6 – including the prescribed deliverables)**	• Outcome/impacts report to Member States and End Users • State-of-the-Art report (initial[3] and final) • Radionuclide release report and grain boundary experiments report – results • Single effect studies on simplified model systems report • Modelling results report
Critical input requirements & identified risks	• Availability of irradiated and characterized fuel samples. This risk will be mitigated by requiring that irradiated fuel is available at each

[3] The initial State-of-the-Art report will be based on the EURAD State of Knowledge Report Spent Nuclear Fuel Domain 3.1.1 (K. Spahiu 2021)

	institute at the start of the project (sample characterization and preparation may be performed within the project). • As a result of extreme conditions (radiation field) and long time frame, experiments might fail and cannot be repeated within the project. • Risk of delay and poor quality of produced model substances.
Major achievements expected by end of Year 2 (Go/No Assessment)[4] **(Maximum 5 bullets)**	• SNF samples prepared • Simplified model systems samples prepared • Structure of Database report drafted
(Optional - Explain what is out of the scope?)	N.A.
List of preliminary interested organisations as partners in the WP contributing effort; **% of effort (person months, by College)**	REs (70%): Amphos-21 (Spain), CEA (France), Energorisk (Ukraine), Eurecat-UPC (Spain), ICSM (France), RATEN ICN (Romania), JRC (EC), FZ-Jülich (Germany), KIT-INE (Germany), KTH (Sweden), SKC-CEN (Belgium), Studsvik (Sweden), Subatech (France), University of Helsinki (Finland) TSOs (20%): Mines Paris (France), CIEMAT (Spain), VTT (Finland) WMOs (10%): SKB (Sweden)[5] We expect the major part of the work to be performed by RE's and, to some extent TSO's, the % effort provided above is however preliminary estimates. Other potentially contributing organisations (not requesting EC-funding): University of Sheffield (UK), PSI (Switzerland), Lancaster University (UK) Observers (e.g. end users); Andra (France), BGE (Germany), ENRESA (Spain), NAGRA (Switzerland), NWS (UK), ONDRAF NIRAS (Belgium), POSIVA (Finland), SURAO (Czech Republic), LEI (Lithuania), ÚJV Řež (Czech Republic), SSM (Sweden)

[4] EC budget being only allocated for the first 2 years, each work package progress will be reviewed at the end of Year 2, to assess its continuation based on the total budget that EURAD-2 will be granted.

[5] Will potentially contribute with WP-management

If applicable - links with previous projects / work packages	FIRST Nuclides, DisCo
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