Form for 2nd International Call for R&D proposals in [TCOFF-II](https://oe.cd/tcoff)

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| --- | --- |
| Name of Organisation(s) |  |
| Name of main researcher(s) |  |
| R&D Theme (Proposal title) |  |
| ID number and systems in R&D call table#1 |  |
| Objectives and expected results and their applicability#2  (max. 200 words) |  |
| R&D tasks#3  (max. 200 words for each task) | [Work package 1: xxx]  [Work package 2: yyy] |
| Uniqueness, challenge, Importance, Options, Topics, Remarks, Comments, etc.#4 (max. 500 words) |  |
| Estimated budget#5 | [Work package 1] aaa Euro (2024), bbb Euro (2025), ccc Euro (2026)  [Work package 2] ddd Euro (2024), eee Euro (2025), fff Euro (2026) |
| Schedule#6 | [Work package 1]  [Work package 2] |
| Relevant references#7  (important 10 papers as max.) |  |

#1 Please refer to Table-I (included below). The call focuses on experimental studies. Proposals based on modelling are acceptable with the condition that the developed models are widely useable by the TCOFF-2 participants models/codes/databases for severe accident studies.

#2 Please clearly indicate the objective and expected results. What will be the added values to the already existing data (in terms of investigated regions/test conditions, techniques, impact on safety issues and so on).

#3 Please outline the R&D tasks in this space, including methods, test conditions (temperature, composition, atmosphere, number of tests, sample amount) and so on. If the proposer(s) wish to add any further information, please add a few pages of supplement to this form, which includes illustrations, figures, tables, photos and etc. If appropriate, please split the scope into work packages.

#4 If proposer(s) want to emphasize the uniqueness or challenges of their study, please outline it in this space.

#5 Our total budget is ~70.5 k€ (for slightly less than two years: Oct 20245-Aug 2026). Considering the international collaborative nature of TCOFF-2 and the priorities highlighted by the project, 2 to 3 projects will be selected through two calls for proposals. The project’s budget is expected to be up to 30 k€. Final selection of the project will be made by TCOFF-2 Management Board (MB). Project’s duration should be 18 months at most.

#6 Please indicate your brief schedule over 18 months (depending on your project’s duration).

#7 Please indicate your major references on similar studies.

Table-I: Systems for R&D proposals

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| **ID number** | **Category**  **I: to improve thermodynamic database**  **II: to validate thermodynamic calculation results** | **System**  **Sub-system** | **Application** | **Expected test conditions**  **(# each proposal is requested to include a part of following test conditions. if proposer needs more detailed information, please contact** [**alice.dufresne@oecd-nea.org**](mailto:alice.dufresne@oecd-nea.org)  **and**  **Ian.HILL＠oecd-nea.org** |
| 1 | I | U-Zr-O  # hypo-stoichiometric conditions | 1. In-vessel corium behaviour model for UO2/Zry 2. Debris characterization for Fukushima-Daiichi Nuclear Power Station (FDNPS) accident | Temperature range: 1273 ~ 2773 K  Composition range: O/(U+Zr) < 2  Particular interests:   1. Phase boundary between fluorite and liquid 2. Phase boundary among fluorite, tetragonal and monoclinic 3. Chemical activity of oxidic phases |
| 2 | I | Sub-systems for Fe-Ni-Cr-Zr-U-(O) | 1. Degradation model for interaction Zry-cladding/steel components with UO2 2. Metal-rich debris characterization for FDNPS accident | Temperature range: < 1873 K  Composition range:  main components (steel and Zr)  minor components (U and O)  Particular interests:   1. Oxygen solubility in metal-rich debris 2. Activity of oxygen |
| 3 | I | Sub-systems for U-Zr-Fe-Cr-O | 1. In-vessel corium behaviour model for UO2/Zry/steel (in particular, interaction between U-Zr-O melt and steel) 2. Identification of “delta” between UO2/Zry and UO2/Cr-coating Zry in terms of in-vessel corium behaviour 3. Debris characterization for FDNPS accident | Temperature range: < 2773 K  Composition range: to be discussed  Particular interests:   1. Oxygen solubility in metallic liquid phase for U-Fe-O, U-Cr-O, Zr-Fe-O, Zr-Cr-O systems 2. Heat of formation and liquefaction temperature of ternary compounds of the U-Fe-O, U-Cr-O, Zr-Fe-O, Zr-Cr-O systems 3. Chemical activity of metallic phases |
| 3’ | II | U-Zr-Fe-Cr-O | 1. Validation of thermodynamic databases for in-vessel corium 2. Identification of “delta” between UO2/Zry and UO2/Cr-coating Zry in terms of in-vessel corium behaviour | Temperature range: > 1973 K  Composition range: to be discussed  Particular interests:   1. Phase boundary between metallic liquid and solid (di-oxides) in equilibrium conditions, influence of Cr or Fe addition to U-Zr-O melt 2. Interaction with U-Zr-O melt with steel in terms of heat of interaction |
| 4 | I | Cr-O-H | 1. Oxidation of Cr-coating layer with steam (as a key system for FeCrAl oxidation) | Temperature range: 973 ~ 1773 K  Particular interest:   1. Oxygen and hydrogen solubility in Cr-metal 2. Volatilization of Cr2O3 in steam conditions (up to 1573 K, at least) |
| 5 | I | Subsystems for FeCrAl-oxides/UO2 | 1. In-vessel corium behaviour model for FeCrAl cladding | Temperature range: > 1673 K  Composition range:  without free metal, to be discussed  Particular interests:   1. Phase boundary between liquid and solid (oxides) in equilibrium conditions for FeO or Fe3O4-Cr2O3-UO2, FeO or Fe3O4-Al2O3-UO2, Al2O3-Cr2O3-UO2 systems 2. Identification of quaternary compounds, if existing. Heat of formation and liquefaction temperature of quaternary compounds for U-Fe-Cr-O, U-Fe-Al-O, U-Cr-Al-O systems 3. Activity of oxides |
| 5’ | II | FeCrAl-oxides with UO2 | 1. Validation of relevant thermodynamic databases 2. Identification of “delta” between UO2/Zry and UO2/FeCrAl or UO2/FeCrAl-ODS in terms of in-vessel corium behaviour | Temperature range: 1673 K < T < 1873 K  Composition range:  without free metal, to be discussed  with steam  FeCrAl or FeCrAl-ODS  Particular interests:   1. Phase boundary between oxidic liquid and solids in equilibrium conditions 2. Phase relation among mono-oxide (e.g. FeO), sesqui-oxides, spinel (e.g. (Fe,Cr)3O4) and di-oxide (e.g. UO2), including solubility of other cation |
| 6 | I | SiC/UO2  SiC/PuO2  SiC/H2O | 1. Fuel degradation and in-vessel corium behaviour model for UO2/SiC and MOX/SiC 2. Identification of “delta” between UO2/Zry and UO2/SiC in terms of in-vessel corium behaviour (under steam) 3. Steam oxidation model for SiC at high temperatures | Temperature range: > 1773 K  Composition range: to be discussed  Particular interests:   1. Phase relation at high temperatures, including liquefaction conditions 2. Heat of formation and liquefaction temperature of compounds, including hydro-oxide |
| 6’ | II | Interaction between UO2 and SiC | 1. Validation of relevant thermodynamic databases 2. Identification of “delta” between UO2/Zry and UO2/SiC in terms of in-vessel corium behaviour (under steam) | Temperature range: > 1773 K  > 1973 K is more important.  Composition range: to be discussed  Particular interests:   1. Phase relation of the interaction products in equilibrium conditions 2. Progress of interaction 3. Influence of steam |
| 7 | I | Eu(or Sm)-Zr-O | 1. Improvement of thermodynamic databases for Accident Tolerant Control Rod (ATCR) to be simultaneously developed with ATF | Temperature range: >1273 K  Composition range:  on tie-lines in the biphasic zone Eu(or Sm)2O3-ZrO2+ Liquid (Eu,Zr,O) (hypo-stoichiometric region)  Particular interest:   1. Phase relation in the hypo-stoichiometric region 2. Composition range of fluorite solid solution at high temperature |
| 8 | I | Subsystems of Ca/Si/Al/Fe-oxides | 1. Improvement of thermodynamic databases for ex-vessel corium behaviour model 2. Key system for FDNPS concrete | Temperature range: > 1473 K  Composition range: Si-rich region  Particular interests:   1. Identification of miscibility gaps among oxidic melts 2. Influence of Fe-oxide addition to Ca/Si/Al-oxides in terms of solidus and liquidus 3. Identification of compounds (mole ratio, liquefaction temperature, solubility range) 4. Heat of liquefaction |
| 9 | I and II | Ca/Si/Al/(Fe)-oxides with U/Zr-oxides  #CaO-SiO2-UO2 system is of particular importance in terms of miscibility gap of liquid phase. | 1. Improvement of thermodynamic databases for ex-vessel corium behaviour model and the validation 2. Identification of “delta” between UO2/Zry and UO2/Accident Tolerant Fuel (ATF) (FeCrAl) Claddings in terms of ex-vessel corium behaviour 3. Key for FDNPS unit-1 accident analysis | Temperature range: > 1473 K  Composition range: to be discussed  Particular interests:   1. Identification of miscibility gaps among oxidic melts 2. Identification of liquefaction/solidification pathway with various prototypic compositions of ex-vessel debris in the quasi-equilibrium condition 3. Identification of compounds in solidified ex-vessel debris, influence of cooling rate and composition |
| 10 | II | Addition of Fe/Cr/Mg-oxides to concrete base system (Ca/Si/Al-oxides) | 1. Improvement of thermodynamic databases for ex-vessel corium behaviour model and the validation | Temperature range: > 1473 K  Composition range:  major components: Ca/Si/Al-oxides  minor components: Fe/Cr/Mg-oxides  Particular interest:   1. Influence of Fe/Cr/Mg-addition in terms of liquidus/solidus, compound formation and solid solubility |
| 11 | I | Fe-Pu-O | 1. Key for MOX fuel models | Temperature range: 1200 K < T < 2500 K  Composition range:  Fe-Pu-Fe2O3-PuO2 region of the diagram  Particular interest:   1. Phase equilibria in the hypo-stoichiometric region |
| 12 | I | Pu/U/Zr-oxides | 1. Key for MOX fuel models | Temperature range: 1500 K < T < 3000 K  Composition range: fully oxidized system O/(Pu+U+Zr)=2 and slightly hypo-stoichiometric to identify the possible existence of a U solubility in the pyrocholore phase Pu2Zr2O7+x  Particular interest:   1. Stability of the fluorite phase, equilibria in the solid state, effect of the oxygen potential on the melting behaviour of the mixture |
| 13 | I | Cs-containing systems, such as Cs-Cr-O, Cs-Si-O, Cs-B-O, Cs-Sr-O | 1. Improvement of FP-databases 2. Identification of predominant phenomena leading to the formation of Cs-containing particles or leading to leaching | Particular interests:   1. Thermodynamic properties of various compounds, such as formation enthalpy and heat capacity, vapour pressure 2. Identification of existing stability conditions of various compounds in terms of temperature and oxygen potential |
| 14 | I | I, Ru, Te, Cs with steam | 1. Improvement of FP-modelling for accident source term evaluation | Particular interests:   1. Thermodynamic properties of various compounds, such as formation enthalpy and heat capacity, vapour pressure 2. Identification of existing stability conditions of various compounds in terms of temperature and oxygen potential |
| 15 | I | Ba, Sr, Mo, Cs  # hyper-stoichiometric condition with UO2+x  # (Ba,Sr)MoO4 is of particular importance. | 1. Improvement of FP-database, in particular, model for FP-release from high burn-up UO2-fuel (fission product release code) | Particular interests:   1. Activity coefficient of FP and/or solubility of FP as function of oxygen potential 2. Phase diagram between BaMoO4 and SrMoO4 (decomposition and melting temperatures) |
| 16 | I | CrUO4, CrU2O6, CrU3O10-x | 1. Base of FP-partition evaluation for Cr2O3-doped UO2 (identification of “delta” to UO2-fuel) | Particular interest:   1. Thermodynamic properties of the various compounds in the Cr-U-O system, such as formation enthalpy and enthalpy increment 2. Effect of the doped Cr2O3 on FP speciation in the fuel under BDBA conditions |