Status of the OECD-NEA TCOFF Project in Support of Fukushima Daiichi Decommissioning

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1. Introduction

The Thermodynamic Characterization Of Fuel Debris and Fission Products project (TCOFF) is based on Scenario Analysis of Severe Accident Progression at Fukushima-Daiichi NPS (FDNPS). It is a 3-year international OECD-NEA joint project supported by the JAEA and the Japanese government (MEXT). Its aim is to improve the thermodynamic databases and hence improve severe accident modelling in support of FDNPS understanding.

This was divided into 3 main tasks: a) Benchmark calculations for the FDNPS accident conditions; b) Identification and prioritization of material science concerns in current thermodynamic databases and c) Improvement and/or enlargement of thermodynamic databases through experimental and analytical (ie modelling) techniques. It is linked to other OECD projects in support of FDNPS decommissioning such as Pre-ADES and ARC-F (see below).

2. Project Motivation

The main motivation was an internationally recognised need of continuous updating of knowledge, the thermodynamic databases and fuel degradation mechanisms. This should also improve the fuel degradation, debris, molten corium and FP-behaviour models and should provide inputs to a) Severe Accident (SA)-codes; b) Issues of severe accident management and fuel debris characterization.

The Japanese Ministry of Export and Trade (MEXT/Japan) proposed a 3-year joint project (2017-2019) to NEA/NSC (Nuclear Science Committee), to maximise synergies with the related joint projects linked to the Fukushima Daiichi (FDNPS). These projects included TAF-ID Database (based at NSC), BSAF-2 [1], PreADES [2] (for accumulation of necessary technology and knowledge for sample extraction and full analysis). There is also ARC-F [3] (aimed at optimizing the FDNPS site water & air monitoring programme) at the NEA/CSNI (Committee of Safety Nuclear Installations). See Figure 1 for the links between the TCOFF and other OECD-NEA (F1-related) projects. TCOFF & Pre-ADES maintain close mutual links by means of presentations at each other's meetings. This ensures the direct use of both projects results.

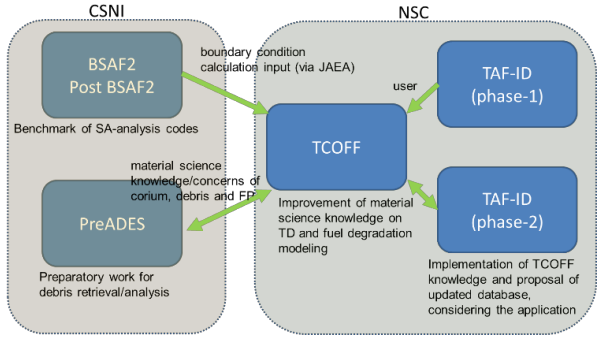

Figure 1. TCOFF Collaborations with FDNPS-related projects in NEA

In order to accelerate the project implementation, MEXT/Japan provided the entire financial funding (720 kEuros over 3 years), which accounts for project management, technical staff support, and, importantly, funds for two international calls for R&D proposals (each for one year, in 2018 and 2019).

The TCOFF project has international research institutes or government organisations, drawn from 10 NEA member countries; these are CVR (Czech Rep.), JRC (European Commission), CEA, IRSN (France), KIT (Germany), CRIEPI, JAEA, TITECH (Japan), KAERI (Korea), Tech. Univ. Delft (the Netherlands) IBRAE, KRI, NITI (Russian Federation), KTH, SSM (Sweden) and PSI (Switzerland). Newer members joined from USA (NRC) and Russian Federation (StP-TechU).

3. Objectives of TCOFF

The major objectives are to Improve quality and/or inventory of thermodynamic databases with reference to the SA-progression analysis for FDNPS accident. The main databases involved are: TAF-ID, NUCLEA, HERACLES, SGTE. For the NUCLEA/MEPHISTA database IRSN were willing to offer this to other members to carry out the calculations and benchmarks. The four main aspects are:

1) Benchmark calculations under conditions experienced during FDNPS accident;
2) Identification and prioritization of material science concerns of the current thermodynamic databases;
3) Improvement and/or extension of thermodynamic databases through experimental and analytical techniques. Contributions would be provided by the members as in-kind work to the project; this would help ensure no unnecessary overlap of current programmes.
4) Conduct joint thermodynamic evaluations of SA-progression at in-vessel and ex-vessel phases of FDNPS unit-1,2, and 3. This was particularly a) fuel melting and molten core relocation; b) Fission product (FP)-behaviour, including volatilization/deposition/re-vaporization and leaching; c) Fuel debris chemical and phase composition, including long term degradation; and finally thermodynamic evaluation of formation of any potential materials which may be detected at the FDNPS.

4. Structure of TCOFF

The NEA-TCOFF project was organised via the NEA Division of Nuclear Science, responsible for financial and administrative matters (see Fig. 1). The technical work programme was overseen by the TCOFF Management Board composed of representatives from the Organisations participating in the project. The work programme was organised into 2 technical task forces in which the in-kind contributions of the members were organized. The Management board (MB) and Project meetings were held twice yearly to monitor and report progress in the task forces (TF) and their activities. There were additional task force activities meetings or teleconferences, as needed, to help co-ordinate the progress of activity work contributions.

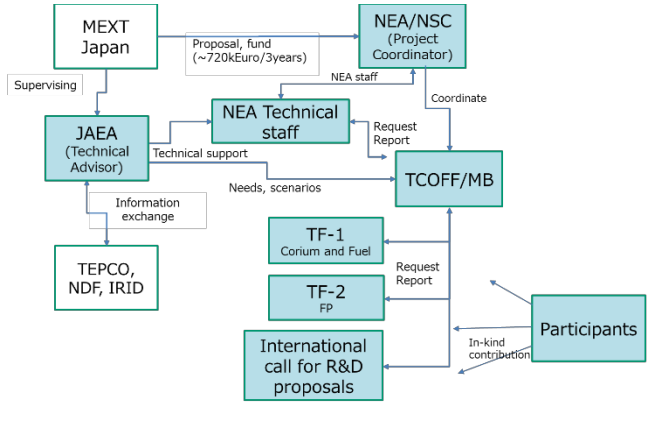

Figure 2. Structure of the TCOFF project

1. TCOFF Task Forces

The Task Forces were divided into TF-1: Corium and Debris, TF-2 Fission Products. TF1 activity was divided into benchmark exercises, improving the U-Zr-O system data (including H2 & N2 impact); data of extended systems e.g. Fe-U-Zr-O and Zr-Fe-B-C. Further TF1 activities were physical chemistry of corium (in-vessel) and molten concrete-corium interaction (MCCI) for ex-vessel conditions and finally, decommissioning needs for FDNPS. TF2 activities include experimental and modelling activities of Cs-complex oxides and Cs-deposits on stainless steel; the long-term leaching and radiological impact of fission product deposits relevant to decommissioning (and storage). A summary of the project activities is given in Table 1.

Table 1. Activities of the TCOFF project.

Task Force 1 **Corium and Debris**	**Task Force 2** **Fission Products**
Activity-1 Thermodynamic Benchmark exercises	Activity 1 Cs-deposits on Stainless Steel)
Activity 2 U-Zr-O base system	Activity 2 Cs-complex oxides and their melts
Activity 3 Sub-systems (eg. Fe-Zr-U-O)	Activity-3 Long term leaching of FPs
Activity 4 Physical-chemistry of corium (mainly In-vessel)	Activity 4 Long term radiological impact
Activity 5 Physical-chemistry of MCCI (ex-vessel)	
Activity 6	

2) TCOFF Calls for Proposals

Discussions about the data needs were carried out in meetings and workshops organised by the project and a committee was set up to determine the remaining areas for research necessary. The committee requested and evaluated the Calls for Proposals made under the project. These proposals for experimental work would be funded by the TCOFF R & D budget (approx. 100k€/call). There were two annual Calls for Proposals open to the project members or other interested organisations. The first Call for Proposal was made for 2018; the following institutes and their proposals were successful and were completed on time:

- NITI (St. Petersburg): Phase equilibria in the U-Zr-O and U-Zr-Fe-O systems;
- TU Delft: Experimental studies of the Ba-Sr-Cs-Mo-O system;
- SPSU (St. Petersburg): Vaporization and thermodynamics of Cs-bearing compounds in the Cs-Si-O, Cs-B-O, Cs-Mo-O, Cs-Cr-O, Cs-Fe-O systems;
- KRI (Khlopin Inst.): Water leaching tests of radionuclides from matrices of aged Chernobyl “lava” and corium;
- TITECH (Tokyo Inst. Of Tech.): Thermodynamics of Cs and Si compounds.

A second Call for Proposals was sent out for 2019. The selection has just been completed and includes further work on leaching of Chernobyl lava, testing with B-rich coria, mass spectroscopy of the Zr-Fe-O system at high temperatures and examination of the stability of cesium polymolybdates.

3) TCOFF Workshops

The TCOFF project also has organized a series of specialist workshops. The first was an international workshop jointly with the TCOFF kick-off meeting in July 2017. Additional workshops have been offered by the project members. NITI & SPSU, St. Petersburg organised a special session at a thermodynamics and material science symposium in March 2018 [4] as in-kind contribution and are holding a further workshop in St. Petersburg in May 2019. CEA proposed as their in-kind contribution to co-organize (with JAEA-CLADS & NEA-OECD a workshop on Materials Science for Severe Accident and Fukushima Daiichi decommissioning WORKSHOP 2019 in J-village on 10-12 July 2019 that will be open for wider experts [5].

A final workshop, aiming at highlighting the major accomplishments of the project is anticipated for the completion of TCOFF (planned in 2020).

References

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