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Tenth OECD/NEA Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of Sodium Cooled Fast Reactors (SFR) (SFR-UAM-10)

2 July 2025

Department of Engineering of the University of Cambridge, Trumpington Street, CB2 1PZ, Cambridge, United Kingdom

The workshop will be held in Cambridge, UK, as part of the Benchmarks Workshops of the Working Party on Scientific Issues and Uncertainty of Reactor Systems (WPRS). The WPRS Benchmarks Workshops event with three parallel tracks combines benchmarking efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis.

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Sponsorship

The Tenth OECD/NEA Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of Sodium Cooled Fast Reactors (SFR)(SFR-UAM-10)will be held on 2 July 2025 in Cambridge, UK, as part of the Benchmarks Workshops Event of the Working Party on Scientific Issues and Uncertainty of Reactor Systems (WPRS). This event with three parallel tracks combines benchmarking efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis. The full schedule for the incoming WPRS Workshops, SINUS-3 school and CTF-11 Meeting and Training is given on the public meeting web page: https://www.oecd-nea.org/jcms/pl_98752/wprs-benchmarks-workshops-2025

Executive Summary

There is a strong incentive to design reactors with improved safety performance while preserving a sustainable source of energy at a rather low cost. The Generation IV International Forum (GIF) has defined the key research goals for advanced Sodium-cooled Fast Reactors (SFR):

- improved safety performance, specifically a demonstration of favourable transient behaviour under accident conditions;
- improved economic competitiveness;
- demonstration of flexible management of nuclear materials, in particular, waste reduction through minor actinide burning.

Sodium-cooled Fast Reactors offer the most promising type of reactors to achieve such Generation IV goals at a reasonable time scale given the experience accumulated over the years. However, it is recognised that new regulations and safety rules as they exist worldwide are requiring improved safety performance. In particular, one of the foremost GIF objectives is to design cores that can, as much as possible, passively avoid core damage when the control rods fail to scram in response to postulated accident initiators (e.g., inadvertent reactivity insertion or loss of coolant flow). The analysis of such unprotected transients depends primarily on the physical properties of the fuel and the reactivity feedback coefficients of the core.

Under the auspices of the Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems (WPRS), an OECD/NEA sub-group on Uncertainty Analysis in Modelling (UAM) for Design, Operation and Safety Analysis of Sodium-cooled Fast Reactors (SFR-UAM) has been formed under the NSC/WPRS to investigate the use of best-estimate codes and data. Neutronics aspects of the benchmark report to the WPRS Expert Group on Physics of Reactor Systems (EGPRS), while multi-physics aspects are overseen by the Expert Group on Reactor Systems Multi-Physics (EGMUP).

The SFR-UAM group has benefitted from the results of the Sodium Fast Reactor Core Feedback and Transient Response (SFR-FT) Task Force work which demonstrated that for the benchmark cores understudy the major source of bias between participants is coming from nuclear data. The final publication is available at the link below:

https://www.oecd-nea.org/jcms/pl_19682/benchmark-for-neutronic-analysis-of-sodium-cooled-fast-reactor-cores-with-various-fuel-types-and-core-sizes

The SFR-UAM has chosen to further study of the large 3,600 MWth oxide core and a medium 1,000 MWth metallic core. Additional core based on 1,500 MWth ASTRID core concept has been proposed to cover a wider range of innovative designs.

Scope and Technical Content of the SFR-UAM Benchmark Workshop

The SFR-UAM working group will have to define the grace time or the margin to melting available in the different identified accidental scenarios, apply the Best Estimate Plus Uncertainty (BEPU) methodology, and possibly recommend some changes to the design so that it meets some safety concerns.

The work is progressive to avoid possible compensating errors. Two SFR cores are being studied: a large 3,600 MWth oxide core and a medium 1,000 MWth metallic core. In order to assess tools being used for studying these cores, various sub-exercises have been developed for neutronics with cell, sub-assembly, super-cell and core benchmarks under steady state conditions either at BOL conditions or at EOEC depending on the benchmark. The results from the sub-exercises were recently made available at the FR-22 conference held in Vienna in April 2022. A sub-assembly depletion benchmark is also being finalised, before considering full-core calculations with depletion.

Since the overall objective is to define the grace period or the margin to melting available in the different accident scenarios and this within uncertainty margins, uncertainties of different origins (methods, neutronics, thermal-hydraulic, fuel behaviour) once identified and evaluated will be propagated. To achieve this objective, collaborations have been setup with the WPFC Expert Group on Innovative Fuel Elements (EGIFE), who will assist with best estimate and uncertainties of fuel properties, and the Expert Group on Reactor Core Thermal-Hydraulics and Mechanics (EGTHM), who will provide best estimates and uncertainty information related to thermal-hydraulic parameters.

At first two simple Unprotected Transients over Power (UTOP) and Loss of Flow (ULOF) are proposed because they allow useful insights without need of accurate modelling of secondary loop and primary vessel (negligible impact). Another benchmark on control rod withdrawal has been added recently and will challenge tools on a particularly difficult asymmetrical transient.

In order to ensure validity to these exercises, the sub-group incorporates some experimental validations on neutronics, thermal hydraulics, fuels and systems. This will be done with neutronic experiments from ICSBEP & IRPhE, SEFOR , thermal hydraulic experiments from Texas A&M, THORS, and system experiments with the SUPER-PHENIX start-up transient programme.

The technical topics to be addressed at the workshop include:

- Review of the benchmark activities after the SFR-UAM-9 workshop;
- Discussion of the updated results for the different core exercises;
- Participants' presentations on their modelling and results for core exercises;
- Discussion of the updated Specification for the different sub-exercises
- Participants' presentations on their modelling and results for the different sub-exercises;
- Discussions on the different sources of uncertainties including those on the fuel behaviour and the core thermal hydraulic
- Discussion of Draft Specification for uncertainties
- Participants' presentations on core characteristic uncertainties
- Discussion on the different experiment specifications in support to the core designs

- Participants' presentations on their modelling and results for the different experiment analyses;
- Discussions on related publications and reports

Organization of the SFR-UAM Benchmark Workshop

The meeting is organised around the discussion in depth of the specifications, comparative analysis of submitted results for the different phases and the proposed work plan and time schedule for the OECD/NEA SFR-UAM benchmark activities. The participants are requested to present their modelling and results for the different phases as well as their experience and expertise in uncertainty and sensitivity analysis of SFRs.

Organisation and Programme Committee of the SFR-UAM Benchmark Workshop

An Organisation and Programme Committee has been nominated to make the necessary arrangements for the Benchmark Workshop and to organize the Sessions, draw up the final programme, appoint Session Chairmen, etc. The members of the Programme Committee (who are also members of the OECD/NEA UAM-SFR Scientific Board) are:

Laurent Buiron – *Co-Chair, and Local Host CEA, France*

Yan Cao - *Argonne National Laboratory, USA*

Eugene Shwageraus – *Co-Chair, and Local Host, University of Cambridge, UK*

NEA Technical Secretariat: **Oliver Buss**
OECD/Nuclear Energy Agency, France

Proposed Program of the Meeting

The proposed program was drawn up by the Program Committee and is enclosed as Annex 1.

Language of the Benchmark Workshop

The official language of the workshop is English.

Proceedings of the Meeting

The program committee and the session Chairs will prepare a summary report on the main results of the meeting. Presentations will be available free of charge to the benchmark participants to download from participants' restricted area of the benchmark website after the workshop.

Contacts and Registrations

Link to the registration page for the WPRS-related workshops and meetings and the overall program:
https://www.oecd-nea.org/jcms/pl_98752/wprs-benchmarks-workshops-2025

Workshop Location

The meeting place/venue for the meetings/workshops during the week of 30 June to 4 July 2025 is the Department of Engineering of the University of Cambridge:

Trumpington Street, CB2 1PZ, Cambridge, United Kingdom.

Annex 1:

OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling for Design, Operation and Safety Analysis of SFRs (SFR-UAM-10) meeting

2 July 2025

AGENDA

14h00-14h30 Status of SFR-UAM

- Update on Phase I and II - L. Buiron, CEA
- Prospect and survey for Phase III; all

14h30-17h30 SEFOR Session

- Validation of Reactivity Feedback Calculations for Sodium Fast Reactors Using SEFOR Experimental Data, Yan Cao, ANL.
- Initial SEFOR Core I-E and Core I-I Doppler Reactivity Feedback Validation using DOE NEAMS Tools, Ahmed A. E. Abdelhameed.
- Modelling of the SEFOR test cases using CTF, Jonas Vanderwaeren and Adrian Sabater, Tractabel.
- SEFOR Benchmark Phase 1: Progress, Paper in Preparation, and possible further activities, Elias Garcia, Héloïse Velardo and Laurent Buiron, CEA.
- Update on the SEFOR benchmark phase II, Elias Garcia, Héloïse Velardo and Laurent Buiron, CEA.
- *Discussion on Future phases II*; all

17h30-18h00 Discussion on OECD/NEA MSR Benchmark

- CEA proposal on a MSR benchmark
- US proposal on a MSR benchmark

Additional contributions welcome.