OECD Nuclear Energy Agency

Nuclear Science Committee

Eighth 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-8)

Bologna, Italy
May 26, 2023 (Track 2)

Hybrid Option Available

Hosted by ENEA, Italy

PROPOSED PROGRAMME

Background of the SFR-UAM Benchmark Workshop

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 2019 a specification for the ASTRID core was made available.

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-7 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
Nicolas Stauff - Co-Chair, Argonne National Laboratory, USA

Secretariat: **Ian Hill**
OECD/Nuclear Energy Agency, France

Participation in the Benchmark Workshops

For Benchmark Workshops sponsored by the Nuclear Science Committee (NSC), participation is restricted, OECD/NEA member countries and in consultation with the local hosts and members of the Nuclear Science Committee.

Proposed Programmes of the Benchmark Workshops

The proposed programme for the Fourth Sodium Fast Reactor (SFR) Uncertainty Analysis in Modelling (UAM) Benchmark Meeting (SFR-UAM-8) is attached in ***Appendix 1***.

Language of the Benchmark Workshops

The official language of the Benchmark Workshops is English.

Proceedings of the Workshops

Summaries of the workshops will be published by the OECD/NEA after the meeting. The summary will be distributed free of charge to the participants in the Workshops and to Delegates of the NSC. The programme committee and the session Chairmen will prepare a summary report on the main results of the meeting for presentation to the NSC. Presentations will be available free of charge to the participants to download from participants' restricted area after the workshop.

Contacts and Registrations

The annual benchmark workshops/meetings of the Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems (WPRS) and the UAM-SFR-8 Benchmark Meeting will be hosted by ENEA in Bologna (Italy). The meetings will take place in two tracks in parallel during the week of 22 May to 26 May 2023 to exchange results and lessons learned for the different WPRS benchmark activities and to discuss future activities.

The link to registration page for the WPRS-related workshops/meetings (including SFR-UAM-8), overall program, and local information for transportation and hotels is: https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

Please send any additional proposed contribution for SFR-UAM-8 workshop to Laurent Buiron – laurent.buiron@cea.fr .

Workshops' Location

The meeting place for the ten meetings/workshops during the week of May 22 – 26, 2023, in three tracks is at the Zanhotel Europa, Bologna, Italy (in-person meeting). As mentioned above the local information for transportation and hotels is given at:
https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

The programme and schedule of the meetings is shown below:

	Track 1	Track 2	Track 3
Monday, May 22	Morning: MPCMIV Afternoon: Burst Fission Gas Release	Morning: CTF UG Afternoon: CTF Training	Morning: SINUS Afternoon: SINUS
Tuesday, May 23	Morning: LWR UAM Afternoon: LWR UAM	Morning: HTGR-TH Afternoon: HTGR-TH	Morning: SINUS Afternoon: CTF Training
Wednesday, May 24	Morning: Task Force on Doppler Effective Fuel Temperature Afternoon: Task Force on AI & ML	Morning: McMaster CTH Afternoon: LFR Neutronics	
Thursday, May 25	Morning: C5G7-TD Afternoon: TVA-WB1	Morning: LFR TH Afternoon: LMFR TH	
Friday, May 26	Morning: TVA-WB1 Afternoon: Rostov-2	Morning: SFR-UAM Afternoon: SFR-UAM	

Appendix 1

OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling for Design, Operation and Safety Analysis of SFRs (SFR-UAM-8) meeting

May 26th, 2023

AGENDA

Day 1: May 26th 2023

10h00-10h30	Status of SFR-UAM Phase I and II - L. Buiron, CEA
10h30-12h00	SEFOR Session I
	SEFOR experimental data legacy for VVUQ- L. Buiron, CEA (20 min)
	WPRS SEFOR specifications (discussions) – L. Buiron, CEA (10 min)
	Phase I preliminary results
	CER results - tbd (20 min)
	UPM results - N. Garcia-Herranz (20 min)
	CEA results - E. Garcia-Cervantes (20 min)
	ANL results – tbd (20 min)
Lunch	
	SEFOR session II
14h00-14h20	Use of SEFOR validation for core target cores - L. Buiron, CEA (20 min)
14h20-15h00	Discussion on next additional cases and next phases - All

Additional contributions welcome.