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Annual meeting of the OECD/NEA Fluoride Salt-Cooled High-Temperature Reactor Benchmark (FHR-2025)

WPRS Benchmarks Workshops 2025

30 June 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 2025 hybrid meeting (in-person & online) of the OECD/NEA Fluoride Salt-Cooled High-Temperature Reactor Benchmark (FHR-2025) will be held on June 30, 2025 (Track 2 morning) 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

Over the last decade, there has been significant interest in several member countries to investigate Fluoride-salt High-temperature Reactors (FHR), cooled with liquid (molten) salt, fuelled with TRISO-based fuel. Such reactor designs share certain similarity (heat removal by molten salt) with the historic Molten Salt Reactor Experiment (MSRE), but also present a fundamental difference in having solid fuel, either in form of circulating pebbles or in hexagonal fuel elements. Either fuel form, due to its double heterogeneity, leads to complex reactor physics and present significant modelling challenges. This is further exacerbated in the case of hexagonal fuel elements, with fuel TRISO particles embedded in plates ("planks"), which due to the complex fuel geometry could be considered a form of "triple heterogeneity". At the same time, there are no experimentally obtained results that would allow validation. This makes cross-verification using different reactor physics codes and methods on carefully defined benchmarks the most viable approach to improve confidence in results obtained by numeric simulations.

The scope of this benchmark is limited to FHR reactors with plate fuel. It is divided in three phases, starting with a single fuel element simulation without burnup, and gradually extending to full core depletion.

Phase I – Fuel assembly (2D/3D with depletion)

- Phase I-A – 2D (pseudo-2D) model, steady state (no depletion)
- Phase I-B – 2D model depletion
- Phase I-C – 3D model depletion

Phase II – 3D full core with depletion

- Phase II-A – Steady-state (no depletion)
- Phase II-B – Depletion

Phase III – 3D full core with feedback and multicycle analysis

Phase III-A – Full core depletion with feedback

Phase III-B – Multicycle analysis

The reactor modelled in this benchmark is based on the ORNL Advanced High Temperature Reactor (AHTR) design presented in a number of ORNL technical reports. Specifications for Phase I-A and I-B (nine exercises, without and with depletion) are given in the NEA document NEA/NSC/R(2020)5. Specifications for I-C exercises (original and modified specifications) are provided in internal PowerPoint presentations posted at the FHR Benchmark restricted website. Fifteen participants from nine participating organizations from four member states contributed to the initial effort on Phase I-A and I-B. Some participants have since changed their affiliation. Nine participants from five countries have completed Phase I-C exercises.

Participants were free to select the reactor physics code and nuclear data library of their choice to perform the required analyses. Notably, three Monte Carlo based codes and one deterministic code were used, together with several nuclear data libraries (mostly ENDF/B-VII based).

While the agreement was generally good in most considered parameters (e.g., multiplication parameter, kinetics parameters, neutron spectra), non-trivial differences were observed in depletion calculations, that were traced to different values of per fission recoverable energy. This led to code-specific recommendations aiming to harmonize depletion assumptions.

Another challenge for 3D depletion simulations is occurrence of non-physical spatial oscillations. Discussion and recommendations moving forward with full core 3D simulations will be one of the main topics of this meeting.

The information about the OECD/NEA FHR benchmark is provided at:
https://mynea.oecd-nea.org/sites/WPRS/benchmarks/FHR/SitePages/Home.aspx

Scope and Technical Content of the Meeting

The topics to be addressed at the meeting include:

- Review of the Benchmark progress and status
- Summary of Phase I results, with emphasis on Phase I-C and I-C modified.
- Participants' presentations on Phases I modelling and simulations challenges
- Lessons learned from Phase I and resulting recommendations for Phase II
- Review and discussion of the Phase II: current version of specifications; results to be required; template(s) for submitting results
- Publishing plan for already collected and for future to be generated results
- Presentations on other related activities linked with the benchmark,

The proposed FHR Benchmark meeting Agenda is attached as Annex 1.

Organization of the Meeting

The meeting is organized around the discussion of the FHR benchmark specifications, preliminary results, participants' concerns, and benchmark-related activities. The participants are requested to present their expertise and experience in benchmark-related modeling and results of all the proposed exercises.

Participation in the Meeting

Meeting participation is not restricted. Benchmark participation is restricted to individuals from OECD/NEA member country institutions who agree to the benchmark non-disclosure agreement (NDA). Participants are asked to sign and send the corresponding NDA form to wprs@oecd-nea.org. Benchmark FHR conditions to release form can be found at:
https://www.oecd-nea.org/upload/docs/application/pdf/2024-10/fhr-conditions_for_release_2024.pdf

Organization of the FHR Benchmark

For all questions and suggestions related to the FHR Benchmark, please contact:

Bojan Petrovic (Benchmark Coordinator)
Georgia Institute of Technology, USA
Jonathon Faulkner (Benchmark Results Analysis)
Georgia Institute of Technology, USA
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 for presentation to the EGPRS, WPRS, and NSC. 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:

Annual Meeting of the OECD/NEA Fluoride Salt-Cooled High-Temperature Reactor Benchmark (FHR-2025)

Host Organization
Department of Engineering of the University of Cambridge, in collaboration with the Cambridge Nuclear Energy Centre, University of Cambridge, United Kingdom
June 30, 2025
Track 2 (Morning)
PROPOSED PROGRAM

- Introduction of (in-person and online) participants and opening remarks

Phase I

- Review of the Benchmark progress and status
- Brief summary of Phase I-A and I-B results and lessons learned
- Summary of Phase I-C and I-C modified results and lessons learned
- Participants' presentations on Phases I modelling and simulations challenges

Phase II

- Lessons learned from Phase I and resulting recommendations for Phase II
- Review and discussion for the Phase II:
  current version of specifications;
  results to be required;
  template(s) for submitting results

Moving Forward

- Publishing plan for already generated/collected results and for future results (to be generated)
- Presentations on other related activities linked with the benchmark (including publications relevant but not generated withing the Benchmark framework)
- Action items and schedule of benchmark activities
- Conclusions and closing remarks