OECD Nuclear Energy Agency NEA

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Fourth OECD/NEA & US NRC Liquid Metal Fast Reactor Thermal-Hydraulics Benchmark (LMFR T/H-4) Workshop

Lucca, Italy
Wednesday, May 22, 2024 (track 2 morning)
In conjunction with the BEPU 2024 Conference

Hosted by N.IN.E. (Nuclear and Industrial Engineering), Italy

Announcement and Proposed Program

Background and Purpose of 4th LMFR T/H Benchmark Meeting

The fourth LMFR T/H Benchmark Meeting (LMFR T/H-4) will be held on May 22, 2024 (track 2 morning), in Lucca, Italy, and is a follow up to the previous workshop. The LMFR T/H-4 meeting will be held in conjunction with the 2024 Best-Estimate Plus Uncertainty (BEPU-2024) international conference as well as with other OECD/NEA Working Party on scientific issues and uncertainty of Reactor Systems (WPRS) meetings/workshops to facilitate co-ordination and sharing of work. The other meetings are being held in three parallel tracks at Lucca, Italy during the same week in order to combine efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis and to make the participation more efficient. The meetings/workshops concerned are:

- *May 19, 2024 (morning)* – COBRA-TF (CTF)-10 a Hands-on Training Session
- *May 19, 2024 (afternoon)* – CTF-10 User Group (UG) Meeting
- *May 20, 2024 (track 1 morning)* – Third OECD/NEA Lead Fast Reactor (LFR) benchmark (LFR-3) workshop – LFR Thermal-Hydraulic (T/H) Stage
- *May 20, 2024 (track 2 morning)* - Third OECD/NEA Fluoride High Temperature (FHR) Reactor Benchmark (FHR-3) workshop
- *May 20, 2024 (track 1 afternoon)* – Third OECD/NEA Lead Fast Reactor (LFR) benchmark (LFR-3) workshop – LFR Neutronics Stage
- *May 20, 2024 (track 2 afternoon)* – Sixth OECD/NEA Rostov-2 VVER-1000 Multi-Physics Transient Benchmark (Rostov2-6*)* workshop
- *May 21, 2024 (track 1)* - Ninth OECD/NEA Sodium Fast Reactor (SFR) UAM Benchmark workshop (SFR-UAM-9)
- *May 21, 2024 (track 2 morning)* - Ninth OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) Benchmark (C5G7-TD-9) workshop
- *May 21, 2024 (track 2 afternoon)* – Fifth Multi-Physics Pellet Cladding Mechanical Interaction Validation Benchmark (MPCMIV-5) workshop
- *May 20*-21 (track 3), 2024 – 2nd OECD/NEA International School on Simulation of Nuclear Reactor Systems (SINUS)
- *May 22, 2024 (track 1)* – Seventeen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-17) workshop
- May 22, 2023 (track 2 afternoon) – First OECD/NEA HTGR-TH Benchmark (Based on HTTF Data) workshop (HTGR-TH-1)
- *May 23, 2024 (track 1)* – Fourth OECD/NEA TVA Watts Bar 1 (WB1) Multi-Physics Multi-Cycle Depletion Benchmark (TVA-WB1-4) workshop
- *May 23, 2024 (track 2 morning)* - Summary session with presentations of recently concluded benchmarks: OECD/NEA First Burst-Fission-Gas Release Benchmark (BFGR) and OECD/NEA McMaster Core Thermal-Hydraulics (CTH) Benchmark
- *May 23, 2024 (track 2 afternoon)* – OECD/NEA Task Force Artificial Intelligence & Machine Learning meeting

The Liquid Metal Fast Reactor (LFMR) is one of the reactor designs included in the next generation of nuclear reactors. Many numerical and experimental studies have been performed on LMFR core geometry but a structured set of techniques for consistent and comprehensive comparisons to

establish modelling and simulation tools needed for LMFR analysis is missing from the current literature. This activity has been already endorsed by the Organisation for Economic Co-operation and Development Nuclear Energy Agency (OECD-NEA) and is in line with the United States Nuclear Regulatory Commission (US NRC) strategy for advanced non-Light Water Reactor (LWR) research with a focus on developing core Thermal-Hydraulic (TH) modelling and simulation capabilities for confirmatory analysis of LMFRs.

This benchmark has been divided into two Phases:

- Phase I
    - Steady-state numerical predictions of Texas A&M University (TAMU) separate effect test and comparison to experimental results; and
- Phase II
    - Numerical predictions of the Thermal Hydraulic Out of Reactor Safety (THORS) integral effect tests and comparison to experimental results.

Each phase will include several exercises and will be planned to accommodate as many numerical prediction methods as possible. The objectives of Phase I are to provide a detailed geometry of the bundle test section and boundary conditions and a high-resolution experimental database of isothermal turbulent flow and pressure drop acquired from a 61-pin wire-wrapped hexagonal fuel bundle (all from TAMU); assess the performance of numerical schemes and turbulent models currently implemented in the state-of-the-art Computational Fluid Dynamics (CFD) codes; and establish best practices for uncertainty quantification (UQ) of model geometry, initial and boundary conditions, and other associated uncertainties for CFD calculations.

The objectives of Phase II are to provide a sodium turbulent flow and heat transfer database for CFD and subchannel model validation; emphasize the importance of uncertainty analysis for TH simulations; establish best practices for quantification of geometry modelling, input data, fluid properties, and other uncertainties associated with the complex flows in LMFR bundles; develop guidance for CFD model/code validation for LMFR fuel bundles that can be used to improve the existing standards; update the current TH models for pressure drop and inter-channel mixing; and develop the hybrid experiment/simulation database necessary to establish and calibrate the low order models with high resolution (both experimental/numerical) data.

The information about the LMFR T/H benchmark is provided at:

https://www.oecd-nea.org/jcms/pl_32180/liquid-metal-fast-reactor-core-thermal-hydraulics-benchmark-lmfr-t/h

Scope and Technical Content of the Meeting

The topics to be addressed at the workshop include:

- Review and discussion of specifications of LMFR T/H Benchmark Phases I and II,
- Presentations on results of LMFR T/H Benchmark Phases I and II,
- Discussion of templates for submitting participants' results for different phases,
- Feedback and concerns of benchmark participants,
- Presentations on other related activities such as model developments, efficiency improvements, verification and validation efforts and applications, and

- Defining a work plan and schedule for LMFR T/H activities.

The proposed meeting program is attached as Annex 1.

Organisation of the Meeting

The meeting is organized around the discussion of the LMFR T/H benchmark specifications, preliminary results, participants' concerns and benchmark-related activities. The participants are requested to present their expertise and experience in benchmark-related modelling, verification and validation, uncertainty quantification and applications.

Participation in the Meeting

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-nnea.org.

Benchmark NDA form:

https://www.oecd-nea.org/jcms/pl_62381/conditions-for-participation-to-lmfr-t/h-benchmark

Organisation and Program Committee of the Meeting

An Organisation and Program Committee has been nominated to make the necessary arrangements for the LMFR T/H-4 meeting and to draw up the final program, etc.

The members of the Program Committee are:

Maria Avramova – *Principal Investigator and Chair*
North Carolina State University, USA

David Holler - *Co-Chair*
North Carolina State University, USA

Alessandro Petruzzi – *Co-Chair, and Local Host*
NINE S.r.l., Italy

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 LMFR T/H-4 meeting is English.

Proceedings of the Meeting

A summary of the LMFR T/H-4 meeting will be published by the program committee after the meeting. The summary will be distributed free of charge to the participants in the meeting. The presentations will be available free of charge to the participants to download from participants' restricted area after the LMFR T/H-4 meeting.

Contacts and Registrations

The meeting place/venue for the BEPU-2024 conference and the eleven meetings/workshops during the week of May 19 to May 23, 2024 is the Real Collegio, which is located inside the city walls of Lucca. The local information for transportation and hotels is given at:

https://www.nineeng.com/bepu2024/index.php/conference-info/about-the-conference

The schedule for the incoming WPRS Workshops, SINUS-2 school and CTF-10 Meeting and Training is given in the table below (all times in CEST):

The program and schedule of the meetings is shown below:

Sunday, 19 May 2024	9:00-13:00	CTF UG Training		
	14:00-18:00	CTF UG Meeting		
	Starting at 18:00	Registration & informal networking		
		Track 1	**Track 2**	**Track 3 (SINUS)**
Monday, 20 May 2024	Starting at 8:00	Registration		
	9:00-13:00	Lead-cooled Fast Reactor Benchmark (LFR) - T/H Stage	FHR - Fluoride High Temperature Reactor Benchmark	OECD NEA International School on Simulation of Nuclear Reactor Systems (SINUS)
	14:00-18:00	Lead-cooled Fast Reactor Benchmark (LFR) - Neutronics Stage	Rostov-2 VVER-1000 Benchmark	SINUS
Tuesday, 21 May 2024	9:00-13:00	Uncertainty Analysis in Modelling (UAM) for Design, Operation and Safety Analysis of Sodium-cooled Fast Reactors (SFR-UAM)	C5G7-TD: The Deterministic Time-Dependent Neutron Transport Benchmark C5G7-TD without Spatial Homogenization	SINUS
	14:00-18:00	SFR UAM	Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) Benchmark	SINUS
		Track 1	**Track 2**	
Wednesday, 22 May 2024	9:00-13:00	Benchmark for Uncertainty Analysis in Best-Estimate Modelling for Design, Operation and Safety Analysis of Light Water Reactors (LWR-UAM)	Liquid Metal Fast Reactor Core Thermal-Hydraulics Benchmark (LMFR T/H)	

	14:00-18:00	LWR UAM including session on EGMUP Task Force on Doppler effective fuel temperature	HTGR T/H Benchmark based on HTTF Data
Thursday, 23 May 2023	9:00-13:00	TVA Watts Bar Unit 1 Multi-Physics Benchmark	9:00-11:00 Summary presentations of recently concluded benchmarks: - Burst Fission Gas Release (1h) - McMaster CTH (1h)
			11:00-13:00 EGMUP Task Force Artificial Intelligence & Machine Learning
	14:00-18:00	TVA Watts Bar Unit 1 Multi-Physics Benchmark	EGMUP Task Force Artificial Intelligence & Machine Learning

ANNEX 1

OECD/NEA & US NRC Liquid Metal Fast Reactor Thermal-Hydraulic (LMFR T/H) Benchmark – Fourth Workshop (LMFR T/H-4)

Host Organisation

Hosted by N.IN.E. (Nuclear and Industrial Engineering)

Lucca, Italy

May 22, 2024 (track 2 morning)

PROPOSED PROGRAM

LT01-08: Session code

Day 1: May 22, 2024 (track 2 morning)

LT01. Introduction and opening remarks
LT02. Overview of benchmark activities since last workshop
LT03. Presentations of related activities and reference analyses
LT04. Discussion of the Phase I specifications
LT05. Discussion of the Phase II specifications
LT06. Participants' presentations on their modelling and results of the LMFR T/H benchmark
LT07. Action items and schedule of benchmark activities
LT08. Conclusions and closing remarks