

**Forth Meeting –
Critical Heat Flux and Thermal-hydraulic Benchmark
(CTH-4)**

Bologna, Italy

- **May 24, 2023 (track 2 morning)**

Hosted by ENEA, Italy

Announcement and Proposed Program

Sponsorship

The third LMFR T/H Benchmark Meeting (LMFR T/H-3) will be held on May 25, 2023, in Bologna, Italy, and is a follow up to the previous workshop. The LMFR T/H meeting will be held in conjunction 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. Thirteen other meetings are being held in three parallel tracks at Bologna, 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 22, 2023 (track 2 morning) – Ninth COBRA-TF (CTF) User’s Group (UG) Meeting (CTF-9) followed by a hands-on CTF training sessions which will be conducted on Monday afternoon, May 22, 2023 and Tuesday morning, May 23, 2023 (track 2);
- May 22, 2023 (track 1 afternoon) – First Burst-Fission-Gas Release Benchmark (BFGR-1) workshop;
- May 23, 2023 (track 1) - Sixteen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-16) workshop;
- May 23, 2023 (track 2) – OECD/NEA HTGR-TH Benchmark introductory presentation and discussions;
- May 22-23 (track 3), 2023 – OECD/NEA International School on Simulation of Nuclear Reactor Systems (SINUS);
- May 24, 2023 (track 1 morning) - OECD/NEA Task Force on Doppler Effective Fuel Temperature meeting;
- May 24, 2023 (track 2 morning) – Fourth OECD/NEA McMaster Core Thermal-Hydraulics (CTH) Benchmark (CTH-4) workshop;
- May 24, 2023 (track 1 afternoon) – OECD/NEA Task Force Artificial Intelligence & Machine Learning meeting;
- May 24, 2023 (track 2 afternoon – LFR neutronics) – May 25, 2023 (track 2 morning – LFR Thermal-hydraulics) – Second OECD/NEA Lead Fast Reactor (LFR) Benchmark (LFR-2) workshop;
- May 24, 2023 (track 1 afternoon) – May 25, 2023 (track 1 morning) - Eight OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) Benchmark (C5G7-TD-8) workshop;
- May 25, 2023 (track 1 afternoon) – May 26, 2023 (track 1 morning) - Third meeting on OECD/NEA TVA Watts Bar 1 (WB1) Multi-Physics Multi-Cycle Depletion Benchmark (TVA-WB1-3) workshop;
- May 26, 2023 (track 2) - Eight OECD/NEA Sodium Fast Reactor (SFR) UAM Benchmark workshop and First Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulics (T/H) Benchmark workshop (SFR-UAM-8);
- May 26, 2023 (track 1 afternoon) – Fifth meeting on Rostov-2 VVER-1000 Multi-physics Transient Benchmark (Rostov2-5).

Purpose of the Meeting

Building on the NEA BFBT and PSBT benchmarks, McMaster University, in collaboration with North Carolina State University, launched a CANDU thermal-hydraulic benchmark under the WPRS Expert Group on reactor core Thermal-Hydraulics and Mechanics (EGTHM). The CANDU Owners Group (COG) provided full-scale experimental data for a 28-element CANDU fuel assembly including pressure drop and detailed pin temperatures for single-phase and boiling conditions.

The purpose of the benchmark is to:

- provide data for validation of numerical models that predict single and two-phase pressure drop;
- provide data over a wide range of geometrical and operating conditions for validation of single and two-phase heat transfer models;
- provide critical heat flux (CHF) data over a wide range of flows, pressures and temperatures and under full-scale reactor conditions for code testing and model development. Of particular importance are the tests where aged reactor conditions are represented and hence the geometry deviates from nominal conditions;
- provide novel “dry patch” mapping data wherein the post-CHF characteristics like dry-area fraction and post-dryout temperatures can be compared to code predictions.

A unique aspect of these data is the traversing thermocouples which provide axial and azimuthal sheath temperatures along every fuel element for both pre- and post-CHF conditions. A wide range of test conditions (inlet pressure, mass flows and inlet temperatures) will be provided to participants along with the temperature scans, CHF location and power, and post-dryout sheath temperatures. Similar to the NUPEC Boiling Water Reactor (BWR) Full-size Fine-mesh Bundle Tests (BFBT) and NUPEC Pressurised Water Reactor (PWR) Subchannel and Bundle Tests (PSBT) benchmarks, the complete set of data will be made available to participants after completion of the benchmark.

The benchmark activities involve two phases with seven exercises in total as follow:

Phase I: Pre-CHF Benchmark

- Exercise 1: Single and two-phase pressure drop benchmark
- Exercise 2: Single-phase heat transfer benchmark
- Exercise 3: Two-phase heat transfer benchmark

Phase II: CHF Benchmark

- Exercise 1: Steady-state CHF benchmark under nominal geometrical conditions
- Exercise 2: Steady-state CHF benchmark under aged channel conditions
- Exercise 3: Transient heat transfer and CHF benchmark

- Exercise 4: Post-dryout sheath temperature benchmark

The meeting will cover the final benchmark specifications, and submitted participants' results. go through the detailed geometry specifications, and the draft submission templates. The pre-qualification data for release will also be covered at this time.

Meeting Content

The meeting will cover the following topics:

- Final specifications and support data;
- Review of participants' submitted results;
- Participants' presentations on their modeling and results;
- Discussion of final report.

Participation in the Meeting

The participation in the meeting is open to all registered participants to the CTH benchmark as well as conclusion of the benchmark activities and preparation of final report.

Organization and Program Committee of the Meeting

An Organization and Program Committee has been nominated to make the necessary arrangements for the CTH-4 meeting and to draw up the final program, etc.

The members of the Program Committee are:

David Novog – *Chair and Coordinator*
McMaster University, Canada

Giacomo Grasso – *Local Host*
ENEA, 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 CTH-4 meeting is English.

Proceedings of the Meeting

A summary of the CTH-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 CTH-4 meeting.

Contacts and Registrations

The annual benchmark workshops/meetings of the [Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems \(WPRS\)](#) and CTH-4 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 CTH-4 Meeting), overall program, and local information for transportation and hotels is:

https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

The link to registration page for the CTF-9 UG Meeting and Training is:

<https://www.ne.ncsu.edu/rdfmg/cobra-tf/ninth-ctf-user-group-ug-meeting-and-training/>

Workshop 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 program 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	

ANNEX 1

Forth OECD/NEA Meeting – Critical Heat Flux and Thermal-hydraulic Benchmark (CTH-4)

Host Organization

Hosted by ENEA

Bologna, Italy

May 24, 2023 (track 2 morning)

PROPOSED PROGRAM

CTH01-08: Session code

May 24, 2023 (track 2 morning)

- CTH01. Introduction and opening remarks
- CTH02. Overview of benchmark activities since last workshop
- CTH03. Presentations of related activities and reference analyses
- CTH04. Discussion of the final specifications
- CTH05. Discussion of submitted results.
- CTH06. Participants' presentations on their modelling and results of the LMFR T/H benchmark
- CTH07. Discussion of final report and action items to conclude the benchmark activities.
- CTH08. Conclusions and closing remarks