
FY1 BIANNUAL MEETING
- MEETING MINUTES -

“Computational and Experimental Benchmarking for Transient Fuel Testing”

FY 2016 NE-IRP

MEETING ATTENDEES

The following is a list of participants who contributed to the Computational and Experimental Benchmarking for Transient Fuel Testing Biannual Meeting:

<u>Participant</u>	<u>Organization</u>		
1. Christopher Lewis	Areva	15. W. David Pointer	ORNL
2. Changho Lee	ANL	16. Wade Marcum	OSU
3. Heather Conway	ANL	17. Brian Woods	OSU
4. John Bess	INL	18. Emory Brown	OSU
5. Colby Jensen	INL	19. Tommy Moore	OSU
6. Dan Wachs	INL	20. Mike Steer	TerraPower
7. Nicolas Woolstenhulme	INL	21. Kevan Weaver	TerraPower
8. Jim Parry	INL	22. Tom Downar	UM
9. Mark Dehart	INL	23. Bill Martin	UM
10. Lin-Wen Hu	MIT	24. Volkan Seker	UM
11. David Carpenter	MIT	25. Yunlin Xu	UM
12. Kaichao Sun	MIT	26. Scott Wilderman	UM
13. Michael Todosow	BNL	27. Haining Zhou	UM
14. Arantxa Cuadra Gascon	BNL	28. Nick Kuciniski	UM
		29. Ethan Pachek	UM

Day 1

1 GREETINGS (ROB GILGENBACH AND TOM DOWNAR @ 8:27 AM)

- The University of Michigan (UM) has representation by faculty in the fields Fission, Fusion, Medical Physics, Measurements, Materials and Radioactive Waste. They are looking to expand their faculty in these fields.
- The University of Michigan has research projects that interact with CASL, Consortium for Verification Technology, and NEAMS.
- UM has extensive renovations occurring to convert a decommissioned nuclear reactor to provide more lab space. This has been a seven-year process and is ongoing at this time.

2 GOALS OF MEETING (WADE MARCUM @ 8:54 AM)

- Wade pointed out that the meeting will start with the high level discussions of the IRP and get down to the specific tasks later on.
- The purpose of the breakout sessions is to produce action items for moving forward until the next IRP meeting.
- Wade reiterated that the website for the IRP is <http://research.engr.oregonstate.edu/treat-irp/> and provided the password to the repository to the attendees. This will be a source of information related to the IRP moving forward.

3 OVERVIEW OF TREAT RESTART (NICHOLAS WOOLSTENHULME @ 9:11 AM)

- Nic described what Transient Testing making the connection to being a “car crash for testing nuclear fuel.” It is important for licensing, vendors, and manufacturers.
- Nuclear Transient Testing allows for radiation effect, correct heating, and reactivity insertion rates when compared to an electrically heated test.
- Historic transient testing facilities include SPERT, TREAT, LOFT, and PBF. TREAT is the only reactor to survive to today.
- A question was asked regarding the definition of a prompt insertion. It was defined as a single insertion event. Two or more insertions is defined as a shaped event.

- A question was asked regarding backing out information from the fuel failure videos. A suggestion was made to use IR cameras to get temperature data from these videos.
 - After inspection, the fuel was determined to be in a good shape. Some plastic was found on the fuel but has since been scraped off and is ready to run.
- 4 RATTLESNAKE, MAMMOTH AND RESEARCH IN SUPPORT OF TREAT KINETICS CALCULATIONS (MARK DEHART @ 10:15 AM)
- The MOOSE framework provides the means to solve all of these modules tightly coupled to provide a more converged multi-physic simulation.
 - The spatial domain for these models is that each fuel element is modeled. Common mesh among all of the modules allows for the solution to be made fully implicitly.
- 5 TREAT LEU CONVERSION ANALYSIS OVERVIEW (HEATHER CONNAWAY @ 10:57 AM)
- ANL conducting study for conversion of TREAT core from HEU to LEU. This is to be completed by 2024, thus all modeling for restart to be done with current HEU core.
 - The converted core must provide same performance and safety while maintaining the Power Coupling Factor (PCF) and the Total Energy Deposition (TED) in the test region.
 - Lin-Wen Hu asked about the feasibility of using temperature (600°C max clad temperature) as the core safety limitation since the thermocouple response will be too slow in transient tests.
 - Wade asked “Other than TED is the pulse shape also being taken into account”. The response was that yes, it is being investigate, and that it is an important figure of merit for the analysis team. Different ratios of HEU/LEU affect the pulse FWHM.
 - Many other changes such as graphite to uranium ratio and particle size all have significant affects on the core. Recent design iterations have improved the PCF from 72% up to 96% (>90% to maintain safety limitation). Also they are looking into using Zirc-3 cladding instead of the current Zirc-4.
 - Dan Wachs asked what the key risks are. The main two were the fabrication challenges and being able to meet experiment requirements for unanticipated future experiments.

- John Bess ask what the lower limit for boron impurities in the graphite can be. The conclusion was that it can be reduce to below 2 ppm but current models use that value to maintain conservatism.

6 OSU LED IRP OVERVIEW (WADE MARCUM @ 11:34 AM)

- Wade gave a brief overview and lead in to the 3 tasks associated with the IRP. He also mentioned that documentation necessary for task 2.1 has been approved for release to OSU from INL through Nic Woolstenhulme.

7 TASK 1 PROGRESS OVERVIEW (TOM DOWNAR @ 11:42 AM)

- Tom talked in his presentation about the challenges in getting consensus between many modelers on the same problem using different codes (both Monte Carlo and deterministic).
- Currently, the largest challenge in matching keff for the Minimum Critical Core (MCC) configuration is the boron concentration. Uncertainty in the statistical variation model leading to large uncertainties in results. Currently the chi squared model seem to be giving the most promising results.
- All models have the MCC mostly done (excluding the issue with boron concentration). The M8CAL configuration has been started using the Serpent MC code.
- Kaichao Sun said that he will request the OpenMC development team at MIT to work on a hydrogen content (?) capability to be include to match the capabilities of both MCNP and Serpent.

8 TASK 2.1 PROGRESS OVERVIEW (BRIAN WOODS @ 11:59 AM)

- Brain gave a brief overview on the problem statement of task 2.1 as laid out the challenges that were had since the last meeting. He then said that HOP 1-6A data is available and that the down-selection seems to be completed.

9 TASK 2.2 PROGRESS OVERVIEW (WADE MARCUM @ 12:07 PM)

- Wade gave a presentation on the progress of task 2.2, including the challenges with the Transient Water Environment Recirculating Loop (TWERL) and the progress made on designing OSU's Transient Reactor Test Loop (TRTL).
- Wade mentioned because of uncertainty in commercial requirements, the uncertainties in Figures of Merits (FOM) in design of TRTL is compounded due to degrees of removal from actual scenario.
- Data from the TRTL will be very impactful since there is no data in accessible literature (one French study was found) for transient critical heat flux.
- Currently the structural design of TRTL 100% complete; Mechanical design - 80% complete; Electrical - 70% complete; and the DAS/Instrumentation – 50% complete.

10 TASK 3 PROGRESS OVERVIEW (LIN-WEN HU @ 12:25PM)

- Lin-Wen said that the sensors are to be tested in MIT (steady state and slow power ramp) and OSU (steady state and pulse) reactors for validation
- Task 3 got a head start on validation work at MIT reactor and is progressing smoothly. They are planning on a 2-week experimentation campaign in the MITR.

11 BREAKOUT SESSION

11.1 Tommy Moore (OSU)

- Tommy gave a presentation on the problem description report and an introduction to Nek5000 (NEAMS CFD tool). The problem description report will be written to create a benchmark test from the historic HOP 1-6A test.
- The HOP 1-6A test was a sodium flow test in a mk. II test loop that was conducted in the early 80s. Documentation has been found that details this test.
- Questions were raised about the origin and details about the pins. It was determined that the the pins all had very similar burnup and were wire-wrapped in individual flow channels.
- Discussion was had about the best steps for moving forward with mesh generation tools for later use with Nek5000. Dave Pointer suggested using Dakota for doing a mesh

sensitivity study. Mike Steer suggested to contact Paul Fischer at ANL for a Python based wire-wrapped meshing script for Nek5000.

- Only the test section will be modeled with CFD. 1-D flow will be used to drive to boundary conditions.
- To help with both meshing and detailing the problem description report, two SolidWorks models will be made (one solid, one fluid). The goal is to have this model to interested parties in 2-4 weeks.
- The problem description report will be completed by September and Tommy will have opportunities to leverage resources out of ORNL during the summer to help complete this task.

11.2 Mike Steer (TerraPower)

- Mike mentioned that it would be possible to create a form model of HOP 1-6A to insert into one of the sodium flow loops at TerraPower.
- TerraPower needs to get more information on the thermocouple wire geometries to correctly model the test section in Star-CCM+.

11.3 Wade Marcum (OSU)

- Wade asked about design changes of TWERL. Nic mentioned that it is likely that TWERL will get rid of the burst disc valve into the discharge tank, thus making it a single volume. May also add a heat exchange to remove heat from the loop (TRTL will have a 125 kW heat exchanger).
- Nic asked where the band heaters for TRTL will come from. Wade will use the same band heaters that are used on the HMFTF at OSU due to positive past experience. Nic was also curious about the flange seal at the top of the loop.
- INL is considering using N₂ as a cover gas (as opposed to He). It will be cheaper and also less likely to leak through mechanical seals.
- Nic is being pushed in the direction to design the TWERL loop to have blow-down capabilities to also simulate a LOCA. Since funding for further design TWERL is not secured, this will be addressed later.
- Wade talked about the analyses done with Harris Thermal Transfer (Jim Nylander) on the heat exchanger as well as flow losses through the loop to match pump operating

characteristics. The flow loss will be managed by adjusting the spring-load on a choke mechanism prior to the test section.

- Wade talked about using a VFD to control the power profile in the heater to produce fast transient results. This suggestion was made by Jim Nylander. This will give a large range on temporal power profile (~1ms).
- Since the TWERL loop is temporarily on hold, the requirements on instrumentation for TRTL should be driven by the benchmark requirements. Additionally, it was agreed that both TWERL and TRTL will model an axially flat power profile on an 8" rod since this will simulate the hottest portion of the fuel.
- TRTL will use fast response pressure transducers (Looking into Validyne high pressure low, ΔP transducers) for fast detection of DNB in the test section.
- Mike suggested utilizing acoustic pressure transducers to determine bubble appearance and to characterize the boiling signal.

11.4 Emory Brown (OSU)

- Emory gave a presentation on the current status of the TRACE model of TWERL. At this time the TWERL is on hold while the TRTL design is completed. Further work will be modeling TRTL instead.
- Dan Wachs asked if Emory had a TRACE expert to talk to. None are available at OSU, however Dave said there are two people (Juan Carbajo and Chris Petrie) at ORNL that can be useful point of contacts.

11.5 Nic Woolstenhulme (RELAP5-3D)

- Nic gave a presentation on behalf of Colby Jenson for his progress on modeling the TWERL loop with RELAP5-3D. The main issue that was brought up was that you can't match the enthalpy rise, hydraulic diameter, and flow area all at the same time. His conclusion was that the CHF lookup table used in RELAP (and presumably all codes that utilize them) is incorrect, thus justifying the need to fill this data gap.

11.6 Christopher Lewis (Areva)

- Chris said that the ATF program (transient testing) will allow for utilities to lower the classification of safety grade equipment to provide economic benefits.

- Dan Wachs asked about future tests unrelated to the IRP for future industry benefits. Chris' response was the the best thing to do currently is to pepper DOE with questions related to this to push for more thought on the topic.

Day 2

12 TASK 1 STAKEHOLDER OUTCOMES (JOHN BESS)

- Jim Parry will likely have restart physics test plan in the next 6 months (desired by stakeholders to be reviewed). A questionnaire will be sent out to interested parties to determine what measurements are desired. Jim will be the final point of contact for all physics tests.
- It is to the facilities benefit to run physics experiments up until the first fuel experiment
- Boron content, H2 content, graphitization, hafnium content are all critical pieces of information that are holding up the IRP as well as future modeling of TREAT.

13 TASK 2 STAKEHOLDER OUTCOMES (NIC WOOLSTENHULME)

- On track and moving forward with task 2.1 due to availability of HOP 1-6A.
- Comparability between TWERL and TRTL will be beneficial in moving forward as design experience with TRTL will accelerate TWERL once funding is secured.

14 TASK 3 STAKEHOLDER OUTCOMES (COLBY JENSEN)

- Vertical access hole assembly as well as the coolant channels seem to be the best candidates for instrumentation locations.

15 FURTHER DISCUSSION

- TerraPower looking to be the first set of experiments put into TREAT. They would like to do static experiments at first and then move to a Mark IV flow loop test
- They are building sodium loops at their lab this summer and could potentially become a QA'd supplier of these loops for TREAT.

16 ACTIVITIES BEFORE OUR NEXT MEETING (WADE MARCUM)

- November 2-3 in Cambridge is the next meeting
- Annual report due October 30th 2016

Action Items

17 TASK 2.1

- Tommy: Solidworks model development of HOP 1-6A test section (2 - 4 weeks).
- Tommy: Setup video conference with David Pointer to talk to ORNL people about Nek5000.
- Tommy will develop CFD model to inform problem description report input requirements.
- Tommy will talk with Paul Fischer (Argonne) about obtaining the python script for wire wrapped fuel in bundles.
- Nic will get the ALIPs information for TerraPower.
- Nic will attempt to get the “Applied Technology” stamp removed from report.

18 TASK 2.2

- Start periodic conversation between Nic, Colby, Emory, and Wade.
- Wade is going to provide INL with high pressure, low ΔP pressure transducer product information.
- Emory: reach out to Dave Pointer and get some contacts to help with Trace modeling
- Wade: talk with AREVA about getting ATF cladding material for heater rods as well as techniques for determining CHF.
- Wade will circulate information regarding the minimum requirements for success on the benchmark so that all parties are informed.
- Continual notes on further design and fabrication of TRTL will be shared with Nic to reduce later complications with TWERL.