MECHANISMS ENGINEERING TEST LOOP (METL) FACILITY

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MECHANISMS ENGINEERING TEST LOOP (METL) FACILITY - OVERVIEW

- Mission and Objectives
- Overview and overall status
- Operations and Testing
- Cleaning of Components
- Summary
METL OPERATIONS AND RESEARCH TEAM

- Derek Kultgen – METL Manager
- Matt Weathered
- Teddy Kent
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- David Bell*
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METL Support

- Mike Hvasta
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- Eric Jin
- Roger Kellogg
- Bill Toter and Argonne Central Shops
- Lu Krajtl
- Dave Chojnowski
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- Tony Reavis
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MECHANISMS ENGINEERING TEST LOOP (METL) MISSION

- To test small or intermediate scale advanced liquid metal components and instrumentation in sodium:
  - Gear Test Assembly for Compact Refueling Machine – FR22 Paper 252
  - Thermal-Hydraulic Experimental Test Article (THETA) – FR22 Paper 238
  - Sodium Level sensor technology
  - Gripper Device for Compact refueling machine

- To develop and provide performance data on systems and components used in sodium and reduce the risk of failures during reactor plant operations

- METL consists of:
  - ~3,000 kg of reactor-grade sodium – purified via cold trapping
  - Two 18-inch (45.7cm) test vessels and two 28-inch (71.1cm) test vessels (Phase I)
  - Max system temperature = 1000°F (538°C) (except for 28-inch test vessels – 1200°F (649°C)
  - Test vessels can be isolated from main loop

- Provides much needed U.S. infrastructure (both personnel and hardware) to test liquid metal systems and components
METL

- Located at the Argonne site (1,500 acres) in B308
- Large highbay structure
- Historically used for liquid metal technology development
  - EBR-II steam generators were fabricated here
METL SYSTEMS AND COMPONENTS

- METL facility consists of:
  - Four Test Vessels (18 and 28 inch)
    - 18’s 304SS
    - 28’s 304H SS
  - Expansion Tank
    - 304 SS
  - Dump Tank
METL SYSTEMS AND COMPONENTS

- METL facility consists of:
  - Vapor traps
    - One for each vessel
  - Main Loop
    - Valving and interconnected piping
    - Main pump and flowmeter
    - 316/316L dual certified stainless
  - Purification System (cold trap)
    - Contains wire mesh
  - Plugging meter – with 2mm orifice
METL SYSTEMS AND COMPONENTS

- METL facility consists of:
  - Structural Mezzanine
  - Catchpan
  - R-grade sodium
  - Heat Tracing and insulation
    - Heat tracing is zoned
    - We adopted use of mineral wool and Pyrogel®
  - Heater and Valve control cabinets
  - Instrumentation and Control
METL TEST VESSEL – GENERIC FLOW

- Argon
- Pressure Transducer
- Vessel
- Supply
- Overflow
- Drain
- Return
- Vent to Vapor Trap
18-inch vessel - ~50 gals (189L)
28-inch vessel - ~150 gals (568L)
28-INCH TEST VESSEL
EXPERIMENT - EXAMPLE
METL – 3.5+ YEARS OF OPERATIONS AND TESTING

- 15 drums of sodium were transferred into the METL dump tank in April 2018
- METL has been operational since September 19, 2018 when the main loop was heated and filled with sodium
- METL has maintained its sodium in a molten state (either flowing or static) since September 19, 2018 until April 20, 2021 when we had to drain and freeze the facility to support work on the scrubber unit.
  - METL was operational for 943 days continuously
  - METL was restored to its operational status on November 16, 2021 after thawing and refilling the loop
- Multiple sodium flowing and purification campaigns were performed during initial 24/7 operations.
  - The METL team has confirmed the functionality of the sodium purification cold trapping system and has purified the METL sodium down to 5 ppm oxygen.
  - We have a convention plugging meter – with multiple 2mm holes
METL - OPERATIONS AND TESTING

- Our first testing campaign was with the Gear Test Assembly.

- The METL team qualified for insertion into METL the first test article – a gear test assembly for insertion into METL.

- The first test article – Gear Test Assembly – was inserted into Test Vessel #1 on 12/11/2018.
  - The Gear Test Assembly has undergone 4 testing campaigns and is currently being disassembled after its 4th test.
  - IAEA FR22 Paper #252 - Gear test assembly: first liquid metal component testing in the mechanisms Engineering Test Loop.
In order to remove a test article from METL test vessel without introducing a lot of contaminants – we use what we call a Flexicask

- The Flexicask underwent testing and refinement to include a clear inert enclosure with gloveports for easier accessibility to removed test articles.
- The flexicask mates with the vessel support ring and forms a seal.
- We provide argon gas to the system and get the oxygen level down to 100ppm or less in order to keep the vessel clean of contaminants.
- When a test article is extracted into the flexicask – two sliding gates are shut. The two gates are de-coupled. One gate goes with the test article and one gate stays with the vessel maintaining the inert atmosphere.
- For vessel insertion – the task is just performed in the opposite manner.
METL – TEST ARTICLE CLEANING

- Test article removed from a METL test vessel contains residual sodium which must be removed.
- METL Team uses a moist carbon dioxide reaction system for reaction of residual sodium from METL test articles.
  \[ 2\text{Na} + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2 \]
- The first extraction using the flexicask was from Test Vessel 1 (GTA extraction from Test Vessel 1)
- GTA was transferred from Test Vessel 1 to the Carbonation Reaction Tank.
- GTA was the first test article to be cleaned using the carbonation process
  - We found that there is compaction of the sodium bicarbonate between components in the test article which may subsequent disassembly an issue
  - So, we react the residual sodium for about a week and then start the disassembly process using alcohol and water in a cleaning bath
METL OPERATIONS AND TESTING

- A second experiment was developed – the Thermal Hydraulic Experimental Test Article (THETA)
- It is a different type of experiment – TH experiment
- THETA was installed into METL 28” Vessel #4
- THETA Test Vessel was filled with sodium week of Nov 16, 2021
- THETA has been successfully operating since insertion.
  - Has been operating independently of the other experiments in METL
- FR22 Paper #238 - Overview of a Sodium Fast Reactor Thermal Hydraulic Test Facility
METL OPERATIONS AND TESTING - SUMMARY

- METL has had a successful operational history for over 3.5 years
  - Including a drain and freeze for a 6-month outage followed by a thaw and refill
- We have developed and tested both component-type and TH-type experiments
- Next test articles are a full-scale gripper test article (GrTA) and a flow sensor test article (F-STAr) (both in fabrication)
- It is a multipurpose facility for testing components and instrumentation
- Please visit our web site: https://www.anl.gov/nse/mechanisms-engineering-test-loop-facility
THANK YOU FOR YOUR ATTENTION!
QUESTIONS?