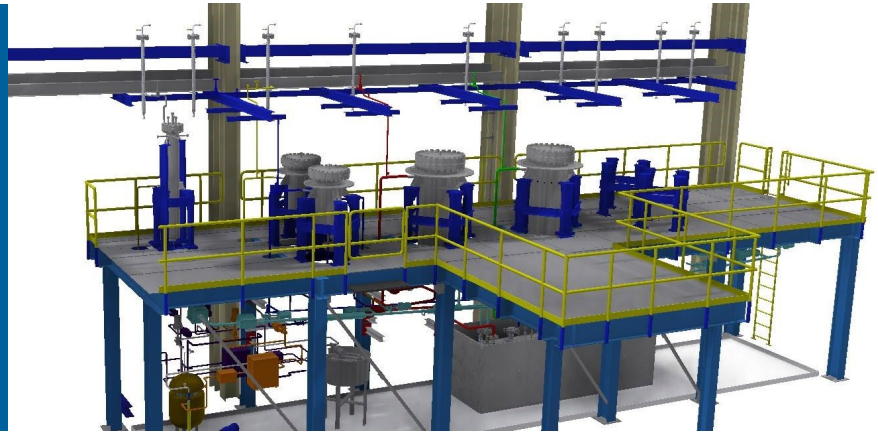
IAEA FR22 INTERNATIONAL CONFERENCE ON FAST REACTOR AND RELATED FUEL CYCLES

Argonne NATIONAL LABORATORY

MECHANISMS ENGINEERING TEST LOOP (METL) FACILITY



CHRISTOPHER GRANDY
Program Manager, Advanced Technology Development

DEREK KULTGEN
TEDDY KENT
MATTHEW WEATHERED
JORDAN REIN
HENRY BELCH

April 20, 2022
Argonne National Laboratory

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
- Jordan Rein
- Danny Andujar
- Dzmitry Harbaruk*
- David Bell*
- Henry Belch*

METL Support

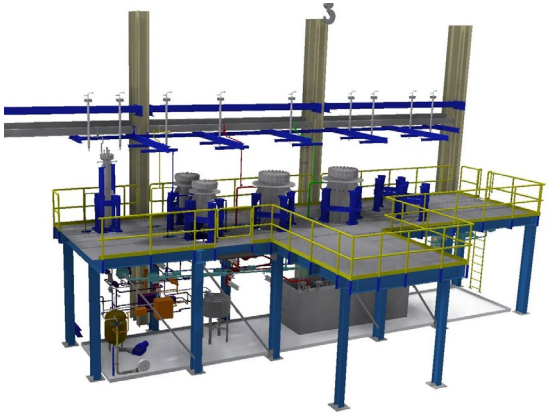
- Mike Hvasta
- Andrew Borowski
- Eric Jin
- Roger Kellogg
- Bill Toter and Argonne Central Shops
- Lu Krajtl
- Dave Chojnowski
- Yoichi Momozaki
- Tony Reavis
- Various other folks have supported METL

Special thanks goes to DOE sponsors:

- Alice Caponiti
- Janelle Eddins
- Brian Robinson
- Tom Sowinski

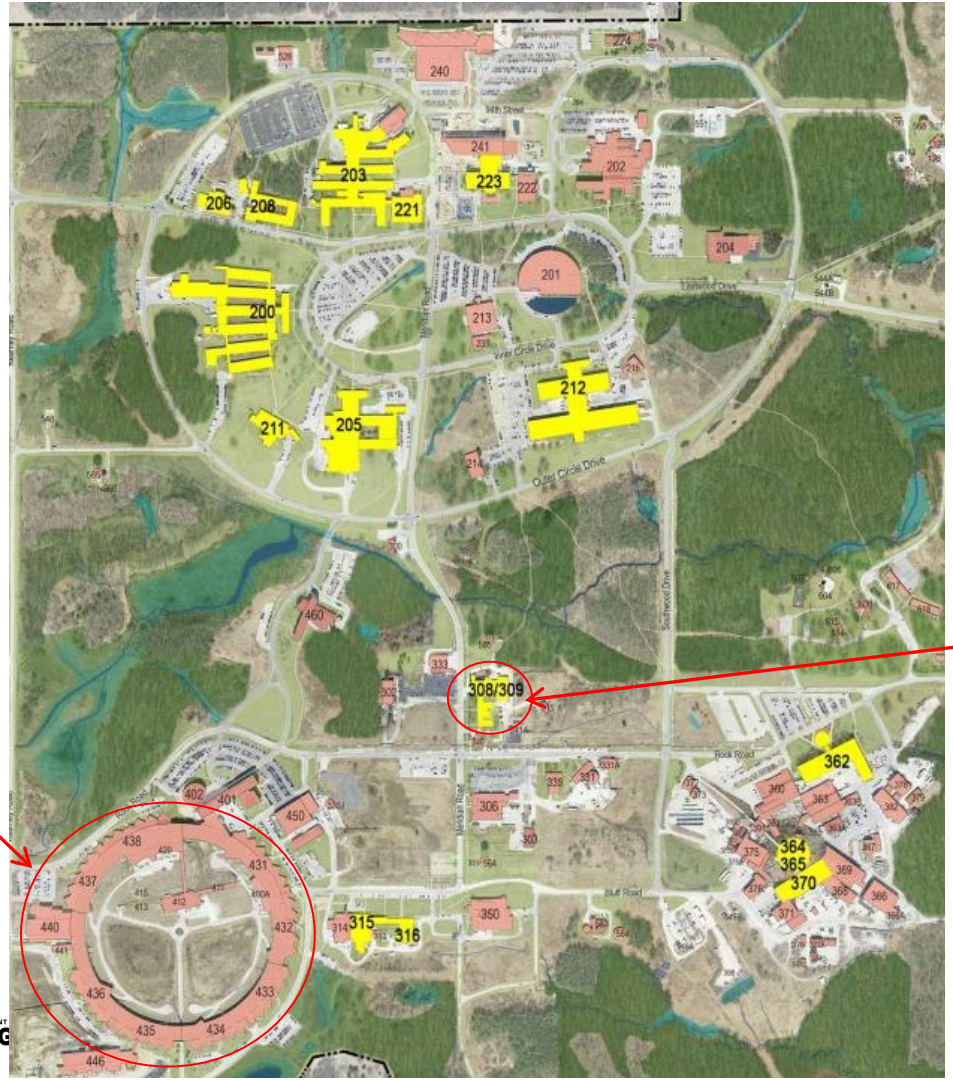
MECHANISMS ENGINEERING TEST LOOP (METL) MISSION

- **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**



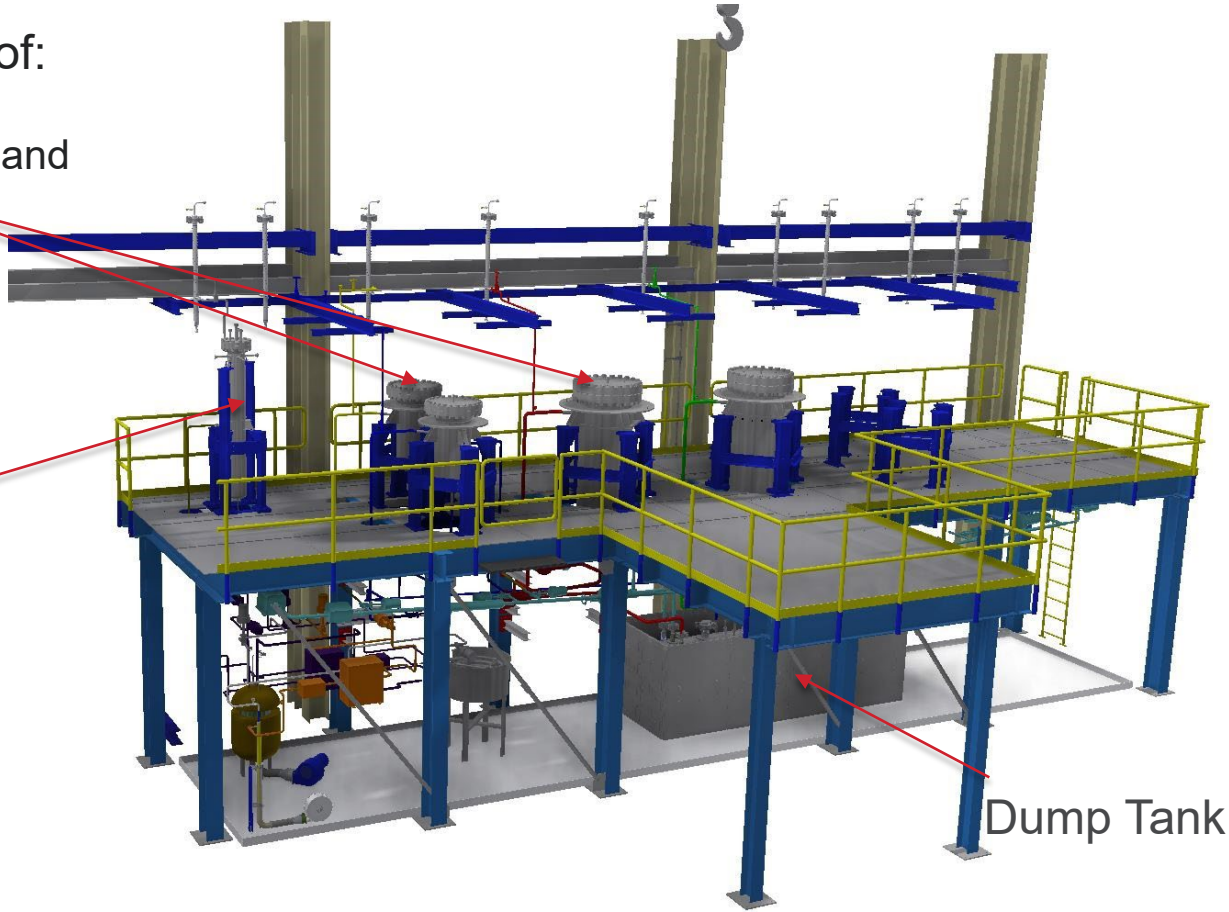
METL

- 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



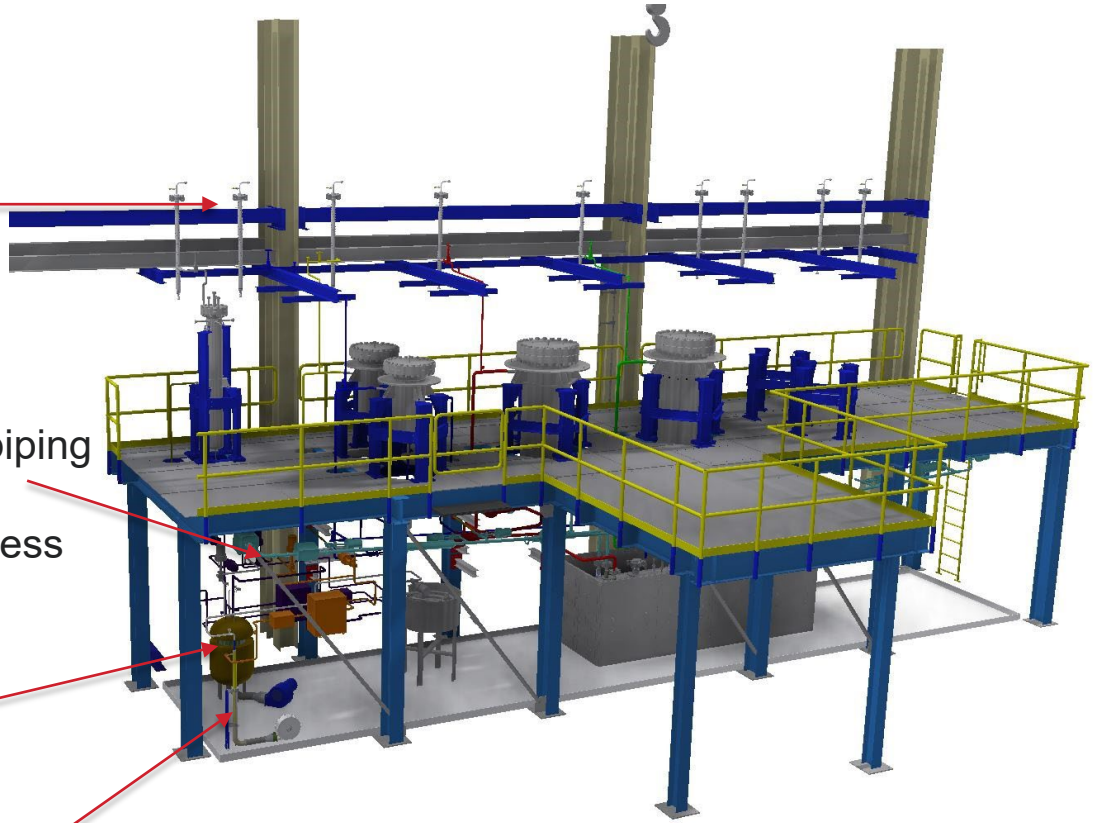
METL SYSTEMS AND COMPONENTS

- METL facility consists of:
  - Four Test Vessels (18 and 28 inch)
    - 18's 304SS
    - 28's 304H SS
  - Expansion Tank
    - 304 SS



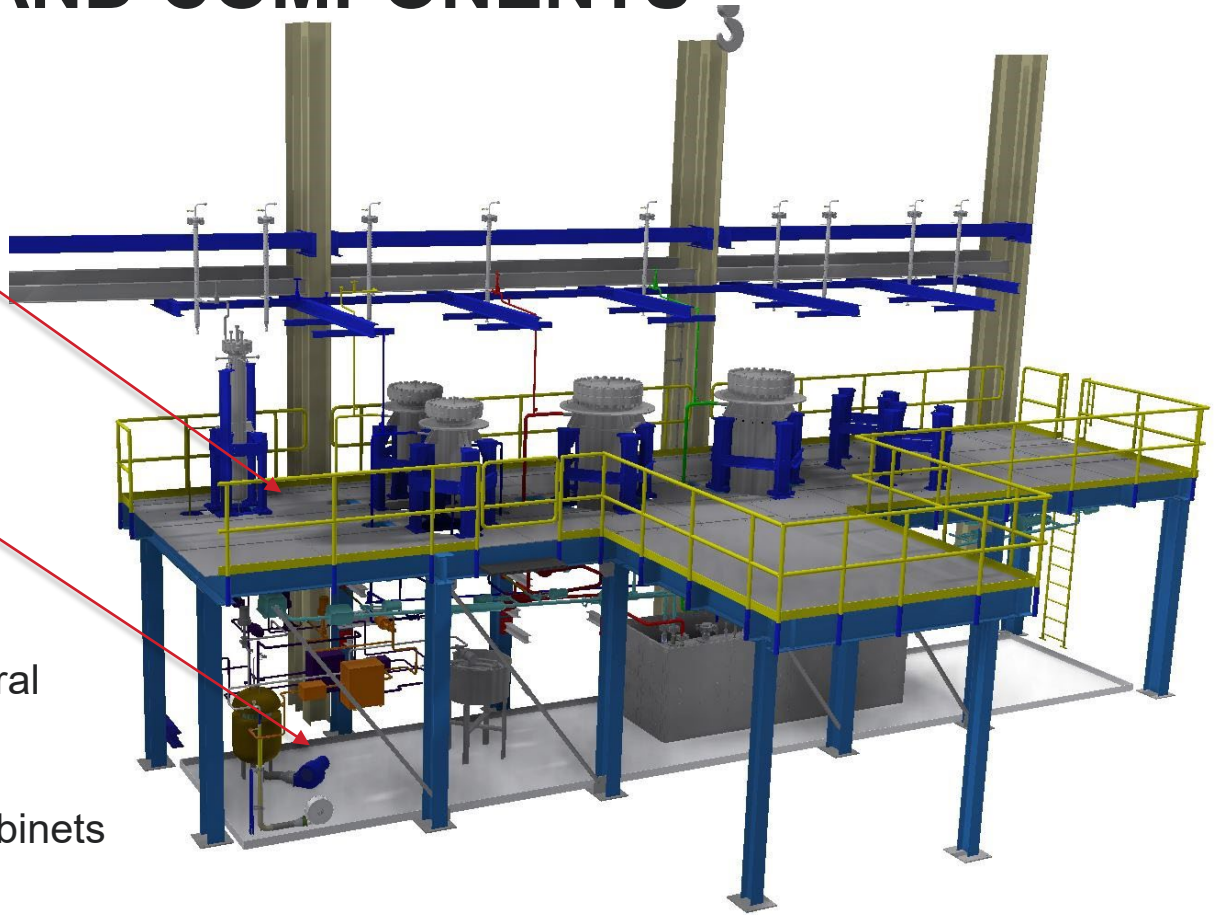
METL SYSTEMS AND COMPONENTS

- 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

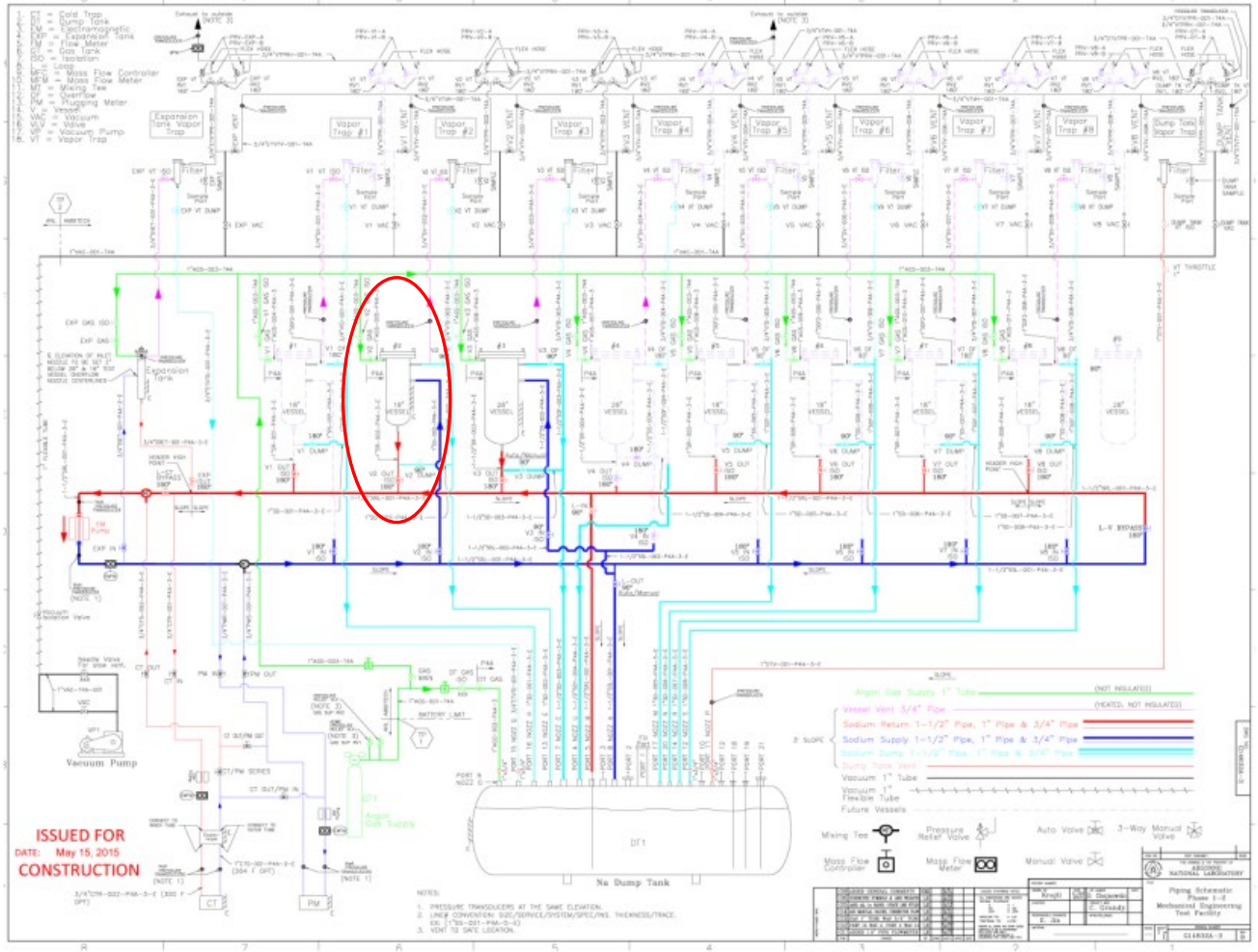


METL SYSTEMS AND COMPONENTS

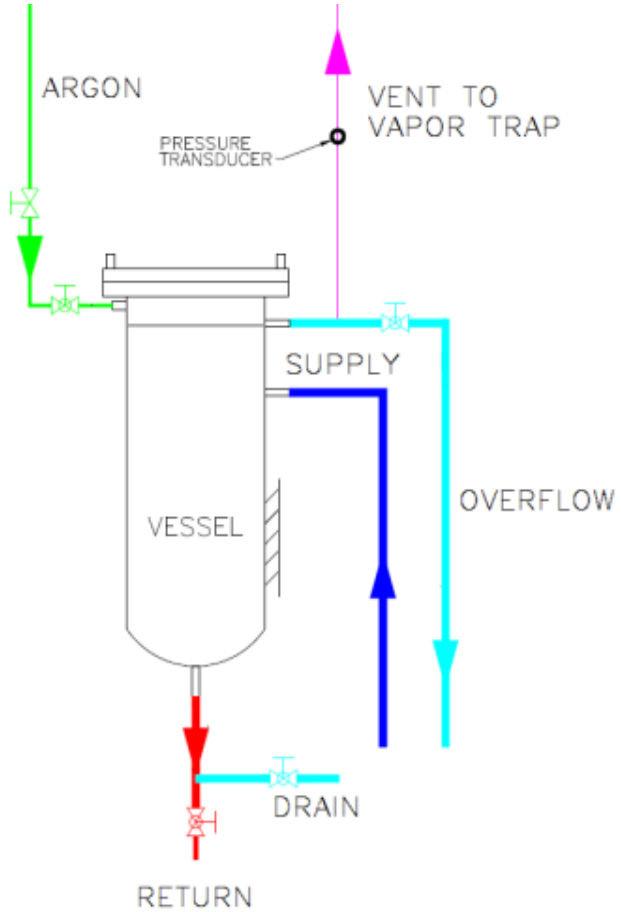
- METL facility consists of:
  - Structural Mezzanine
  - Catchpan
  - R-grade sodium
  - Heat Tracing and insulation
    - Heat tracing is zoned
    - We adopted use of mineral wool and Pyrogel®
  - Heater and Valve control cabinets
  - Instrumentation and Control



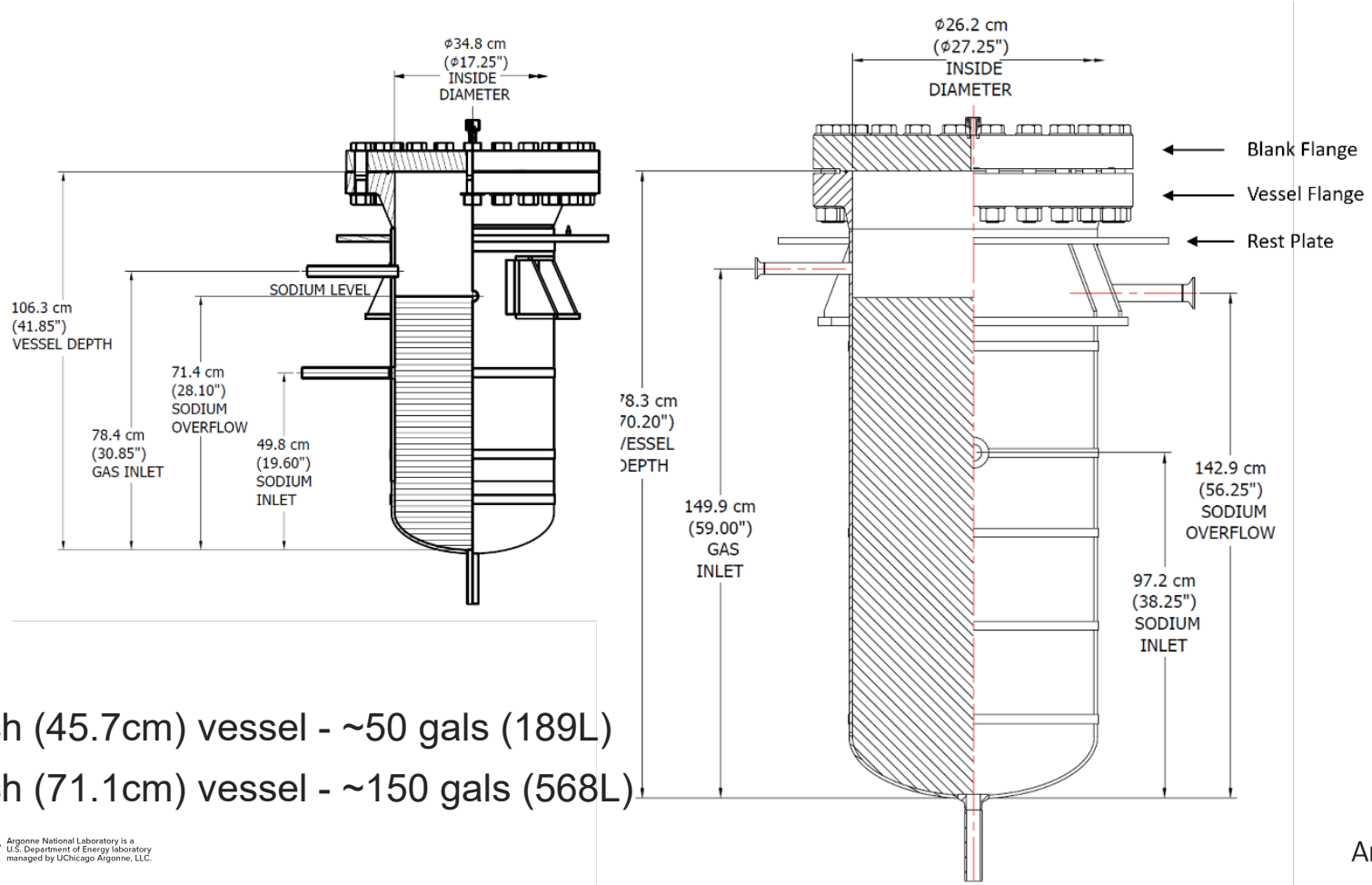
METL P&ID



METL TEST VESSEL – GENERIC FLOW



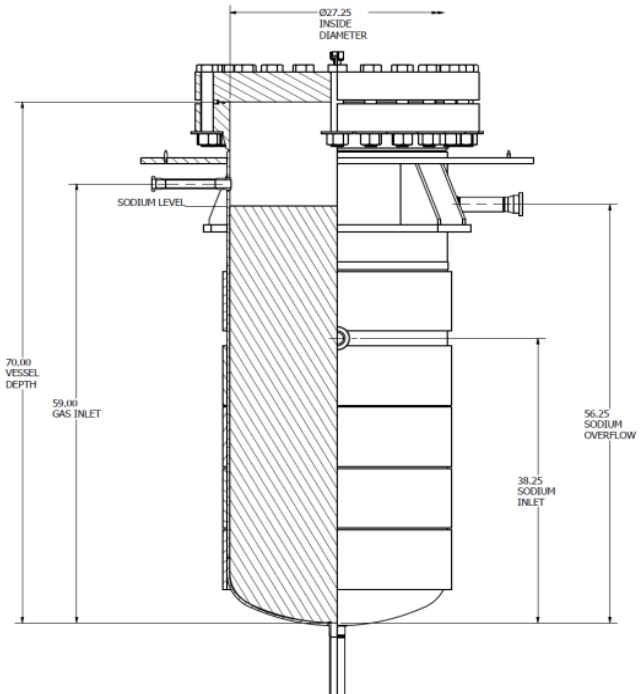
18-INCH VESSEL + 28-INCH VESSEL

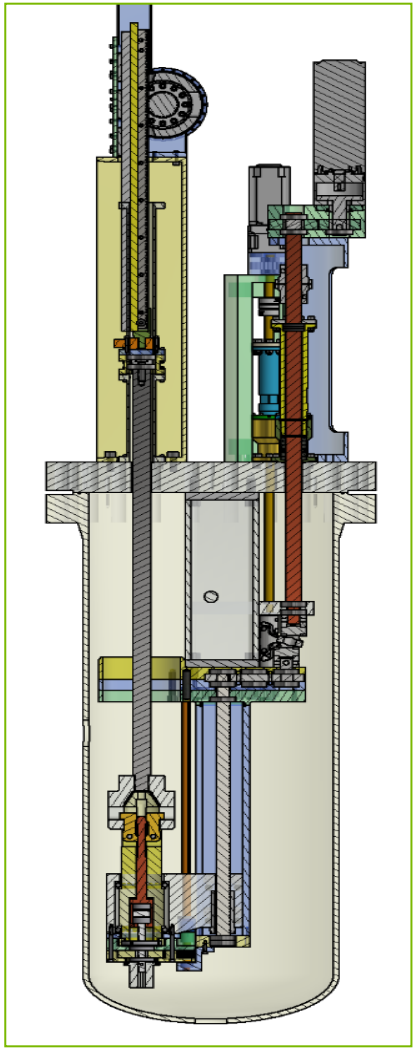


18-inch (45.7cm) vessel - ~50 gals (189L)

28-inch (71.1cm) vessel - ~150 gals (568L)

28-INCH TEST VESSEL EXPERIMENT - EXAMPLE





METL – 3.5+ YEARS OF OPERATIONS AND TESTING

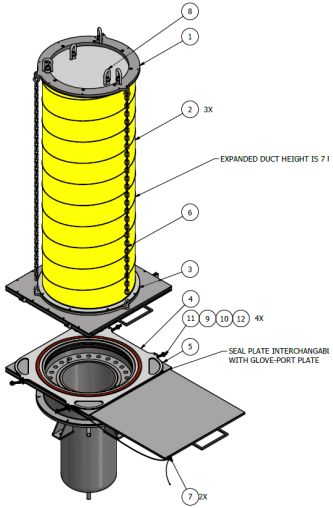
- 15 drums of sodium were transferred into the METL dump tank in April 2018
- METL has been operational since September 19, 2018 when the main loop was heated and filled with sodium
- METL has maintained its sodium in a molten state (either flowing or static) since September 19, 2018 until April 20, 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

METL - OPERATIONS AND TESTING

- 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.



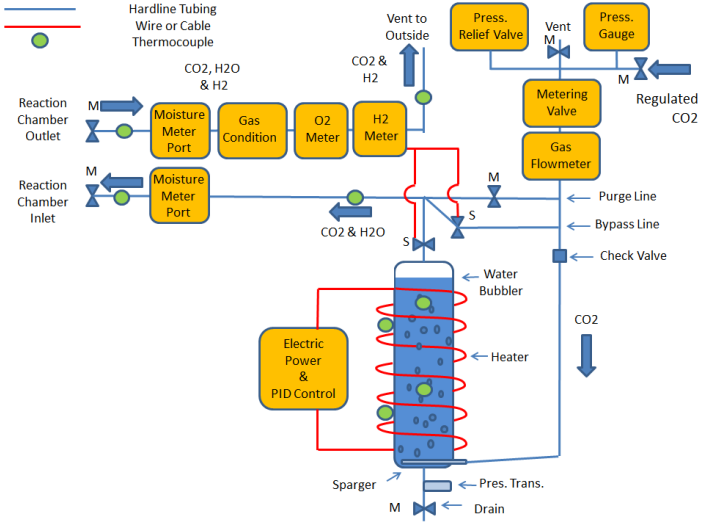
Original Flexicask

Flexicask – sliding gates together – vessel flange extracted into the glovebag

Flexicask – separation of sliding gates from vessel

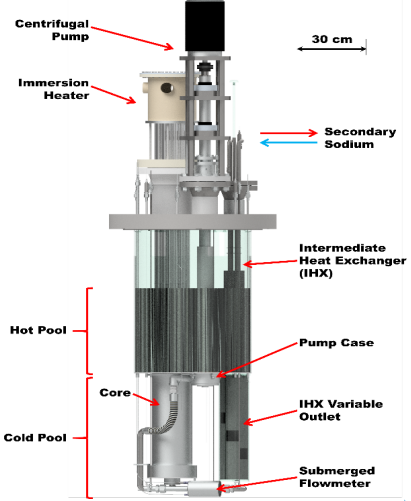
METL – TEST ARTICLE CLEANING

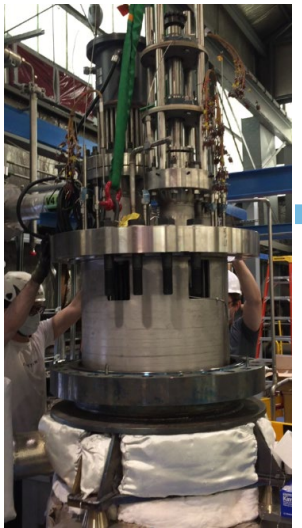
- Test article removed from a METL test vessel contains residual sodium which must be removed.
- METL Team uses a moist carbon dioxide reaction system for reaction of residual sodium from METL test articles.
  - $2\,Na + \ CO_2 + H_2O \ \rightarrow \ Na_2CO_3 + H_2$
- The first extraction using the flexicask 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

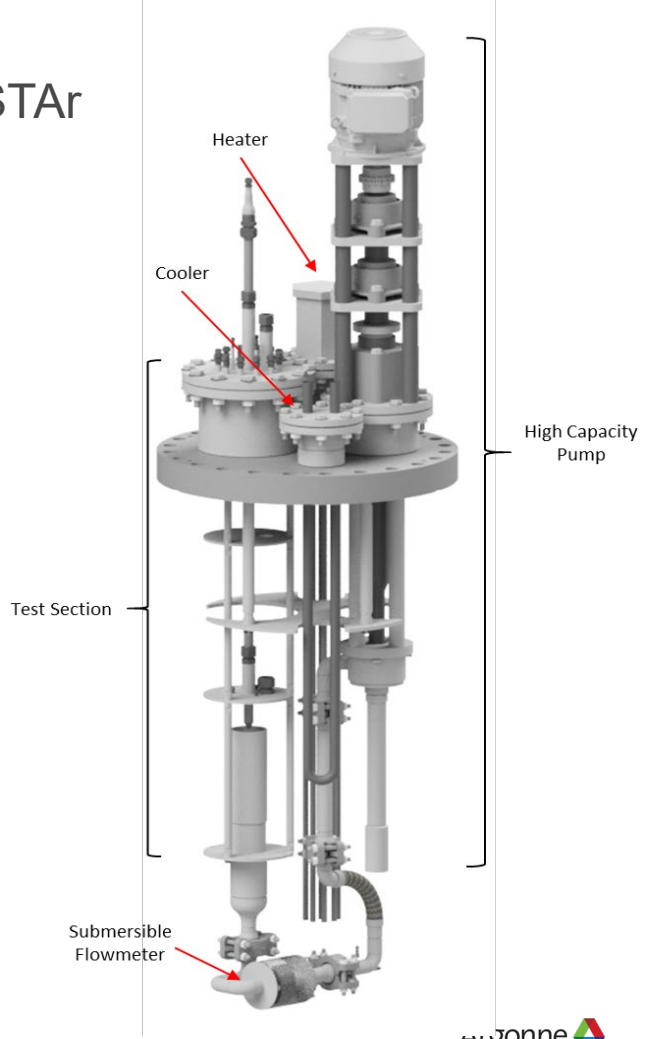




METL OPERATIONS AND TESTING - SUMMARY

- 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

F-STAr



THANK YOU FOR YOUR ATTENTION!

QUESTIONS?