

Office of **NUCLEAR ENERGY**



Advanced Sensors and Instrumentation

METL Sensor Test

Advanced Sensors and Instrumentation (ASI) Annual Program Webinar November 4, 6-7, 2024

Rick Vilim Argonne National Laboratory

Project Overview

- Objective Review and identify sensor qualification needs of liquid metal reactor (LMR) developers in terms of the environmental conditions sought for testing.
- Approach
 - Consulted existing literature to determine state of the ART and gaps
 - ANL report that surveyed LMR needs
 - INL report that identified sensors under development
 - Identified upgrades to ANL TAPS facility that address identified gaps in capabilities for LMR sensor qualification
 - Evaluated thermal stresses associated with performing qualification tests in an upgraded TAPS facility



Birds-Eye View of ANL TAPS Facility

Project Overview – Sensor Qualification in TAPS

- Qualifying a sensor involves performing calibration and test procedures to ensure that the sensor meets standards or specifications.
- Ensures that the sensor is suitable for its intended application and provides accurate and reliable data.
- TAPS can provide the thermal and hydraulic conditions needed for qualifying sensors in a liquid metal environment



P&ID of ANL TAPS Facility

Project Overview

Schedule

• Oct 2023 – July 2024

Deliverable

Design and Evaluation of TAPS Modifications for Sensor Qualification – July 2024

Participants - ANL

Alex Heifetz

Taeseung Lee

- Sasan Bakhtiari
 Review of sensor literature
- Bill Lawrence Characterization of TAPS facility
 - Conceptualization of TAPS upgrade
 - Thermal stress analysis calculations

Participants – Purdue University (PhD student)

Charie Tsoukalas Data organization and report writing

Technology Impact

- Surveyed and established the needs of liquid metal reactor (LMR) developers in the U.S.
- Identified the need for qualification of non-submerged flowrate sensors
- Established the feasibility of upgrading the TAPS facility for non-submerged sensors
- Developed an approach to high temperature qualification where a vendor would drop in their sensor mounted in a test article
- Performed stress analysis calculations to verify acceptable service life of the TAPS facility for use in qualification testing

Identified test conditions achievable at ANL across the two applicable facilities (Task 2 Feb – Mar 2024)

Table Operating conditions for SFR, LFR and ANL test facilities

	Reactor Conditions		ANL Test Facility Conditions		
	SFR	LFR	METL	TAPS - Na	
Sensor form factor			Submerged	Submerged	
Temperature (°C)	450-530	500-600	650	350	
Pressure (atm)	~1	~1	~1	~1	
Max. Flowrate	180 gpm		20 gpm	20 <u>gpm</u>	

 Intent is to extend TAPS-Na for testing non-submerged sensors at temperatures up to 650 °C Identified Industry Sensor Qualification Needs (Task 3 Apr – Jul 2024)

Table First-Hand Expressed Need for Sensor Qualification

	Advanced Reactor Developer *		DOE NE Lab		Total
	Conceptual AR	Facility	Conceptual AR	Facility	
	Design		Design		
Mass Flow.	3			2	5
Pressure		1		1	2
Temperature	1				1
Level	1				1
Neutron Flux			1		1
Species Conc.	1				1

* KAIROS, TerraPower, Oklo, Westinghouse

Test article approach for qualification testing of external nonsubmerged sensors (Task 3 Apr – Jul 2024)



TAPS facility vessel head

- Need to have a minimum 1-2 inch pipe flange to accept vendors test article containing a sensor
- Inlet pipe shown in white with black border has ¼ in.
- Possibly need to modify inlet pipe to larger diameter and add bigger capacity pump. But it is welded to vessel so maybe go with diameter reduction when transition from upstream pump to inlet pipe?



Figure 6-1. Modifications with new piping and test section.

Hardware modifications to achieve 600 °C operating conditions (Task 3 Apr – Jul 2024)

- Modify TAPS vessel to accept piping associated with flanged test-article section
- Upgrade insulation and strip electrical heaters



TAPS facility with exposed pipes and with heater tape and insulation

Thermal stress analysis (Task 3 Apr – Jul 2024)

- COMSOL Multiphysics was used to calculate
 - Thermal expansion of the TAPS vessel and test article
 - Thermal stress of the structure for the structural boundary condition set by the user
- Top left: Non-restrained system shows minimal stress. That is the actual system
- Right side: Rigid piping restraint stresses are consistent with expected results. More a test of CONSOL problem solution. Piping is not rigid.



Figure 7-3. Graphical representation of Von Mises stress of TAPS vessel and test article at operating conditions in (a) Case #1, (b) Case #2 and (c) Case #3.

Sensor calibration test procedure and siting of Coriolis flow meter in facility (Task 3 Apr – Jul 2024)

 A large pipe run exists in the main flow channel and could be used to admit a Coriolis flowmeter



Concluding Remarks

- Designed upgrades to ANL TAPS facility that address identified gaps in capabilities for LMR sensor qualification
- Developed an approach to testing qualification whereby a reactor vendor drop-flanges in their test article
- Evaluated thermal stresses associated with performing qualification tests and found them to be acceptable
- Identified the need for a Coriolis flowmeter to be installed in TAPS to properly calibrate tests



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Thank You

Rick Vilim

Plant Analysis, Control and Sensors Department Nuclear Science and Engineering Division, ANL <u>rvilim@nse.anl.gov</u> W (630)-252-6998 <u>https://www.anl.gov/profile/richard-b-vilim</u>