INL/MIS-24-77512-Revision-0

# 01-07 Reactor Supplemental Shielding For the NRIC DOME Test Bed 01-07 Reactor Supplemental Shielding For the NRIC DOME Test Bed 2

April 2024

Kyle Reno, Chance Price

Changing the World's Energy Future

Idaho National Laboratory

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**April 2024**

**Idaho National Laboratory**
**Idaho Falls, Idaho 83415**

**http://www.inl.gov**

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# Reactor Supplemental Shielding For the NRIC DOME Test Bed

ENERCON Presentation

Executive Summary

Tuesday, 2/13/2024

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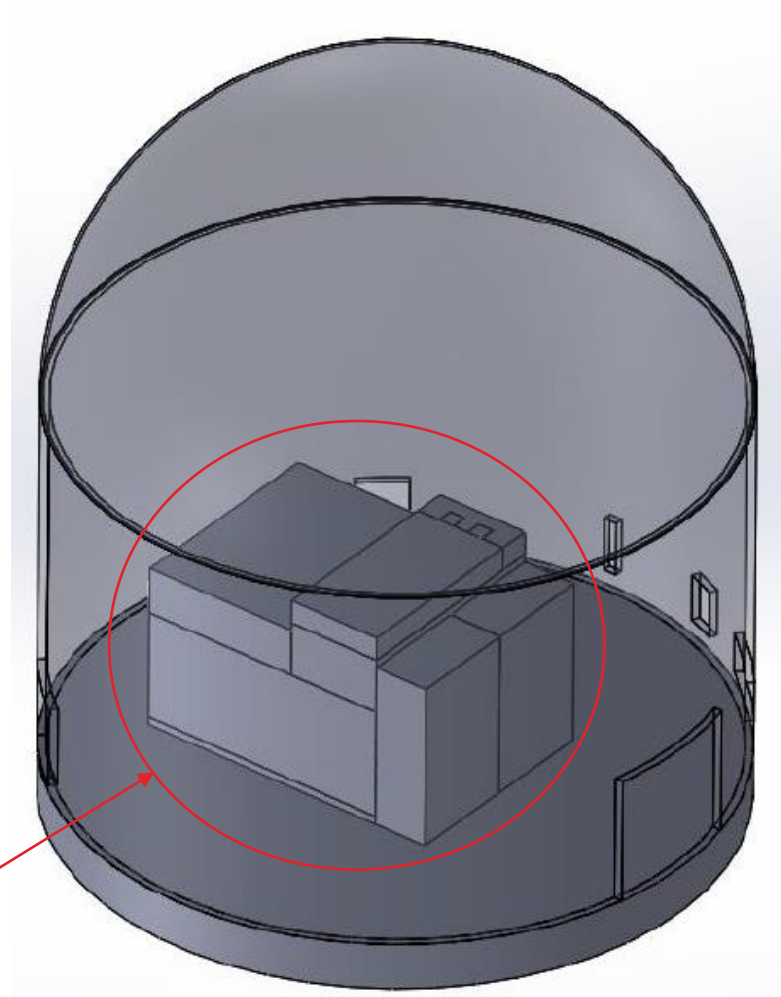
# Agenda

- Objective
- Reactor Supplemental Shielding Design
  - Shielding Requirements
  - Layout
  - Materials
  - Thermal Analysis
- Open Discussion

# Objective

Provide an overview of the reactor supplemental shielding being developed for the DOME test bed.

The RSS provides the radiation shielding necessary to keep dose requirements within limits when the test reactors are at full power as well as after shutdown conditions.

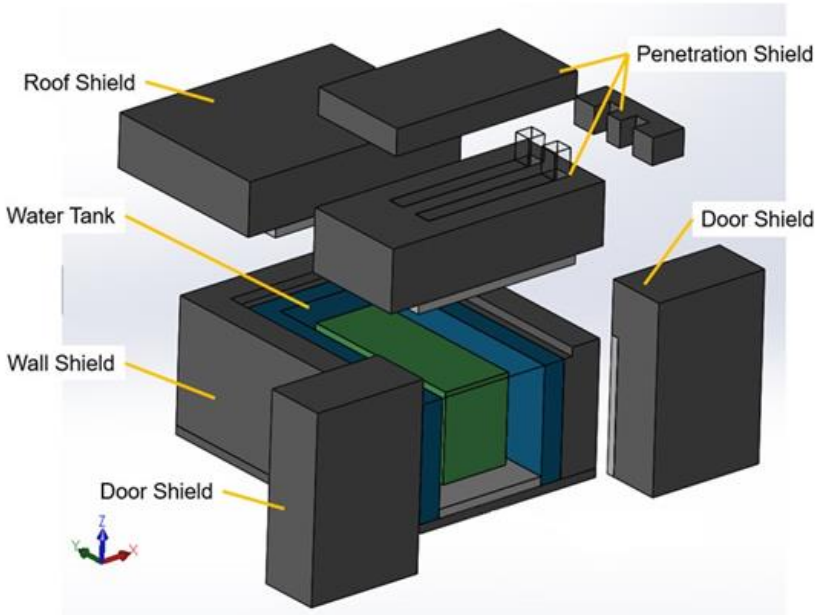


The RSS within the EBR-II containment

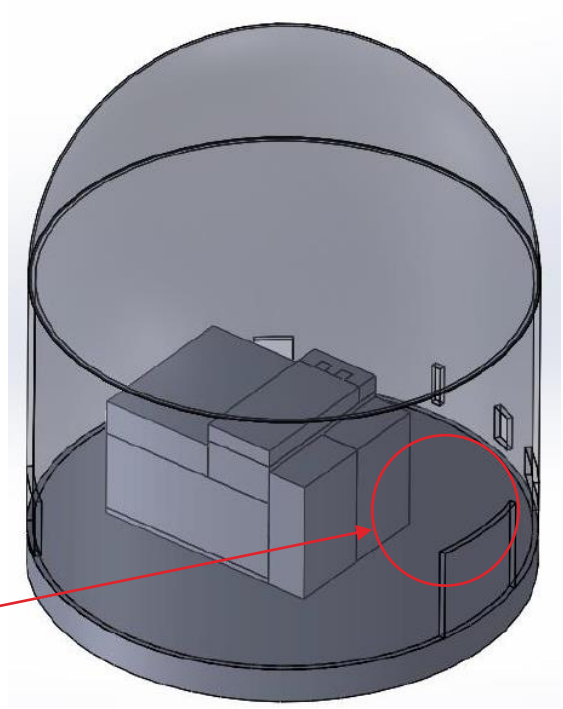
# Shielding Design

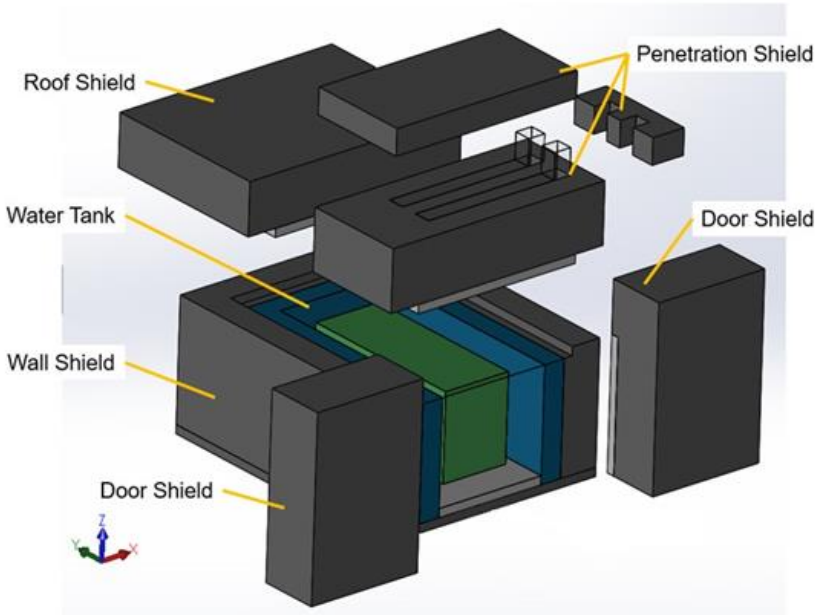
Shielding keeps dose below these levels:

- 0.05 mrem/hr 50’ from exterior wall of DOME
- 5 mrem/hr at the exterior wall when operating
- 30 cm from components 90-days post shutdown 0.5 mrem/hr outside the shield and 5 mrem/hr inside the shielding enclosure
- ~7’ thick concrete or 4.5’ concrete + 2.5’ of water is needed to keep radiation levels within the above limits.



# RSS Layout




Equipment Entry/Removal Point

Modularized RSS Design to Facilitate Installation and Removal within the DOME

Space for reactor to be located within RSS

# RSS Materials

Various materials have been considered for use in shielding the reactor. In addition to the shielding capability, the following characteristics are considered

- Activation (will the materials become radioactive after exposure to radiation)
  - Activation drove the selection of aluminum over steel for the water tank
- Cost
  - Concrete is an excellent radiation shield and relatively low-cost material, so it has been used heavily for the shield design
- Weight/Space Limitations
  - These factors have been able to be accommodated without requiring the use of more exotic, expensive materials

# Thermal Design/RSS Cooling

The RSS is designed to accommodate developer microreactors that output ~10 MW of thermal power during normal, full-power operation.

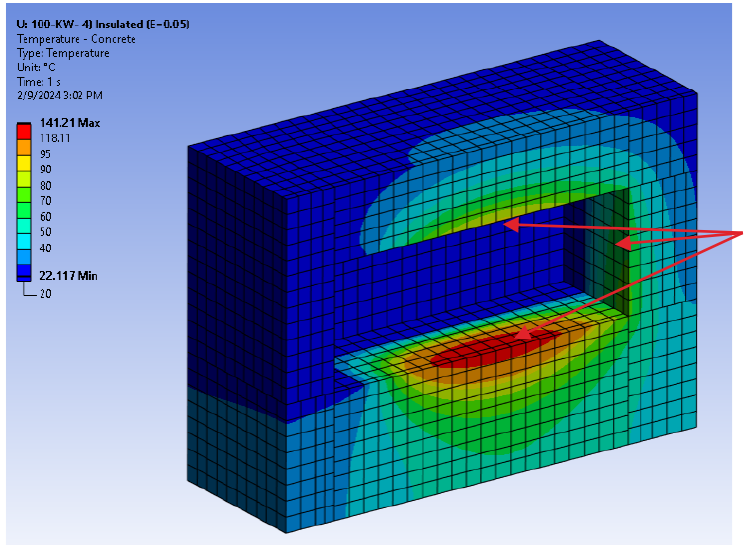
Normal Operation:

- 99% of the heat is removed by the primary fluid during normal operation
- The remaining heat (1% or up to 100 kW) is removed by active cooling of the water tank through a chilled water system.

Post-accident/Shutdown:

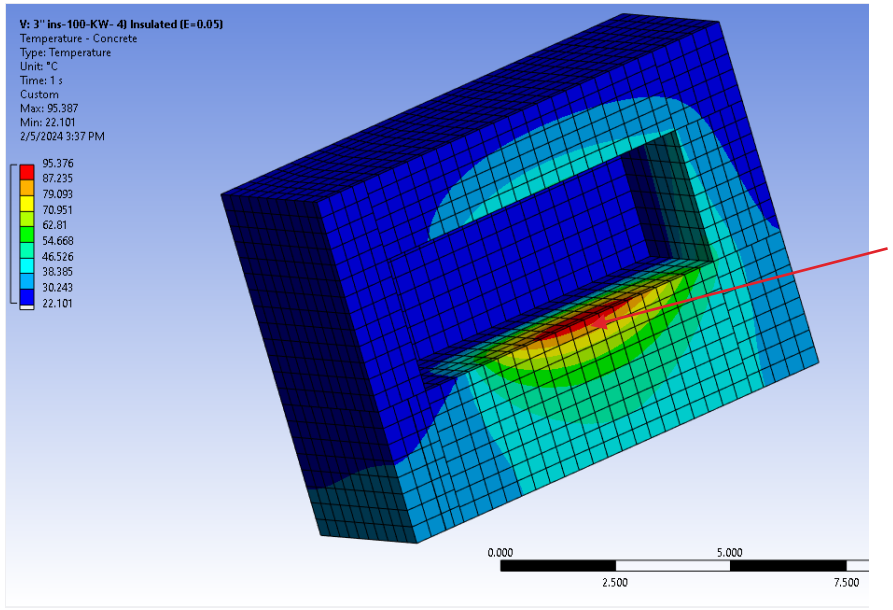
- If active cooling systems are lost, the RSS must accommodate the decay heat coming from the reactor for a period of three days. This decay heat is initially ~7% of the reactor power (up to ~700 kW) and must be passively cooled.
- The water tank is sized to hold enough thermal mass for the three-day accident period to protect the surrounding materials from exceeding their temperature limits.

# Thermal Design/RSS Cooling




Reflective insulation added on floor, door, and roof

Steady-state concrete temperatures from conceptual design




Steady-state concrete temperatures from preliminary design

Aluminum plates added under insulation on floor to help spread heat toward the water tank away from floor. These resolved the overtemperature issue on floor concrete and brought max concrete temperature <100C

The goal of the thermal design of the RSS is to protect materials from experiencing temperature above their limit.

# Summary

- The DOME test best will enable developers to gain valuable operating time and test data on their designs at reduced cost and using the world-class capabilities of the US National Lab System.
- Three microreactors are currently planned to be tested at DOME.
  - Radiant (Kaleidos)
  - Ultra Safe Nuclear Corporation (Pylon)
  - Westinghouse (eVinci)
  - We expect a lot more over the course of 30-40 year life of DOME
- DOME RSS Preliminary Design Efforts are underway!

# Q & A

- Questions/Open Discussion