U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Task 2 Desired Stakeholder Outcomes

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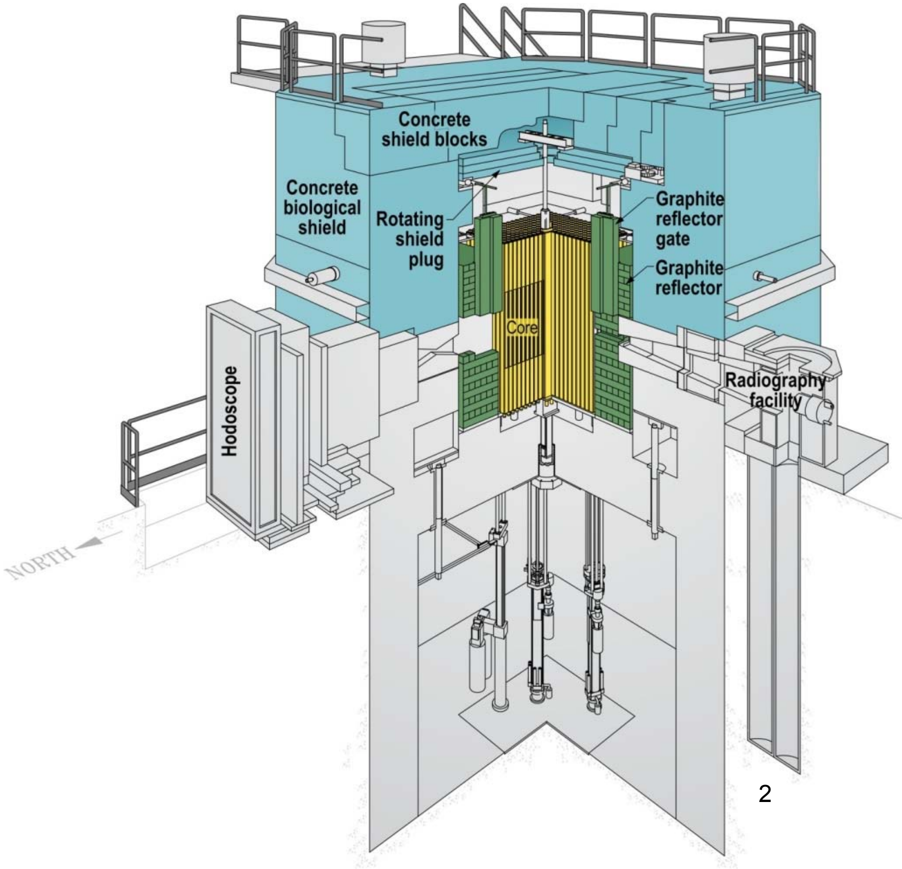
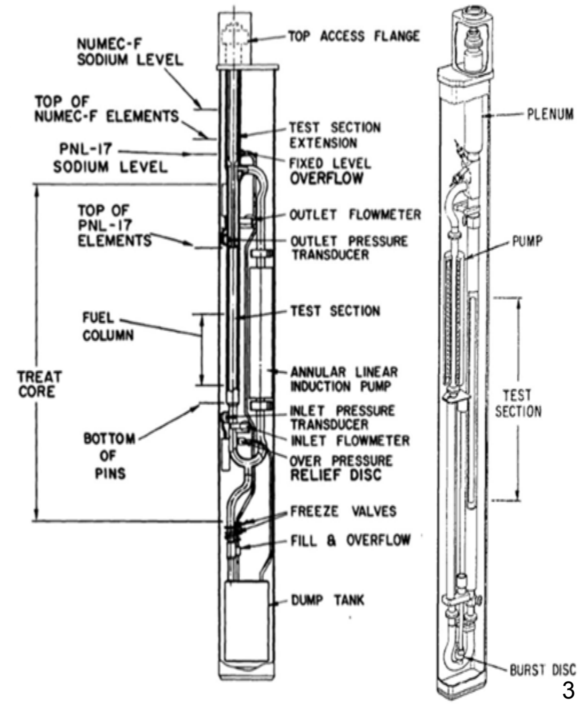
Background

- **Development of advanced nuclear fuels will require nuclear transient testing**
- **Resumption of operations at the Transient Reactor Test facility (TREAT) at the Idaho National Laboratory is planned for this testing**
- **TREAT is a dry reactor**
  - Driver fuel: Zircaloy-canned blocks of urania dispersed in graphite
  - Test assemblies handled in shielded cask
- **Tests typically displace driver fuel assemblies to create experiment cavity**
  - Each fuel assembly is 10cm × 10cm in cross section
  - 122cm of active core length
- **4 slots with view of core center, 2 in use**
  - Fast Neutron Hodoscope
  - Neutron Radiograph



Background

- **TREAT is well suited to self-contained drop-in test devices**
  - Installation, testing, and withdrawal in a matter of days
  - Enables support for different-environment test devices (e.g. water or sodium)
  - Assembly and disassembly in shielded hot cells
  - Test device geometry limited by core volume and shielded handling casks
    - *Loop handling cask 25cm diameter X 387cm long*
- **TREAT's historic testing focused on sodium-cooled fast breeder reactor specimens**
  - Highly successful with package-type sodium loops
  - Piping primary containment, sheet metal leak-tight secondary enclosure
  - Pumps, heaters, instrumentation, all contained within enclosure
- **Similar package-type devices are envisioned for future testing**
  - Water, steam, inert gas, sodium in "static capsules"
  - Recirculating water loops
  - Recirculating sodium loops

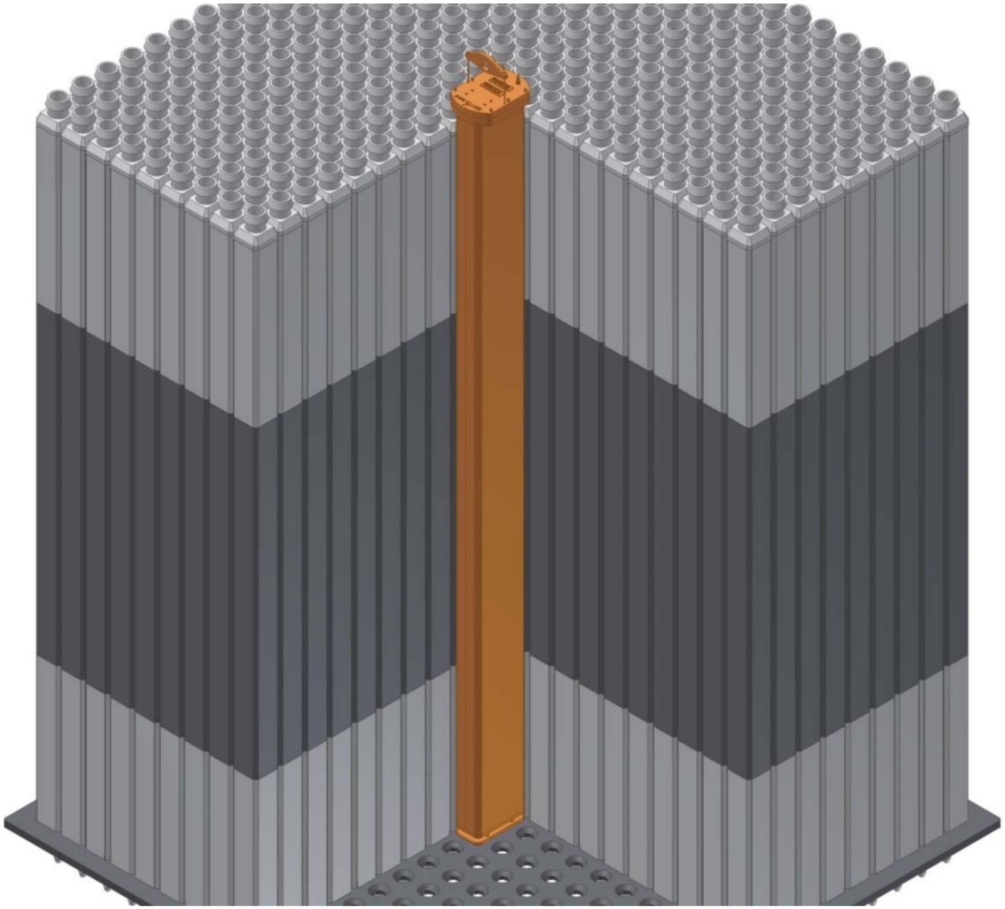


Historic Mk-series Sodium Loop

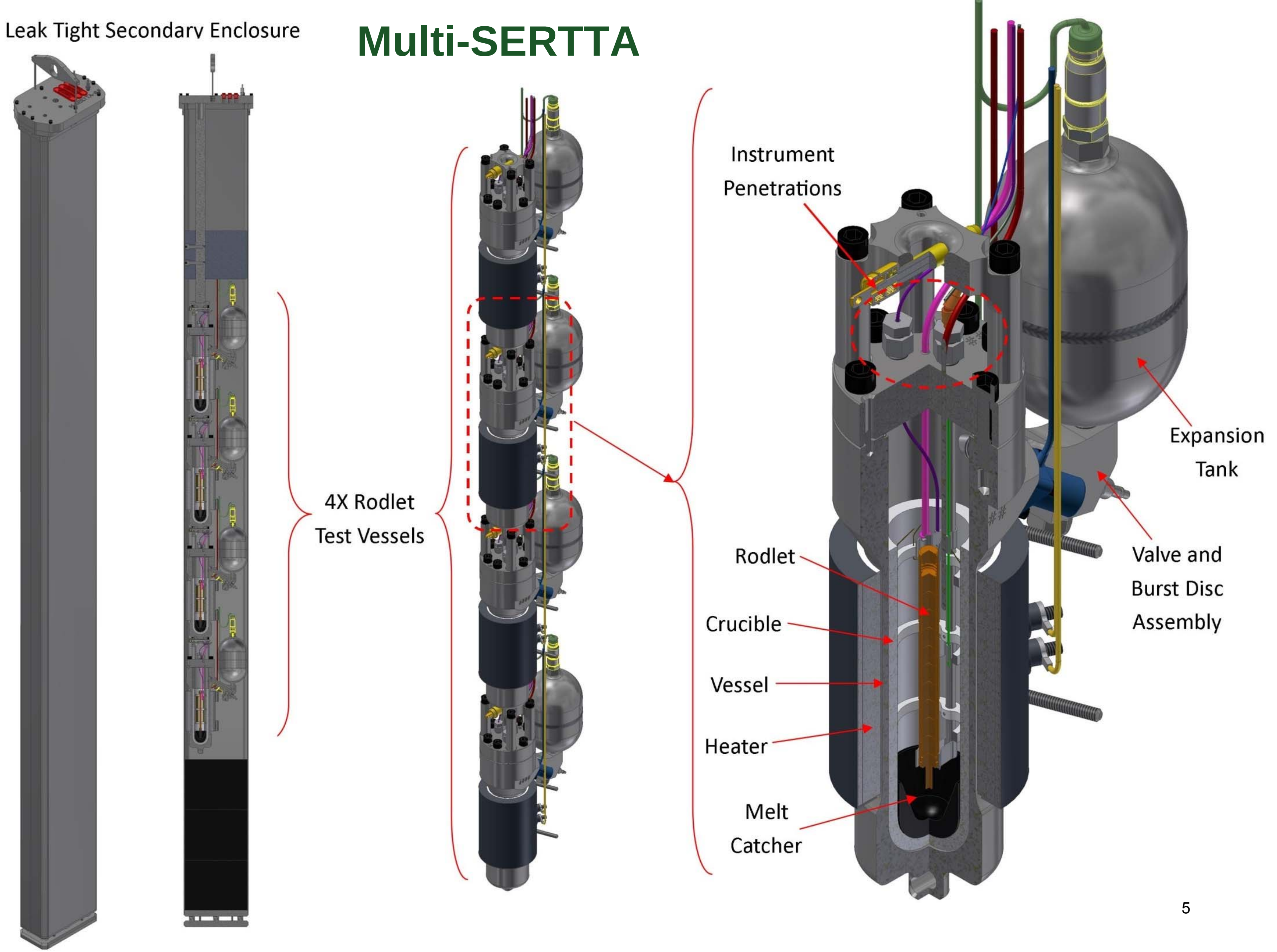
Static Environment Vessel

Static Environment Rodlet Transient Test Apparatus (SERTTA)

- **General purpose device <u>without</u> forced convection**
- **Pre-pressurized and electrically heated**
  - Liquid water up to PWR condition (320C 16 MPa)
  - Inert gas or steam
  - Liquid sodium capability envisioned
- **Vessels designed with tremendous safety margin**
- **Several SERRTA "modules"**
  - Multi-SERTTA for 4X rodlets
  - Super-SERTTA for full length rods (48")
  - LOCA-SERTTA to be developed



Multi-SERTTA

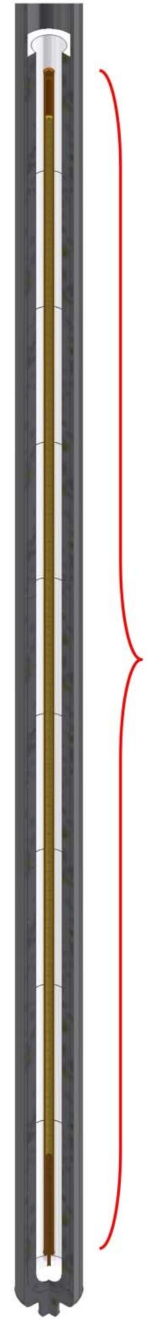


Super-SERTTA

(preliminary concept only)

Full Vehicle

Single Vessel

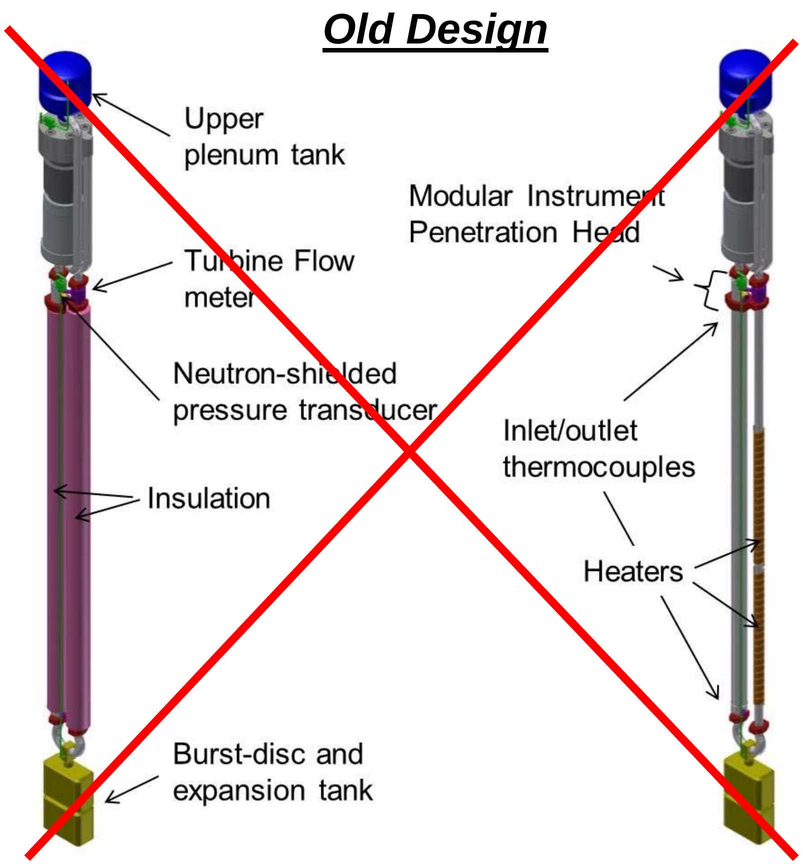


Ample Room for Instrument Penetrations

Flowing-Water Loop

TREAT Water Environment Recirculating Loop (TWERL)

- **Based on MK-series concept**
- **Water pump needed**
  - High pressure/temp, compact, no leakage
  - Quotation and rough design received from Teikoku on a custom canned motor pump
- **Loop piping superalloy UNS N07718**
- **FY14's design concept (upon which the IRP was based) has been considerably reconfigured**
  - Pump-on-top → pump-on-bottom
  - Much easier to load test train in hot cell
  - Larger core footprint, entirely fills shipping cask



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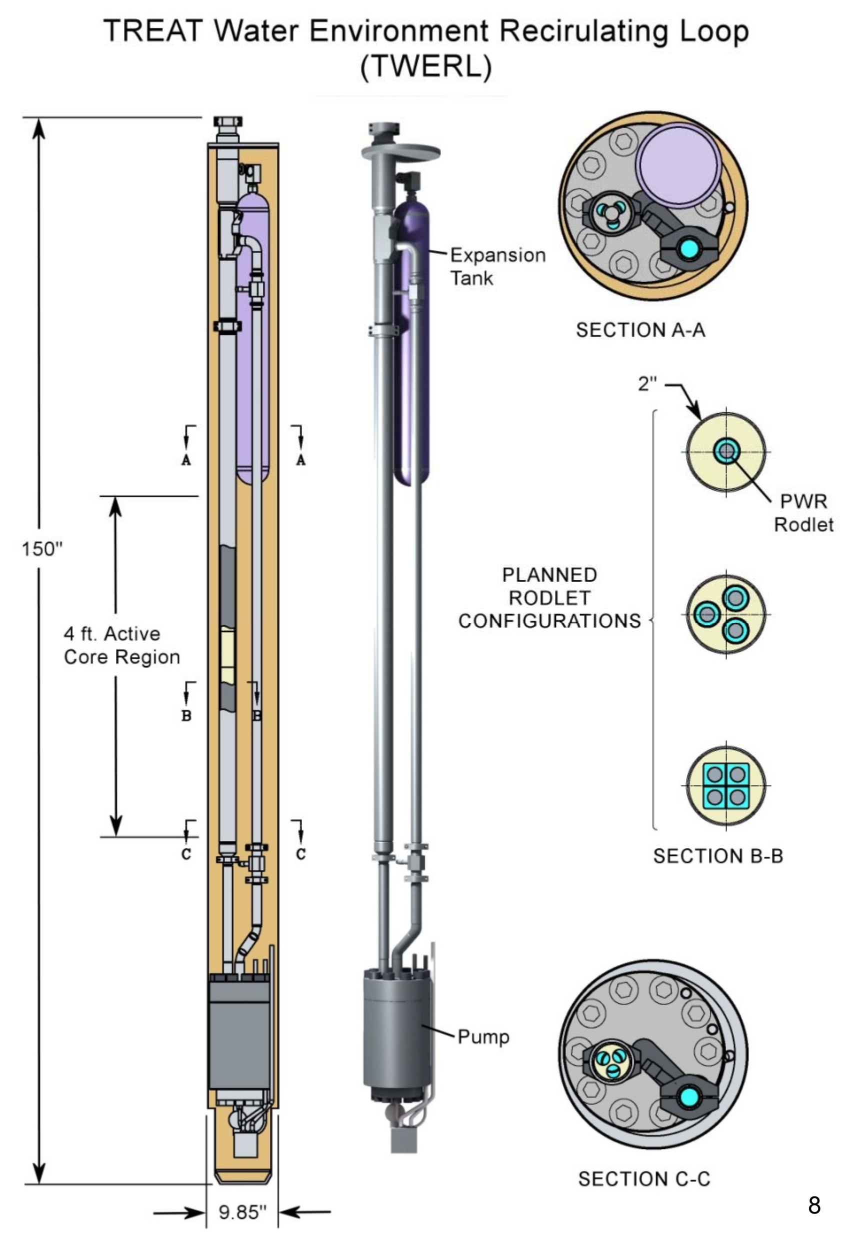
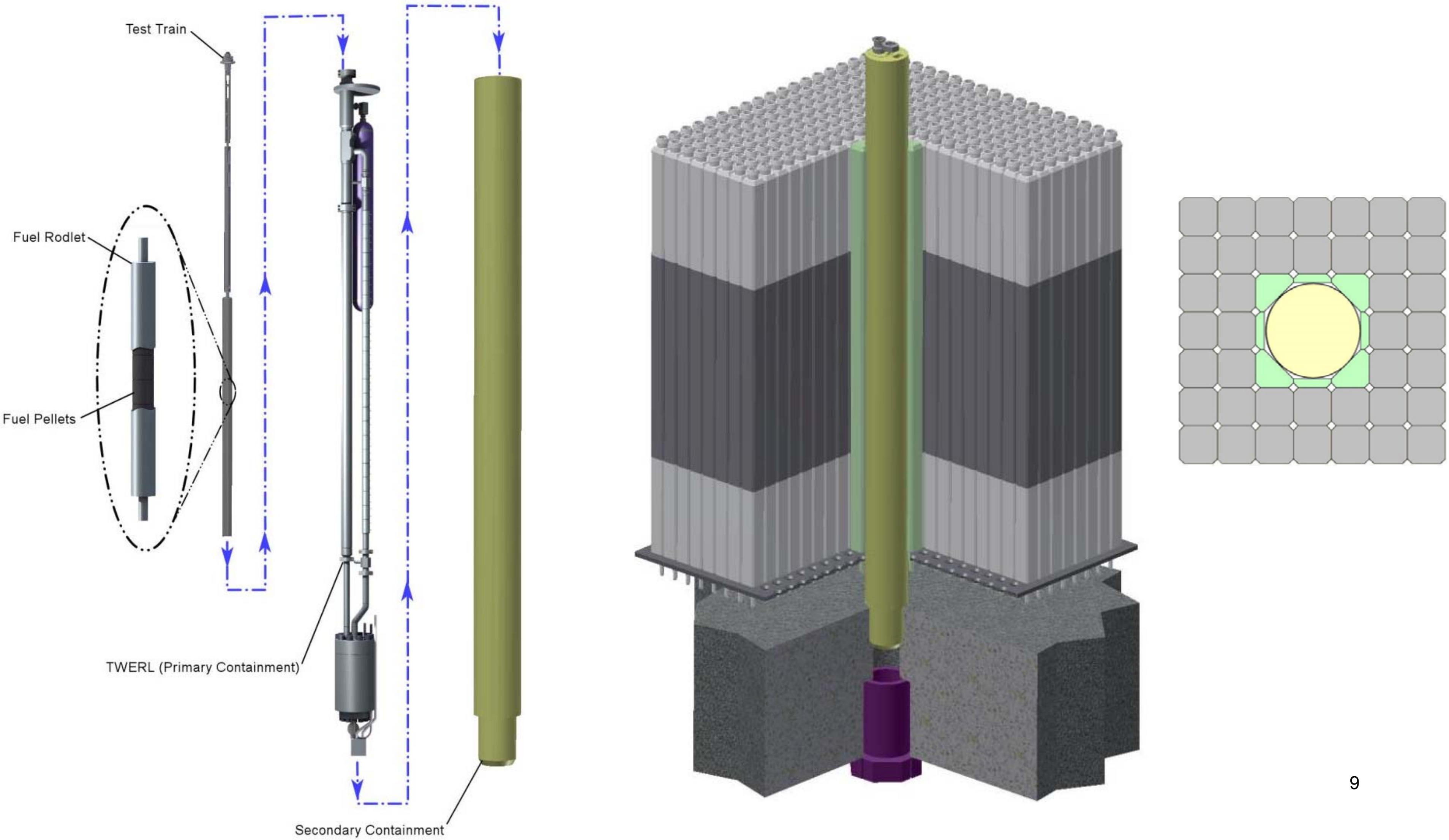
TWERL

New Design!

- ***Pump on bottom design conceptualized, but not complete***
- ***Test train is modular:***
  - One rod in a flow tube for highly instrumented test trains
  - Up to three rods in individual flow tubes for concurrent testing
  - Four-rod bundle Test-specific instrument designs
- ***Detailed design concept underway for a single-rod test train only (for ATF-2)***
- ***New design was described in a recent internal report, but no detailed drawings yet available***
  - Further TWERL design work currently unfunded

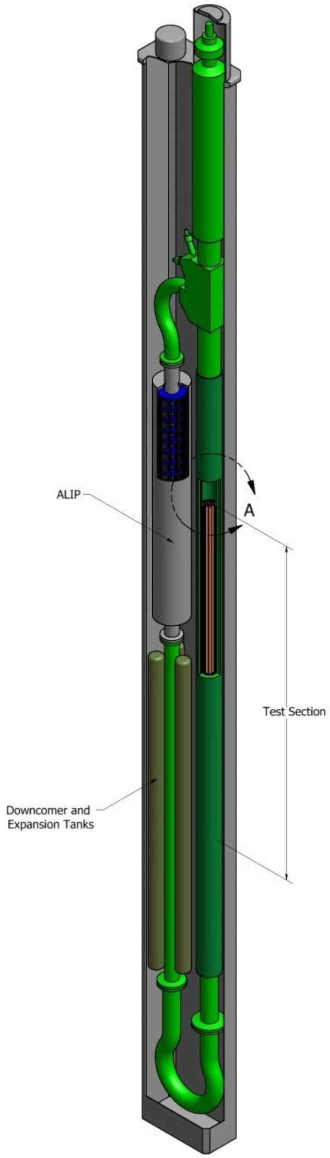


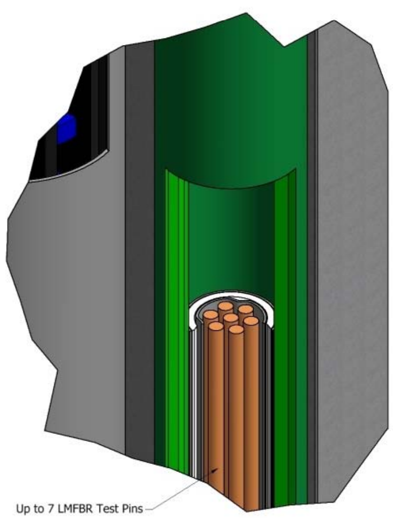
TWERL


Test Train
Fuel Rodlet
Fuel Pellets
TWERL (Primary Containment)
Secondary Containment

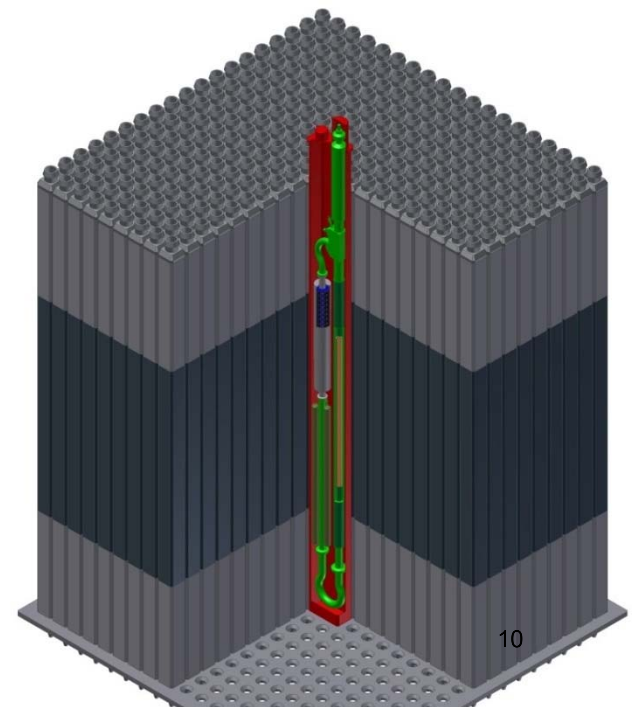
Sodium Loop

- Like the historic TREAT, something akin to the MK-II and MK-III loops will be the heart of fast reactor testing
- Up to 7 pins, sodium recirculated by compact annular liner induction pumps (ALIP's)
- Design concept is well established
- Currently working on recovery of historic design/operational basis and identifying hardware needs





Representation of Historic MK-II loop



Sodium Loop

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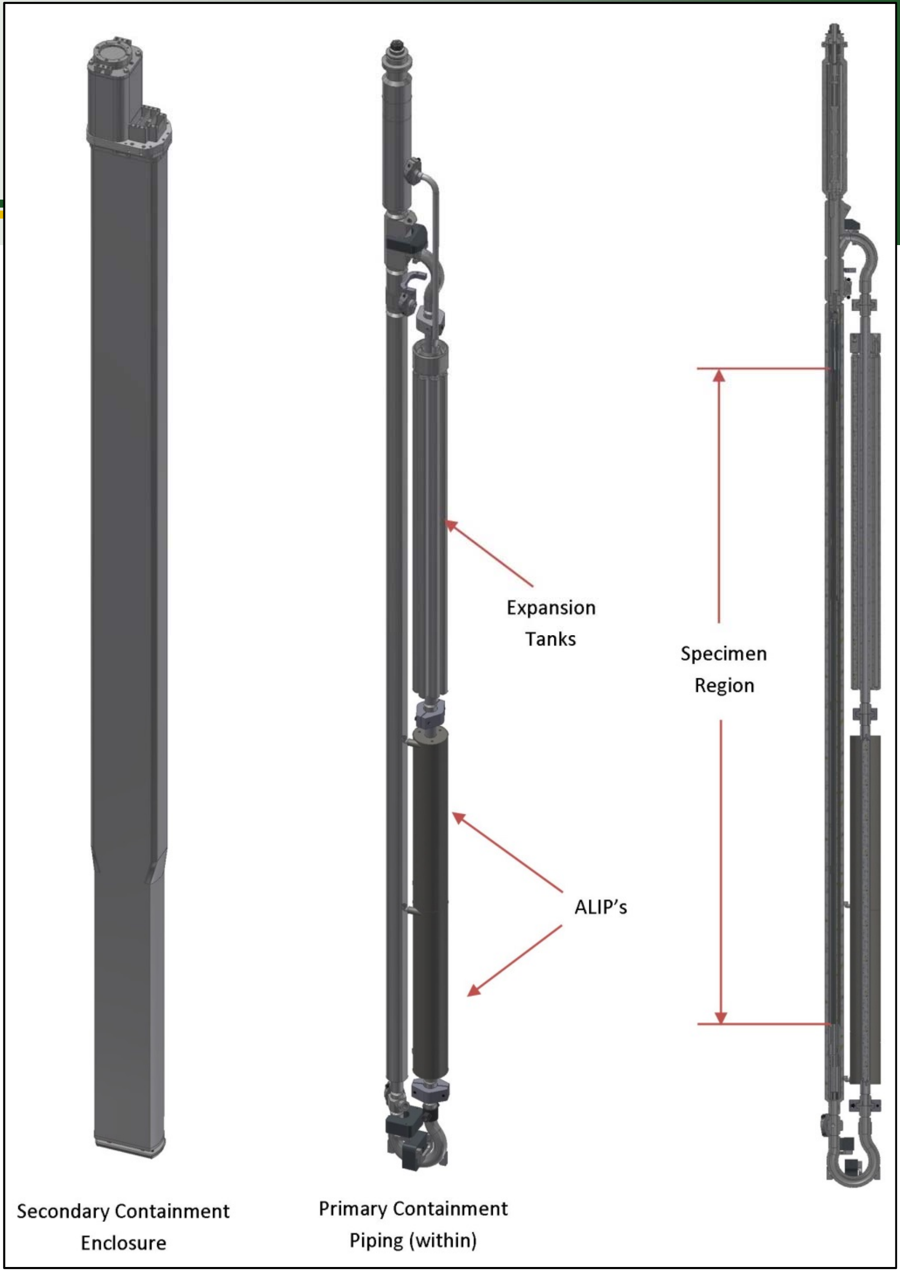
- **INL recently recovered several MK-III drawings**
  - Rebuilt design in CAD format (right)
- **Design is remarkably “configurable”**
  - 1 or 2 pumps, amount of expansion tanks
  - 1, 2, 3, 7 pin test trains with instruments
  - Top and bottom plenum pins
- **Have yet to assemble one complete test, loop, and instrument configuration packages, and link to data from a transient test**
  - Work in progress, currently unfunded
- **Design update needed for future “MK-IV” sodium loops**
  - Modern test and data needs
  - Modern materials and instruments
  - Currently unfunded
- **ALIP technology subject of SBIR grant**



Task 2 Desired Outcomes

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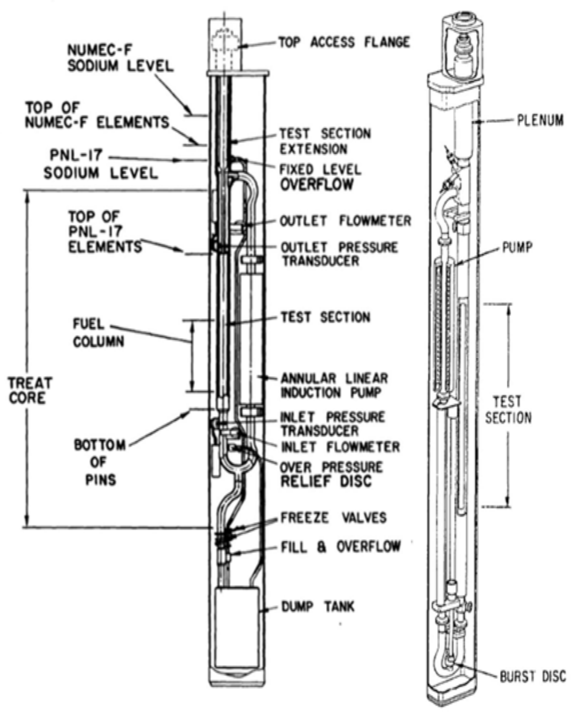
Task 2 is focused on creating benchmark cases for loops

- **Historic Sodium Loops**
  - Identify a few tests and configurations of interest
  - Recover geometric information and build models
    - *INL's support needed to dig out old documents, etc.*
  - Compare to test data
    - *Pre-test loop checkout*
    - *Transient test*
  - Use tools/methods useful for state-of-art modelling of sodium loops
    - *Leverage for modern MK-IV design effort*



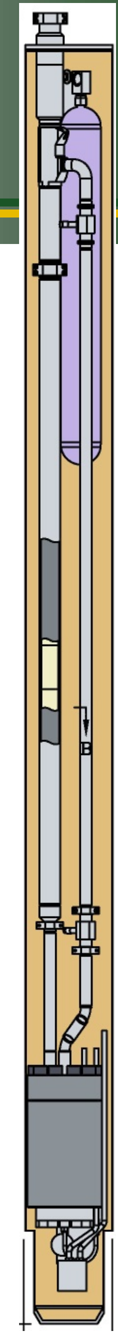
Task 2 Desired Outcomes

- **Future Water Loops**
  - No historic examples, must construct an “affordable” prototype of the TWERL
    - *INL will eventually build a true-to-design TWERL prototype with superalloy piping, custom pump, etc. to verify design and operation*
  - Prototype should be “true to the essence” of the TWERL
    - *Compact, upright, small internal volume, no pressurizer, pump/system curves*
    - *Something akin to the secondary enclosure is desirable*
    - *Modularity (ability to install other types of test train)*
  - Heated rod simulant should be pursued if feasible
    - *Heating rates need not simulate that possible in TREAT*
    - *Single rod test train recommended*
    - *Only the most basic test train features and instruments need to be included*
    - *Other test train concepts can be installed later if scope remains*
  - Run the loop through its paces, gather data, benchmark against models
    - *INL has primarily used RELAP5-3D to model TWERL thus far, other tools could be used and compared*
- **IRP team should have two plans**
  - One assuming that INL does not receive near-term project funding for TWERL detailed design
  - Another [hopefully more likely] scenario where INL is well funded to continue design and can stay in-sync with OSU during the IRP and TWERL design processes

Task 2 Desired Outcomes

"You learn more at first prototype than at any other point in the design process" –Greg Roach, Professor of Mechanical Engineering, BYU-Idaho

- **In addition to creating benchmark cases, this prototype will INL's first glimpse of the design's performance**
- **Observations that could be made**
  - TWERL is a sealed pressurized system (with precise pressure targets), yet it has no pressurizer.
    - *Can the target pressure be achieved in a repeatable manner?*
    - *What is the effect of slow plenum gas leakage from seals while in storage?*
  - What is the best plenum cover gas (leakage from system, absorption into water, inertness)
  - Reliability of loop instruments (pressure transducers, turbine flow meters)
  - How does the system pressure respond as energy is input from the rod?
  - Can the system be operated at near-saturation conditions (BWR), will the pump cavitate, how much energy can be input from the rod before the system becomes unstable?
  - What is the surface temperature of the secondary enclosure during operation?
  - Can the system be maintained at steady state PWR conditions or will temperature slowly climb due to pump heat input



Questions?

Acknowledgments

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- **Greg Housley** – TWERL Lead Engineer
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