Task 2 Desired Stakeholder Outcomes

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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
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
Static Environment Rodlet Transient Test Apparatus (SERTTA)

- General purpose device **without** forced convection
- Pre-pressurized and electrically heated
  - Liquid water up to PWR condition (320°C, 16 MPa)
  - Inert gas or steam
  - Liquid sodium capability envisioned

- Vessels designed with tremendous safety margin

- Several SERTTA “modules”
  - Multi-SERTTA for 4X rodlets
  - Super-SERTTA for full length rods (48”)
  - LOCA-SERTTA to be developed
Super-SERTTA
(preliminary concept only)

Rod up to 48” long

Ample Room for Instrument Penetrations

Full Vehicle

Single Vessel
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
- **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
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
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

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
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