U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Canister Inspection

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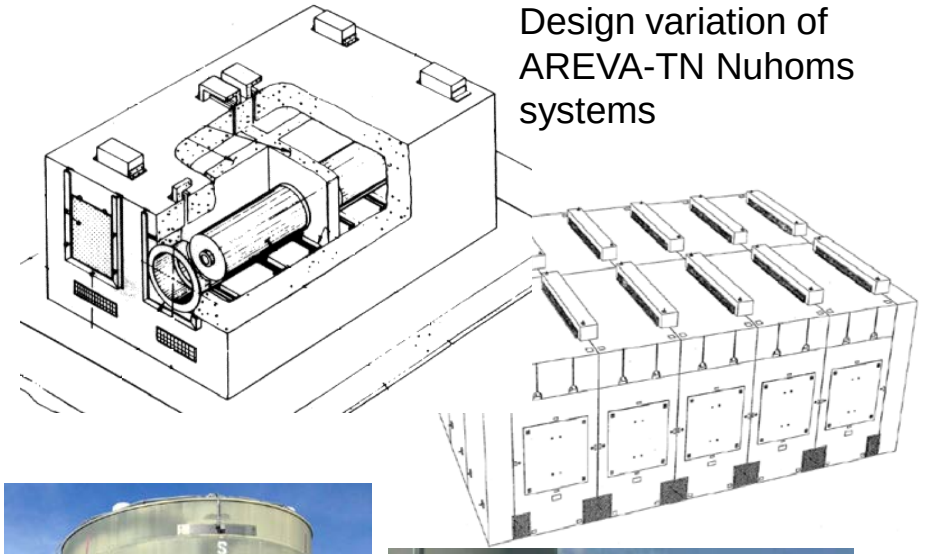
Inspecting Surfaces of UNF Canisters

- **Strategy**
  - In-situ inspections
  - Ex-situ inspections
- **Ex-situ**
  - Highly complex and complicated job
  - Can survey almost 100% of canister surface
  - Being investigated by storage system vendors
- **In-situ**
  - A bit less complex, still complicated
  - Survey may not be 100% of canister surface
  - Variation of storage systems requires adaptability of methods/tools used
  - DOE and industry investigating these methods



Design variation of AREVA-TN Nuhoms systems

Design variation of Holtec Hi-Storm 100 systems

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Gaining Access to Canisters

- **Up to this point, entries into storage systems have been manually performed**
  - No robotic systems are available
    - High radiation, high temperature, limited space, variable surface texture
- **Storage systems were not designed for inspection**
  - Canisters do not have to sit straight
  - Canisters do not have to be centered
  - Expect large tolerances

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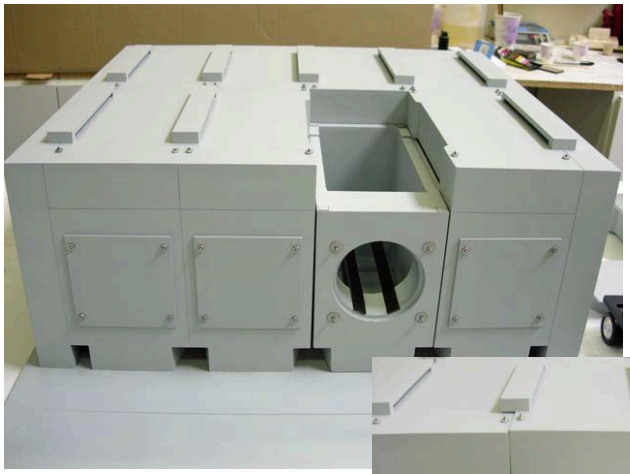
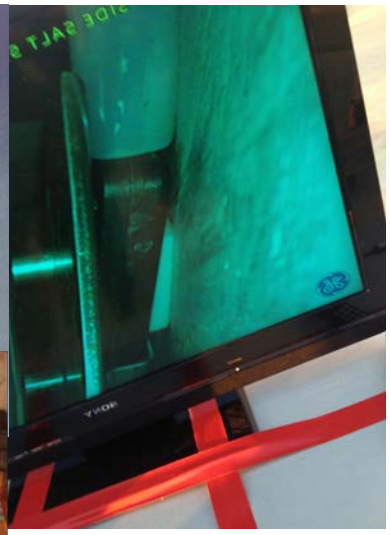
Challenging Spaces

- **Limited accessibility**



Model of Nuhoms systems

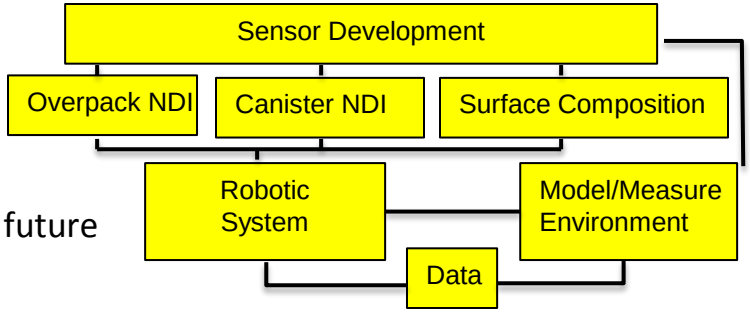


Photos from inside a Holtec Hi-Storm 100 system and a mock-up empty system.

Integrated Research Project

Multi-sensor Inspection And Robotic Systems For Dry Storage Casks

- Pennsylvania State University funded in 2014 to:
  - Perform research and then develop a robotic device and new sensing systems to monitor for conditions conducive to stress corrosion cracking and inspect surfaces of dry storage canisters. Basic requirements include:
    - Perform visual inspection of surface
    - Perform chemical analysis of surface deposits
    - Inspect for cracking
    - Measure temperatures, radiation dose
    - Be capable of revisiting a location at a point in the future



Success is defined by successful deployment on one vendor's system.

- Focus is on the Holtec Hi-Storm 100 and Multi-Purpose Canister System

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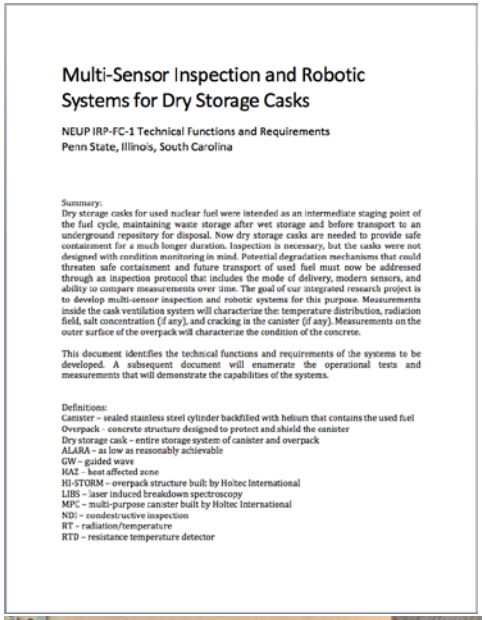
Project Challenges

Material Compatibility

- Component hardening for high radiation and temperatures
- Do no harm (leave no scratches, leave no organics behind)

Functional Design

- First of a kind equipment deployment, not off the shelf
  - Obtain accurate temperature measurements in moving, hot air
  - Obtain accurate chemical compositions of deposits
    - High sensitivity is needed (0.05-10 g/m^2 salt)
    - Salts are sensitive to handling and analysis methods
  - Ability to find potential cracks that may exist in any direction
    - How long? How deep? Helps govern revisit interval.
  - Logging locations for a revisit in the future
  - Flexibility to deal with a space of variable geometry
  - "Traction"



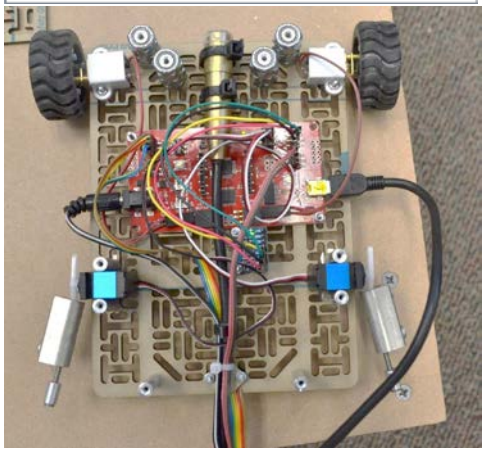
Multi-Sensor Inspection and Robotic Systems for Dry Storage Casks

NEUP IRP-FC-1 Technical Functions and Requirements
Penn State, Illinois, South Carolina

Summary:
Dry storage casks for used nuclear fuel were intended as an intermediate staging point of the fuel cycle, maintaining waste storage after wet storage and before transport to an underground repository for disposal. Now dry storage casks are needed to provide safe containment for a much longer duration. Inspection is necessary, but the casks were not designed with condition monitoring in mind. Potential degradation mechanisms that could threaten safe containment and future transport of used fuel must now be addressed through an inspection protocol that includes the mode of delivery, modern sensors, and ability to compare measurements over time. The goal of our integrated research project is to develop multi-sensor inspection and robotic systems for this purpose. Measurements inside the cask ventilation system will characterize the: temperature distribution, radiation field, salt concentration (if any), and cracking in the canister (if any). Measurements on the outer surface of the overpack will characterize the condition of the concrete.

This document identifies the technical functions and requirements of the systems to be developed. A subsequent document will enumerate the operational tests and measurements that will demonstrate the capabilities of the systems.

Definitions:
Canister – sealed stainless steel cylinder backfilled with helium that contains the used fuel
Overpack – concrete structure designed to protect and shield the canister
Dry storage cask – entire storage system of canister and overpack
ALARA – as low as reasonably achievable
GW – guided wave
HAZ – heat affected zone
HI-STORM – overpack structure built by Holtec International
LIBS – laser induced breakdown spectroscopy
MPC – multi-purpose canister built by Holtec International
NDI – nondestructive inspection
RT – radiation/temperature
RTD – resistance temperature detector



Proto-type test bed used to evaluate circuitry layout and function.

Status

- **Current efforts are focused on development of inspection tools that can be deployed with the canister in place (in-situ)**
  - Integrated Research Project Team is moving quickly:
    - Functional Requirements complete
      - Measurement methods selected
      - Laser-Induced Breakdown Spectroscopy for chemical assay
      - Guided Wave NDE (Electomagnetic Acoustic Transducer/Eddy Current Analysis) will be developed for crack detection
      - Geiger-Muller detector for radiation measurements
      - Temperature by thermocouple and/or RTD
- **No effort being expended on ex-situ inspection as this is being led by dry storage system vendors**