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Functional Monitoring of Dry Cask Storage Systems for Extended Storage and Transportation

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Outline

- Extended Storage and Transportation (EST) Research Activities
 - Background
 - Current Status
- Available Methods for Functional Monitoring
 - Objective: analyze strengths and weaknesses of available monitoring methods and techniques
 - Findings

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EST Background

- Since 2011, RES has provided assistance to NMSS in developing the technical basis and assessing potential information needs for the extended storage and transportation of spent nuclear fuel

Schematics of vertical (left) and horizontal (right) dry cask storage systems (NRC, 2015)

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EST Deliverables

- Early products from EST activities included:
 - Technical Information Needs (TIN) report ML14043A402
 - Atmospheric stress corrosion cracking (SCC) testing – NUREG/CR-7170 ML14051A417
 - Canister non-destructive examination (NDE) analysis ML13276A196
 - Vacuum drying adequacy and test plan ML13169A039
ML13192A125
ML13192A127

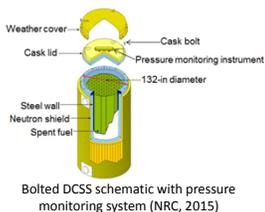
Current Status

- RES has recently completed and published reports on the following topics:
 - Horizontal cask thermal modeling - NUREG/CR-7191 ML14352A098
 - Functional monitoring ML14323A067
- Work is ongoing in the following areas:
 - Stress analysis of cladding
 - Vertical cask thermal modeling
 - Concrete degradation modes
 - Aging management tables for dry cask storage system (DCSS) structures, systems, components (SSCs)

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Functional Monitoring

- Background:
 - Currently, there are limited NRC requirements for monitoring DCSSs in service*
 - License renewal applicants may propose monitoring as part of an aging management program
- Objective:
 - Provide NRC reviewers with a tool to evaluate the potential success of a monitoring technique proposed by an applicant in an aging management program



*10 CFR 72.122(f), 72.122(h)(4), 72.124(c), 72.126(c)

Approach

- Evaluate the current state of technology for monitoring environmental conditions and potential degradation of dry cask components
- Perform literature review of potential methods for monitoring environmental conditions and degradation
 - Considered commercially available techniques as well as methods under development

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Scope of Review

- Scope of parameters considered for monitoring:
 - Environmental conditions internal and external to canister:
 - External: temperature, humidity, chloride concentration, microbial activity
 - Internal: temperature, humidity, pressure
 - Degradation phenomena:
 - Stress corrosion cracking (SCC) and localized corrosion of canister
 - Degradation of concrete, cask bolts, cladding and other internal components

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Overview of Findings

- Many relevant techniques are well-established in other industries, but require adaptation to DCSSs
 - Less mature techniques in development also hold promise
- Challenges found with nearly all techniques:
 - Power supply and calibration
 - Geometry to adapt to DCSSs
 - Environment: temperature and radiation
- Monitoring of canister internals poses greatest challenge
 - Lack of mature techniques and significant operational challenges

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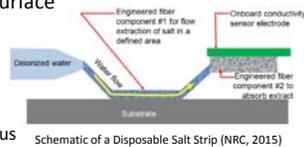
External Temperature and Humidity

- External temperature can be monitored by proven techniques:
 - Thermocouples and resistance temperature detectors
 - Other techniques require development to demonstrate radiation and temperature tolerances
- External humidity poses greater challenges
 - Psychrometers have been used in nuclear applications, but require presence of water
 - Other techniques require development to overcome limitations such as radiation or temperature tolerances

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External Chloride and Microbial Activity

- Considered chloride and microbial activity monitoring on external canister surface
- Chloride monitoring appears to require sample collection
 - Limited information available for continuous methods
- Sensors for microbial activity require development
 - Most existing sensors designed for use in bulk liquid environments
 - Temperature and radiation limitations and sample collection would have to be considered



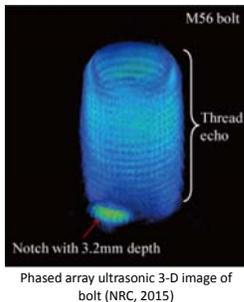
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External Degradation Phenomena

- Limited options for canister SCC sensors
 - Surrogate sensors could provide condition monitoring
 - Other methods have unknown radiation and temperature tolerances
 - Inspection-based methods could be used
- Concrete degradation sensors are well-developed and sensitive to degradation
 - Limitations include interrogation depths and sensor placement

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Cask Bolt Monitoring



- Proven technologies exist to monitor cask bolt degradation
 - Include phased array ultrasonic methods
- DCSS modification likely needed for continuous monitoring

Canister Internal Monitoring

- Unique challenges associated with monitoring environment or degradation inside canister
 - Temperature range: up to 400°C during drying
 - Radiation field: may require radiation hardening
 - Ease of access: how to provide power to and receive signal from sensor
 - Potential penetrations would require evaluation for confinement and leakage in normal and accident conditions
- Limited methods available for monitoring canister internal
 - External gamma ray spectroscopy could provide indication of cladding confinement

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Summary

- NRC pursuing research in support of extended storage and transportation of spent nuclear fuel
 - Several high-priority activities completed and others ongoing
- Functional monitoring methods exist or could be adapted for monitoring external conditions and degradation
- Much greater challenges exist for monitoring canister internals

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References

- "Available Methods for Functional Monitoring of Dry Cask Storage Systems", ML14323A067, NRC, 2015.

Acknowledgements

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