Vacuum Drying Events and Associated Issues

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Presentation Overview

- Description of Event
- Vacuum Drying System Issues
- Generic Questions
- Vacuum Drying Systems
- NRC Issued Guidance to Prevent Oxidation
- Conclusions

Description of the Event

- On Saturday, August 28, 2010 while performing vacuum drying a MPC containing spent nuclear fuel was left unmonitored
- The process required cooling of the water contained within annulus between the HI-TRAC and the MPC
- The cask system required that the MPC shell temperature be maintained below 125° F

Description of the Event

- The licensee determined that, due to the heat loads selected for this canister, heat rates were not high enough to exceed fuel temperature limits even in the event of a chiller shut off

- Therefore, the licensee concluded that no monitoring was necessary overnight

- No specific analysis was performed to support this determination

Description of the Event

- Morning of August 29, 2010, the licensee identified that the chiller had unexpectedly shut off overnight

- However, the licensee failed to recognize that the annulus water temperature corresponded to a safety limit for fuel cladding temperature as discussed in the FSAR

Description of the Event

- The inspectors notified the licensee of the design basis annulus water temperature limit of 125° F, which was specified in the FSAR

- The inspectors estimated that the 125° F limit was likely exceeded by several degrees.

Description of the Event

- The licensee began a prompt evaluation to determine if any fuel cladding safety limits were exceeded

- Working with the licensee's vendor, the prompt evaluation concluded that no fuel cladding safety limits were exceeded

Vacuum Drying Systems (VDS) Issues

- NRC's Spent Fuel Storage and Transportation (SFST) Division provided technical support to Region III's specific questions regarding vacuum drying systems

- While supporting Region III, SFST raised questions that may be generic issues associated with vacuum drying systems

VDS – Generic Questions

- What is the vulnerability of vacuum drying systems to failure modes that would allow air ingress into the canister (and what actions have been taken or proposed to date)?
- Are vacuum drying systems correctly categorized with regards to their significance to safety?
- During vacuum drying, are design basis fuel cladding temperatures supported by our current understanding of the thermal models?

Vacuum Drying Systems

- Vacuum drying systems used at some Nuclear Power Plants (NPP) are usually very simplistic
- When performing drying operations, the canister is connected to the vacuum pump through a hose that could rupture allowing air ingress to the cavity
- This may be the case for an unmonitored system as in the loss of cooling event case

Vacuum Drying Systems

- Oxidation may occur rapidly and cause significant swelling of fuel pellets and fragments, which could result in gross fuel cladding breaches and release of fission products to the surrounding cask environment, if the time-at-elevated temperature after water removal is excessive

Vacuum Drying Systems

- Large cladding breaches could result in loss of retrievability and a configuration not analyzed for thermal, confinement, shielding, and criticality

- Further, the release of fuel fines or grain-sized powder into the inner cask environment from ruptured fuel may be a condition outside the licensing basis for the cask system

NRC Guidance to Prevent Fuel Oxidation

- (1) Maintain the fuel rods in an appropriate environment such as argon, nitrogen, or helium to prevent oxidation

- (2) Assure there are not any cladding breaches (including hairline cracks and pinhole leaks) in the fuel pin sections that will be exposed to an oxidizing atmosphere

NRC Guidance to Prevent Fuel Oxidation

- (3) Determine the time-at-temperature profile of the rods while they are exposed to an oxidizing atmosphere and calculate the expected oxidation to determine if a gross breach would occur

Conclusions

- Loss of cooling event uncovered potential vulnerabilities on VDS
- VDS failure (hose rupture) could result in air ingress to the spent fuel dry cask cavity
- Spent fuel experiences high temperatures during vacuum drying
- If air enters the cavity, oxidation may occur very rapidly if a cladding breach exists (such as a pinhole)
- Users should consider NRC guidance to prevent oxidation and address it in the FSARs as an accident condition assuming a hose rupture