Exelon Experience and Observations – Thermal Issues Identified During Loading of Spent Fuel Storage Casks

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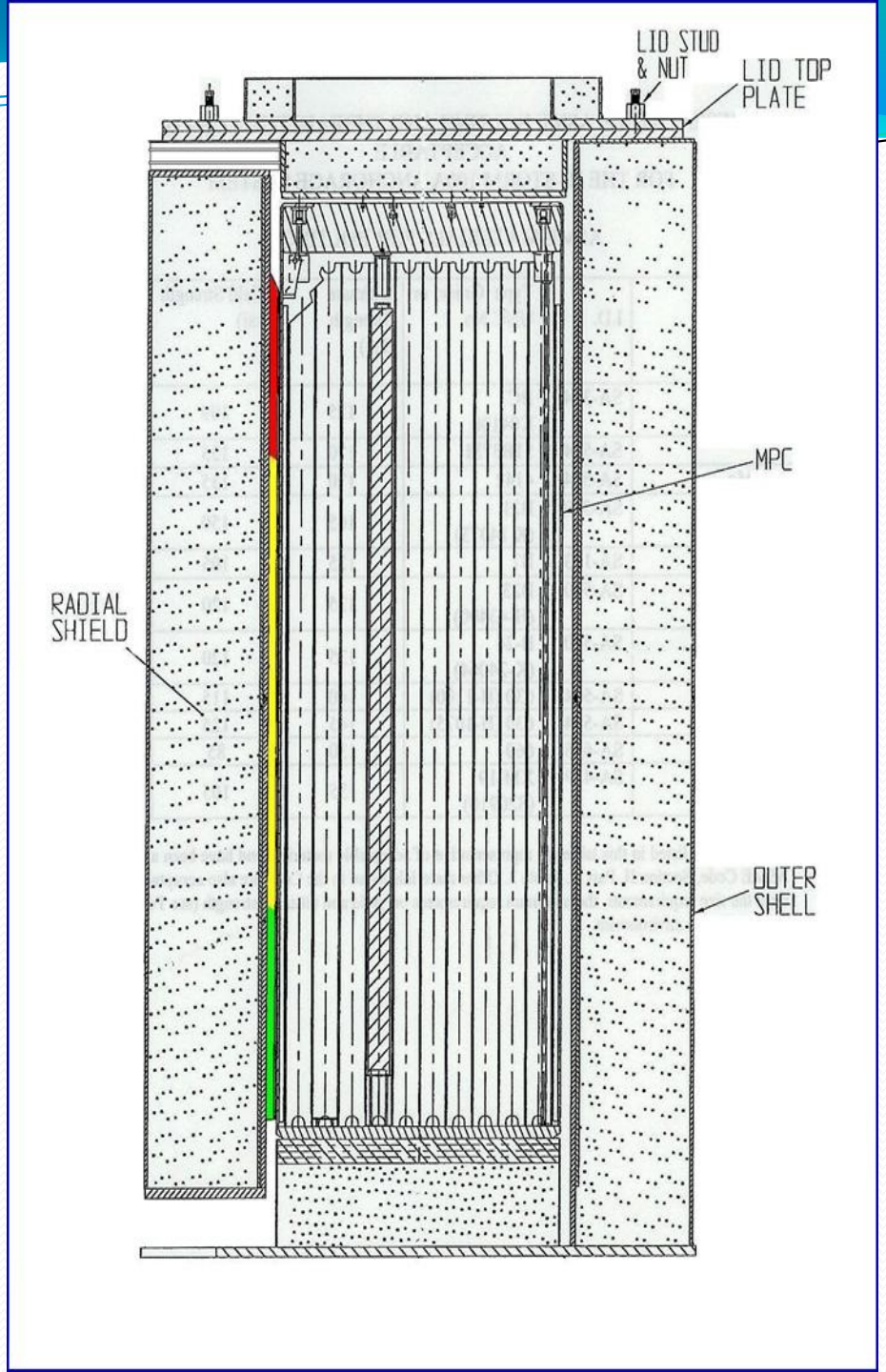
September 12/13, 2012

NRC IN 2011-10

- August 28-29, 2010, multi-purpose canister (MPC) containing used fuel assemblies, loaded in transfer cask, was left unattended for the evening
  - Annulus cooling system used to keep MPC exterior surface temperature below allowable limit was found to be inoperable the next morning
  - Six issues described in IN 2011-10 arose as a result of the investigation


LID STUD
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Industry OPEX

- Noteworthy problems have occurred at several stations while irradiated fuel was being loaded into dry fuel storage casks, including:
  - Selecting / loading assemblies not consistent with the license basis
  - **Loss of cask cooling**
  - Ignition of hydrogen

Six Points Listed in Info Notice IN 2011-10

1. No means to prevent or mitigate air ingress into the canister containing fuel assemblies which could cause fuel oxidation if certain failures of the vacuum drying system occurred, such as hose rupture or valve failure
2. Cladding temperatures could exceed CoC tech spec limits if annulus cooling system is inoperable for an extended period of time (this is the event which occurred overnight August 28-29, 2010)

Six Points Listed in Info Notice IN 2011-10

- 3. CoC technical specifications for vacuum drying were non-conservative for the particular heat load of the used fuel being loaded
- 4. CoC and FSAR did not address the need for a new vacuum drying time limit for subsequent vacuum drying attempts

Six Points Listed in Info Notice IN 2011-10

- 5. COC and FSAR did not address necessary requirements for annulus cooling when decay heat of an individual fuel assembly reached a limiting condition for operation (no LCO was specified)
- 6. No evaluation was performed by licensee to justify use of nitrogen for blowdown

IN 2011-10 Point 1

Prevent or mitigate air ingress into container containing fuel assemblies during vacuum drying

- ✓ Concern is fuel oxidation
- ✓ Potential cause is failures such as hose rupture between vacuum pump and canister, or valve failure

Drying Systems typically classified as NITS (Not-Important-to-Safety)

- **NUREG/CR-6407**
  - Section 6 describes classification for dry used fuel storage systems
  - VDS / Processing systems not described
  - There is a reference for “temperature control components” described as fins, heat shields, other methods to control temperature under normal and accident conditions

NUREG/CR-6407

Category A – Category A items include structures, components, and systems whose failure could directly result in a condition adversely affecting public health and safety. The failure of a single item could cause loss of primary containment leading to release of radioactive material, loss of shielding, or unsafe geometry compromising criticality control.

Category B – Category B items include structures, components, and systems whose failure or malfunction could indirectly result in a condition adversely affecting public health and safety. The failure of a Category B item, in conjunction with the failure of an additional item, could result in an unsafe condition.

Category C – Category C items include structures, components, and systems whose failure or malfunction would not significantly reduce the packaging effectiveness and would not be likely to create a situation adversely affecting public health and safety.

NRC IN 2011-10 Point # 1

- *IN 2011-10 - NRC states that Vacuum Drying System (VDS) is NITS when there is appropriate operator attendance to address system failures*
- *Is NRC assumption of continuous process of vacuum drying, with appropriate personnel in attendance an NRC regulatory position?*

NRC IN 2011-10 Point #2

- *Cladding temperatures could exceed CoC tech spec limits if the annulus cooling system is inoperable for an extended period of time*
- *This point from IN 2011-10 came from actual event, others were revealed during investigation*
- *This point was addressed by the following actions:*

Corrective Actions

- Extensive benchmarking activities were initiated and the dry cask storage organization company-wide was overhauled, including changes to roles and responsibilities
- Clear, frequent, and formal communication and training of roles and responsibilities were established for dry fuel storage and plant operations personnel for all aspects of DFS activities.

Corrective Actions

- Responsibilities and methods for monitoring system conditions were clearly established to ensure that the required operational configuration is maintained (ensure everyone is working to and monitoring the same **dry cask storage roadmap** for the cask)
- All dry cask procedures were reviewed and revised as required to ensure 100% alignment with cask licensing and design bases, and O&M manuals

Corrective Actions

- Actions were implemented by changes in procedures and changes in governance and oversight organization, including establishment of additional oversight for critical activities based on identified and defined risk levels.
- All dry cask activities were reviewed and plant staff were provided color-coded risk information for each activity, including parameters to monitor, required tech specs, and contingencies (DCS Roadmap)

NRC IN 2011-10 Point #3

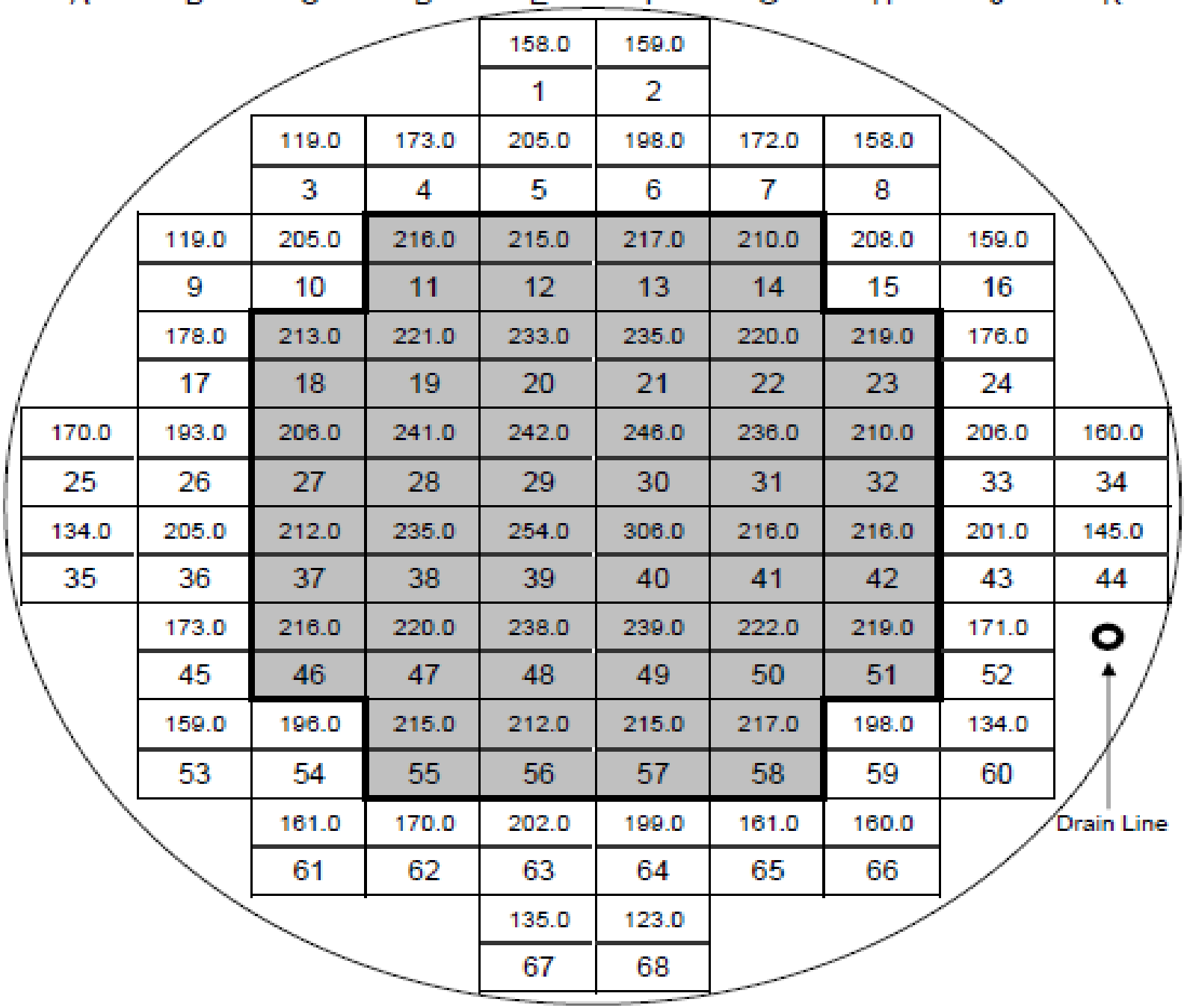
- CoC Tech Specs for vacuum drying were non-conservative for heat load of spent fuel being loaded
  - Discovered as a result of performing thermal analysis for cask w/ annulus cooling secured
  - For MPC-32 / 24E, TS are clear that annulus flushing required w/ vacuum drying in operation
  - Other sites loading cells to "uniform loading limit" specified in tech specs for MPC 68 / 24.
  - Thermal analysis identified that cells cannot be loaded to TS uniform loading limit w/out annulus flushing, even below TS limit (Example: < 21.52 KW for MPC-68 may still require annulus flushing)
  - Issue has been addressed, all users informed and took appropriate actions, vendor licensing follow-up in progress

NRC IN 2011-10 Point # 4

- *CoC requires that cask be helium backfilled if vacuum drying time limit reached*
  - *CoC and Tech Specs did not address need for new vacuum drying time limit if initial limit reached, thus*
  - *Procedures did not contain specificity required for contingency actions for loss of VDS, helium backfill, restart of VDS, etc*
  - *Issue has been addressed, all users informed and took appropriate actions, vendor licensing follow-up in progress*

NRC IN 2011-10 Point # 5

- *Non-conservative CoC / TS (from Point 3) allowed loading fuel w/ decay heats above allowable limits which require annulus cooling*
  - ✓ *Example – TS allow "uniform loading configuration" for fuel up to 414 watts*
  - ✓ *Thermal analysis showed that loading cells to 414 watts (uniform loading limit specified in tech specs) could exceed thermal limits*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67 68
Drain Line

NRC IN 2011-10 Point # 5 (cont'd)

- Users typically do not load all cells to design basis limit
- Allowance by Tech Specs could prove to be an error trap, potential loading scenario where annulus flushing required but not implemented
- In fact, without a specific thermal analysis for each specific loading pattern, the required limit for this example using VDS was an upper decay heat limit of 316 watts, much lower than the uniform loading decay heat limit specified in tech specs
  - Issue has been addressed, all users informed and took appropriate actions, vendor licensing follow-up in progress

NRC IN 2011-10 Point # 6

- Operating procedures in FSAR allowed for canister blowdown using either helium or nitrogen
- No evaluation was performed by licensee to justify use of nitrogen
  - Key lesson – all numbers, all assumptions, all materials, all equipment utilized which can potentially affect fuel integrity MUST have an associated analysis or basis for its use
  - Users MUST NOT accept all info in the FSAR/CoC at face value, but rather must fully comprehend and challenge the basis for each action they take.

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