

Spent Fuel Storage Issues

How did we get here?

2017 ANS Winter Meeting

November 1, 2017

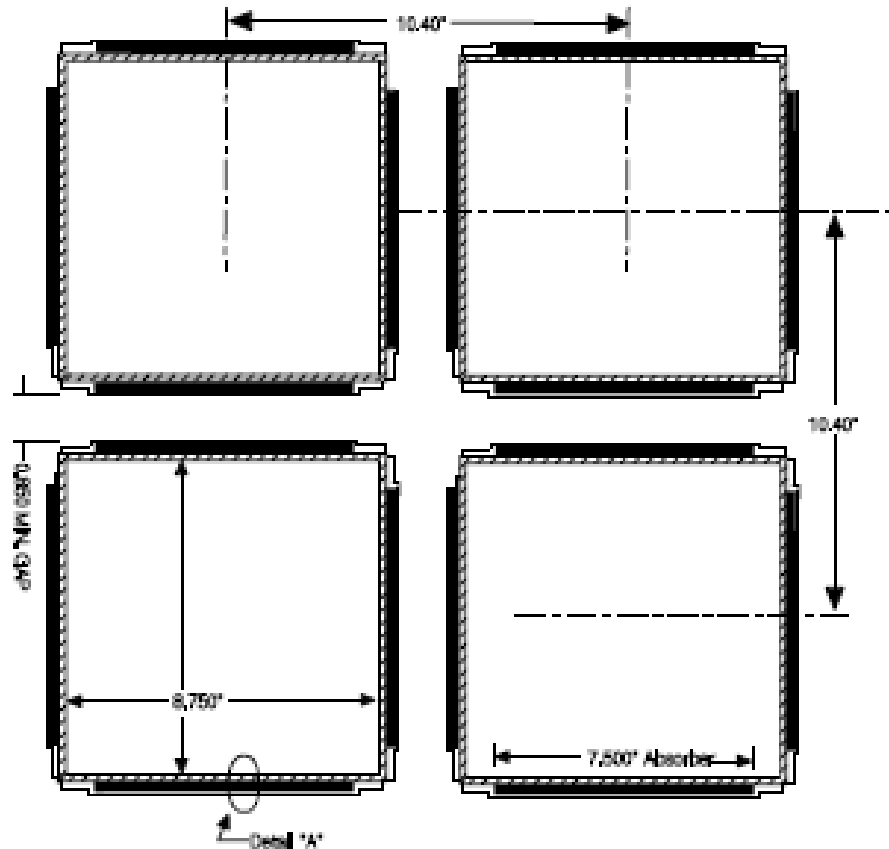
Bob Hall, Dominion Energy



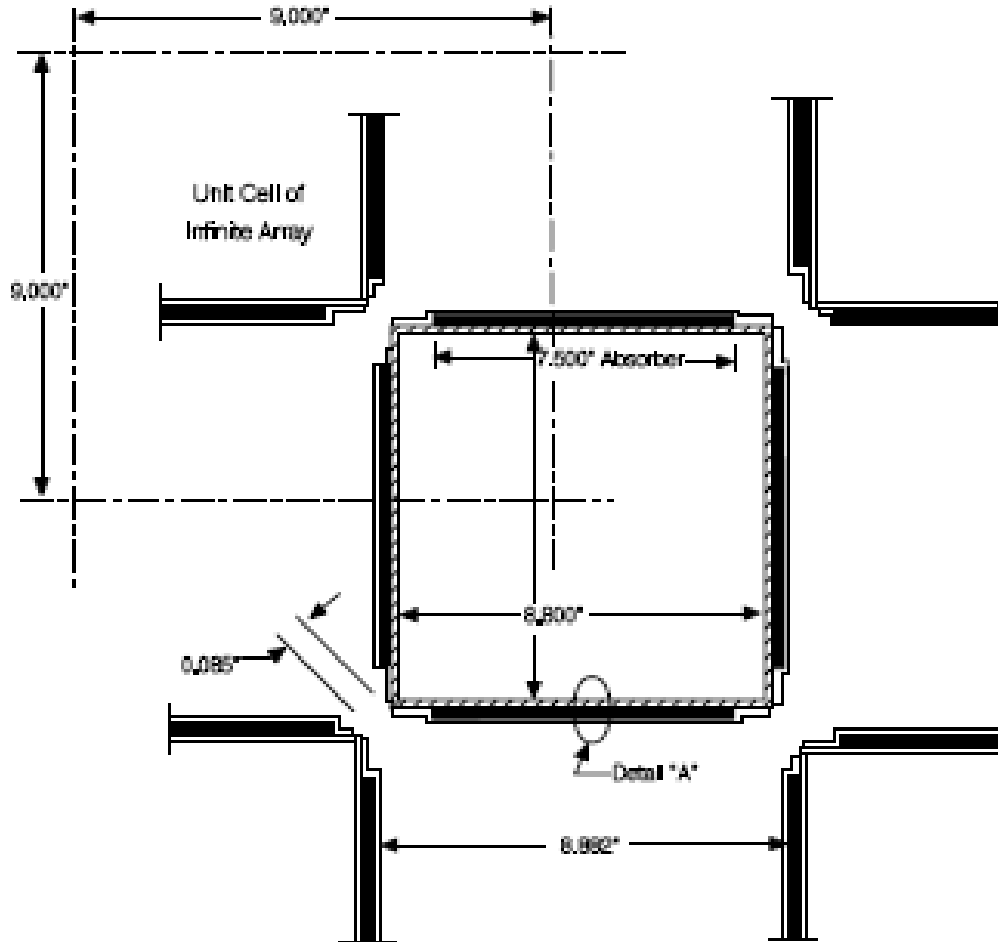
1960s – 1970s

- Spent fuel pools are “low density”
 - Reliance on fuel spacing only
- Expectation for national repository
- Timing concerns arise - “what if”
 - Neutron poison racks (high density)
 - “Carborundum” (B_4C in resin)
 - “Boraflex” (B_4C in polymer)
 - Two designs

Flux Trap Design



Non-Flux Trap Design



1980s

- Nuclear Waste Policy Act of 1982
 - DOE to take spent fuel in 1998
 - Need more storage!
 - Dry cask storage begins 1986
- Boraflex degradation
 - Need to offset loss of neutron absorption
- Plant operations and economics change
 - Higher fuel enrichment
 - Higher fuel burnup

1980s

- Analyses become more complex
 - Soluble boron credit
 - Fuel burnup credit
- New generation of computer codes
 - Monte-Carlo codes
 - Fuel depletion codes
- New neutron poisons
 - New / replacement racks
 - Primarily BORAL

1990s

- Boraflex issues snowball
 - Gapping, washout, silica in the pools
- Industry slow to respond
 - EPRI Racklife code
 - Managed degradation (“partial credit”)
 - “Blackness” testing
- Kopp Memo (NRC analysis guidance)
- NRC: Boral is robust, no coupons needed
- NRC/ORNL and the NUREGs
 - Burnup credit, boron credit, code benchmarking
 - Failure of WCAP-14416

2000s

- Re-racking continues
 - Boron and metal matrix materials
- Analysis complexity increases
 - Partial / no Boraflex credit
 - Neutron absorber rack inserts
 - Geometric patterning
 - Attempts to capture available margin
- NRC/ORNL: more analysis issues
 - Control rod insertion
 - Region to region interface
 - Effect of depletion history (power uprates, burnable poisons, etc.)
 - Code validation and uncertainty

2010s

- More neutron absorber “degradation”
 - BORAL blisters, corrosion, pitting
 - In-situ measurement problems (carborundum)
- More new issues:
 - Multiple fuel mis-load
 - Grid expansion
 - Volatile fission product migration
 - Clad creep
 - Power history
 - Boral blisters
 - In-situ B-10 measurement uncertainty vs analysis B-10
 - Burnup worth uncertainty
 - Interface treatment
 - Asymmetric fuel placement – bias or uncertainty?
 - Etc.....

2010s

- Industry/NRC initiatives
 - Improved BADGER in-situ measurements
 - EPRI Zion Boral project
 - EPRI Boral accelerated corrosion project
 - EPRI depletion benchmark project
 - NEI 12-16
 - NEI 16-03

Are we there yet?

- Almost.....
 - No standard approach for
 - Interfaces
 - Asymmetry
 - Volatile fission products
 - Multiple misload
 - Power history could be a zombie
 - Load follow
 - 24 month cycles
 - New codes (acceptance and validation challenge)
 - In-situ B-10 measurement conundrum
 - Confirmatory or definitive?
 - What if we don't have coupons?
 - How durable are the new absorbers?
 - What would we do for accident tolerant fuel designs?

Feeling overwhelmed?
Relax, we're almost there.

