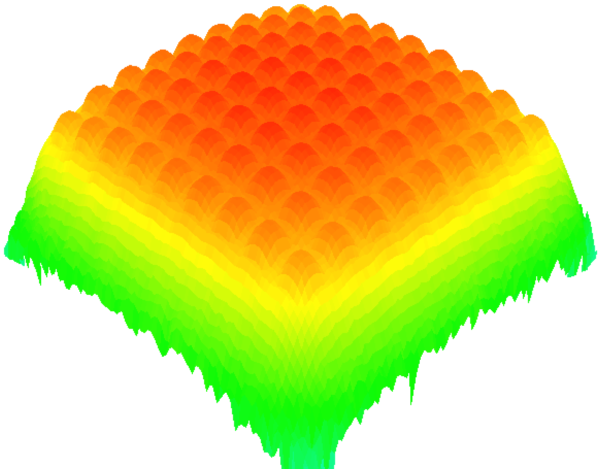


1ST WORKSHOP ON METHODOLOGIES FOR SPENT NUCLEAR FUEL POOL SIMULATIONS

(SAFETY & SECURITY)

June 23-25, 2015

Virginia Tech Research Center

Arlington, VA

Introduction

Ali Haghighat
Tuesday Morning

Sponsors

- Curtiss-Wright
- National Capital Region (NCR)
- Nuclear Science and Engineering Lab (NSEL)
- VT Mechanical Engineering Department

Instructors & Speakers

Instructors from VT

- Dr. Alireza Haghighat, Professor of Nuclear Engineering
- Dr. Katherine Royston, Postdoctoral Fellow
- Nathan Roskoff, PhD Student
- Dr. William Walters, Postdoctoral Fellow

Invited Instructors

- Matthew Eyre, Eyre Nuclear Energy Consultancy
- Dr. Vefa Kucukboyaci, Westinghouse

Invited Lunch Speaker

- Kristopher Cummings, NEI

Workshop Organization Support

- Jessica Brow, Project Manager, Continuing & Professional Education, Blacksburg Campus

- Larissa LaCour, Manager, *Executive Briefing Center Mgr, Arlington Campus*

- Anna Gest, Coordinator, Executive Briefing Center Event, *Arlington Campus*

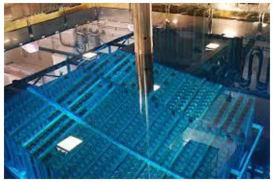
Introduction of Participants

Overview of the Purpose and Objectives of the Workshop

Ali Haghighat
Tuesday Morning

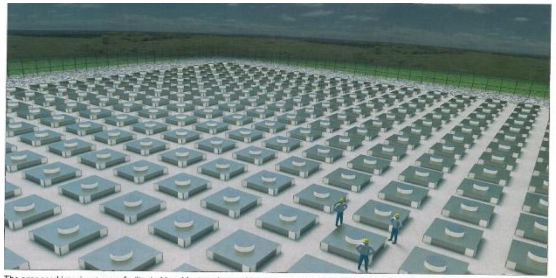
Spent Nuclear Fuel Storage

- Pool



- Dry cask

- Long Interim Storage



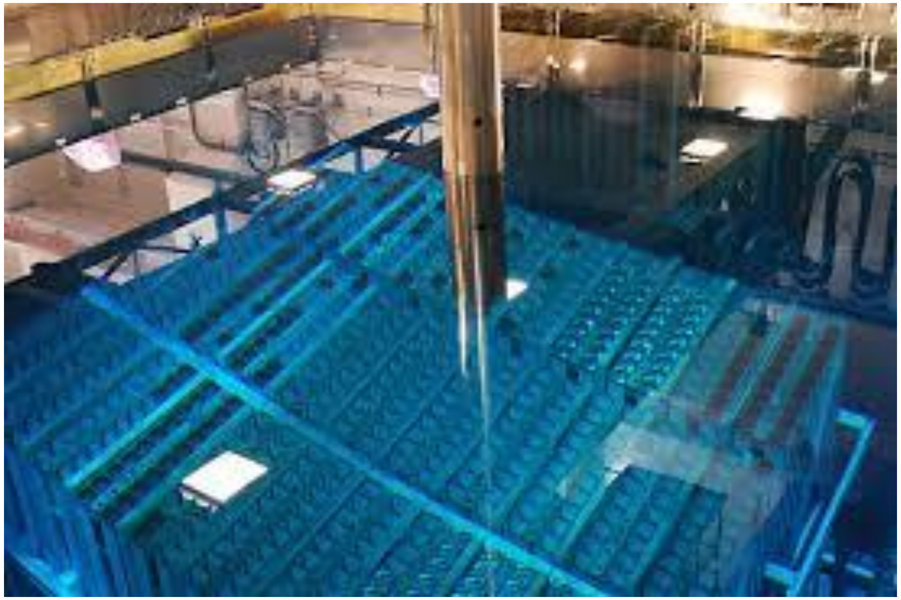
The proposed interim storage facility in New Mexico, depicted here in a computer-generated rendering, would store commercial spent nuclear fuel underground.

- Permanent storage

Handling & Transportation

History Spent Fuel Pool (SFP) Design

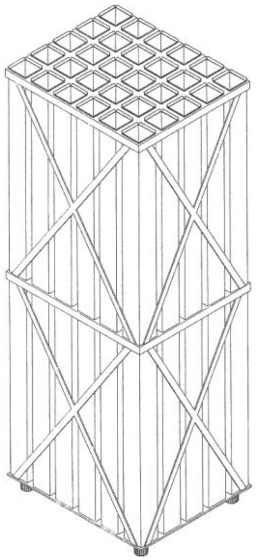
- Initial generation
  - ‘non-poison” racks for restraining the SF assemblies; the racks were anchored (bolted or welded) to the pool slab
    - Issues:
      - 1) ALARA
      - 2) “container” integrity
- “poisoned” free-standing racks
  - Increasing storage capacity
  - Referred to as high-density racks
  - No need for bolting, and overcoming the issues of the initial racks



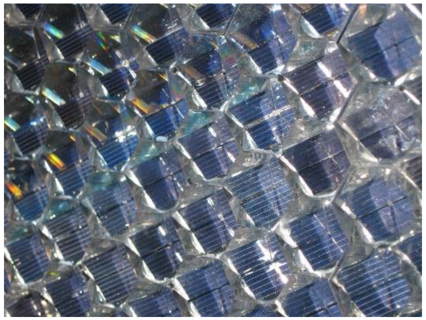
Issues with pools & racking

- Neutron absorbers [B_4C in metal matrix (Boral, Metamic), or polymer matrix (Boraflex, Carborundum, and tetrabor)]
- Fabrication of racks considering the need for precise dimensions to avoid criticality
- Integrity and safety
  - Pool structure evaluation
  - Fatigue failure
  - Criticality conditions
  - Rack dynamics, e.g., seismic activities

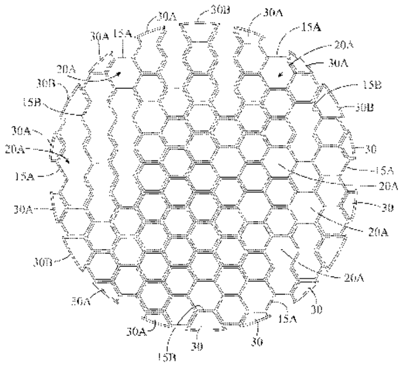
Rack designs



- End connected construction (ECC)
  - Connections only at the box end



- Honeycomb construction (HCC)
  - Continuous connection along entire edges of the box



Simulation of SFP

- Why?
  - Eigenvalue – criticality safety
  - Subcritical multiplication – inspection, confirmation, safeguards
  - Fission density distribution – gamma heating, and material accountability

- Current regulatory requirement
  - Conservative calculations with added uncertainties for achieving a maximum multiplication factor (k_{eff})

- Current issues:
  - Effective use of a pool
  - Misplacement
  - Potential for false alarm due to conservatism

A brief Background on Regulations

- 10 CFR 50 App. A ("Design Criteria for Nuclear Power Plants Criterion 61, Fuel Storage and Handling and Radioactivity Control")

- 10 CFR 50.68 ("Criticality Accident Requirements") was promulgated in 1998
  - Issued through an NRC internal memorandum from L. Kopp to T. Collins; referred to as Kopp Memorandum.

- DSS-ISG-2010-01 "Staff Guidance Regarding the Nuclear Criticality Safety for Spent Fuel Pools," was issued in 2011

- NEI 12-16, Rev. 1 (April 1014) if approved, it will become the permanent version of the aforementioned ISG

And Review Guides

- NUREG-0800, standard review plan, Section 9.1.1, "criticality Safety of Fresh and Spent Fuel Storage and Handling," Revision 4
- NUREG-0800, standard review plan, Section 9.1.2, "New and Spent Fuel Storage," Revision 3.

Notes (1)
Criticality Accident - Double Contingency Principle

- ANSI/ANS 8.1 standard, for a spent fuel pool we need to apply Double contingency principle:
  - Sufficient factors of safety should be incorporated such that at least *two unlikely , independent, and concurrent events* have to occur before *a criticality accident* is possible
    - Example for a PWR pool
      - Loss of soluble boron below the TS limit
      - Fuel assembly misloading or misplacement

Note (2)
Conservatism - Acceptance Criteria

- These criteria refer to maintaining subcriticality conditions under highly conservative assumptions, for example for
  - Fresh fuel , the criterion sets k<0.95 (with 95% confidence) if the fresh assembly was flooded with water
  - Spent fuel racks, the criterion sets k<0.95 (with 95% confidence) if rack is loaded with fuel of max assembly reactivity and flooded with unborated water

Goals of this workshop (1)

- Review of established methodology
  - Industry state-of-the-art methodology for determination of max. k_{eff}
  - NETCO Snap-In technology

- Overview of VT^{3}G *best-estimate* methodologies and tools; introduction to MRT and Fission Matrix (FM)

- Discussion on state-of-the-art methodologies and tools for simulation of SFP; issues associate with the standard Monte Carlo and importance of MRT methodology and the FM method

Goals of this workshop (2)

- Introduction to Hands-on exercises
  - Computer codes and their inputs
  - VT^{3}G utility codes for input processing

- Hands-on exercises
  - Solving seven sample problems addressing different aspects of a SFP simulation

Goals of this workshop (3)

- Discussion on a MRT methodology for SFP safeguards

- Demonstration of VT^{3}G tools
  - INSPCT-s (Inspection of Spent-nuclear-fuel Pool Computation Tool, spreadsheet version)

  - RAPID (Real-time Analysis of spent-nuclear-fuel Pool *In-Situ* Detection)

Thanks!

Questions?

Completed June 2011