1ST WORKSHOP ON METHODOLOGIES FOR SPENT NUCLEAR FUEL POOL SIMULATIONS (SAFETY & SECURITY)

June 23-25, 2015
Virginia Tech Research Center
Arlington, VA

NSEL Workshop Series
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

• Permanent storage
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 \([\text{B}_4\text{C}}\) 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

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. $k_{\text{eff}}$
  • 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
  • VT³G 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