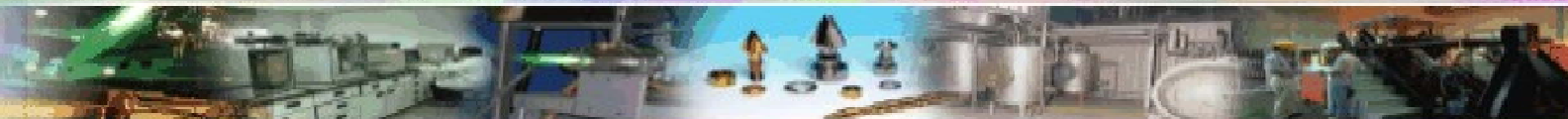# Findings from Spent Fuel Pool Criticality Analysis

2011 USNRC/TAEC Bilateral Technical Meeting
Washington DC, USA
3~4 May 2011

Institute of Nuclear Energy Research

Outline

- **Introduction**
- **Findings from SFP Criticality Analysis**
- **Need of Assistance from USNRC**
- **Future Works**

Introduction

- **How does INER get involved in SFP criticality analysis?**
  - **Commitment to ROCAEC for more tangible independent reviews**
  - **Dedication to R&D as a research facility**
  - **Early preparation for the upcoming new & more challenging SRP/NUREG**
  - **Boral degradation --- Blisters found on test coupons in Chinshan & Kuosheng NPPs**

Introduction (cont'd)

- ## What did INER do?
  - ### Set up a task force of analysis, including
    - ➢ 2 senior engineers with neutronics background & experiences in nuclear analysis of LWRs and Monte Carlo calculations
    - ➢ 1 junior yet promising engineer with neutronics background
  - ### Built up a preliminary analysis model and
  - ### Performed calculations & studies for Chinshan & Kuosheng SFP criticality safety (focusing on BWRs currently)

Findings from SFP Criticality Analysis

- **Safety margin & acceptance criteria**
  - The tighter the safety margin, the more flexible the acceptance criteria (meaning that fuel bundles can be put into SFP more freely); e.g., Chinshan NPP used up all margin but Kuosheng NPP took 15mk of margin

- **Computing tools**
  - In general, one deterministic code (e.g., CASMO-3/4) and one stochastic code (e.g., KENO, MCNP) will be used
  - The deterministic code will be mostly used as the production tool
  - A conservative bias against the stochastic code will be determined
    - Depending on the models, the deterministic code will normally give underestimated values (against the actual values calculated by the stochastic code without taking any approximation)

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Acceptance Criteria for Kuosheng Storage Racks

- **Any of the currently used BWR FAs designs with enrichment ≤ 3.4 wt% can be accommodated within the Kuosheng storage racks.**

- **Cases below the straight line in SCCG* could be accommodated in Kuosheng storage rack.**

- **Any FAs design with lattice-average uniform enrichment ≤ 4.8 wt% could be accommodated within Kuosheng storage rack if Gd content ≥13G2 or 8G3**

NON-ACCEPTABLE DOMAIN

$K\text{-}inf(e) = -0.0281e + 1.462$

ACCEPTABLE DOMAIN

Lattice-Averaged Uniform Enrichment (wt%)
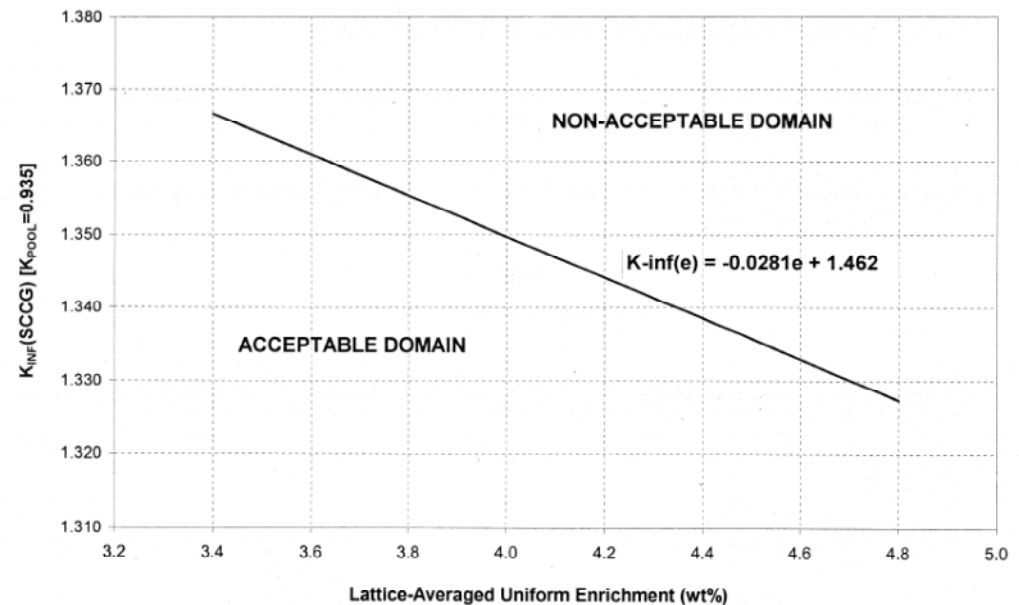
*SCCG: Standard Cold Core Geometry
(Uncontrolled lattice with a pitch of 6" and at 20°C)

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Findings from SFP Criticality Analysis (cont'd)

- **Critical experiment benchmarks**
  - Data are not easily and readily available, especially for SFP with neutron absorbers, e.g. Boral

- **Uncertainties & Bias**
  - For conservatism, a negative bias will be taken as zero; while a negative uncertainty should be still accounted for
  - Manufacturing tolerances are provided by rack vendors
  - There is no standardized or specific rule now for the determination of uncertainties & bias
    - Different vendors can use different sets of tolerances and/or abnormal event/accident scenarios
    - Depletion uncertainty plays a major role but is also very confusing (Kopp letter does not say specifically how to apply that 5% in details)

$$K_{max} = K_{Nominal} + \Delta K_{Total} = K_{Nominal} + \sum \Delta K_B + \sqrt{\sum (\Delta K_U)^2} \qquad [1]$$

Findings from SFP Criticality Analysis (cont'd)

- **Issue of Boral degradation**
  - The impact of Boral degradation to SFP criticality analysis is unknown now
  - No SFP criticality analysis includes the scenario of losing Boral to a various degree
    - Minimum Boral areal density is used in the models

Need of Assistance from USNRC

- The mechanism, safety impact and regulation for degradation of neutron-absorbing material permanently installed in spent fuel pool.

- The latest guidance and Standard Review Plan in "On Site Spent Fuel Criticality Analyses NRR Action Plan" & the reaction of fuel vendor proposed to new guidance and Standard Review Plan.

- Data of criticality experiments for benchmark according to latest guidance and SRP for spent fuel pool.

Future Works

- More extensive/intensive studies on SFP criticality analysis, including:

  – Model refinement & improvement

  – More analyses, especially to cope with the new SRP

  – Code benchmarks against critical experiment data

- Build up a licensing model for SFP criticality analysis

Thank for your attention!