OAK RIDGE National Laboratory

Calculation of Spent Fuel Pool Time-to-Boil using Polaris/ORIGAMI

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Overview

- Goal: calculate time-to-boil (TTB) for a Spent Fuel Pool (SFP)
  - TTB is important for SFP management
  - Represents the amount of time available to address loss of forced cooling
- Calculate and compare TTB for two cases using SCALE:
  - SFP containing representative LEU fuel (≤ 5 wt %)
  - SFP containing representative LEU+ fuel (5 – 8 wt %)
  - Approximately 2300 fuel assemblies in the SFP for each case

Methodology

$$\tau_{boil} = \frac{C}{Q_{GEN}}(212\,°\mathrm{F} - T)$$

- C is the SFP water thermal capacity (BTU/°F)
- Q_{GEN} is the heat generation rate in the SFP (BTU/h)
- T is the SFP bulk water temperature (°F)
- τ_{boil} is the time-to-boil (h)
- Time-to-boil requires decay heat of SFP
  - Water properties are known/assumed
  - SCALE is used to calculate Qgen term:
    - Depletion calculations performed using Polaris
    - Discharge/decay calculations performed using ORIGAMI

Methodology (cont.)

- For LEU:
  - Decay heat is taken as sum of:
    - (1 + 1/3) times discharge core decay heat (per NRC request), and
    - Decay heat of representative fuel already in the SFP
      - Data for representative fuel taken from UNF-ST&DARDS database
  - Depletion has been previously performed using TRITON to generate ORIGEN libraries for use with ORIGAMI
  - ORIGAMI calculations are run for core and SFP assemblies

Methodology (cont.)

- For LEU+:
  - Two cases are analyzed:
    1. (1 + 1/3) LEU+ core + representative LEU fuel in SFP (represents first LEU+ discharge core)
    2. (1 + 1/3) LEU+ core + representative LEU+ fuel in SFP (represents future LEU+ core)
  - To calculate decay heat for representative LEU+ SFP:
    - Start with representative LEU SFP assembly parameters
    - Multiply all burnups by a scaling factor of 1.35
    - This represents the approximate factor of 75 GWd/MTU divided by 55 GWd/MTU (LEU+ burnup divided by LEU burnup)
    - Enrichment and other parameters are not changed
  - Run Polaris to generate ORIGEN libraries for LEU+ core and representative LEU+ fuel in SFP
  - Run ORIGAMI to generate decay heat

Methodology – Discharge Cores

- LEU/LEU+ discharge cores are grouped to minimize calculations required. For each core:
  - Assemblies are sorted into four groups based on enrichment, absorber content, and location
  - Polaris depletion calculation is performed for each assembly over a range of burnups
  - Average burnup is calculated for each group
  - A single ORIGAMI discharge calculation is performed for each group
    - Group-wise enrichment, MTU, and average burnup are used
    - 100 hours is assumed between reactor shutdown and fuel being loaded into the SFP

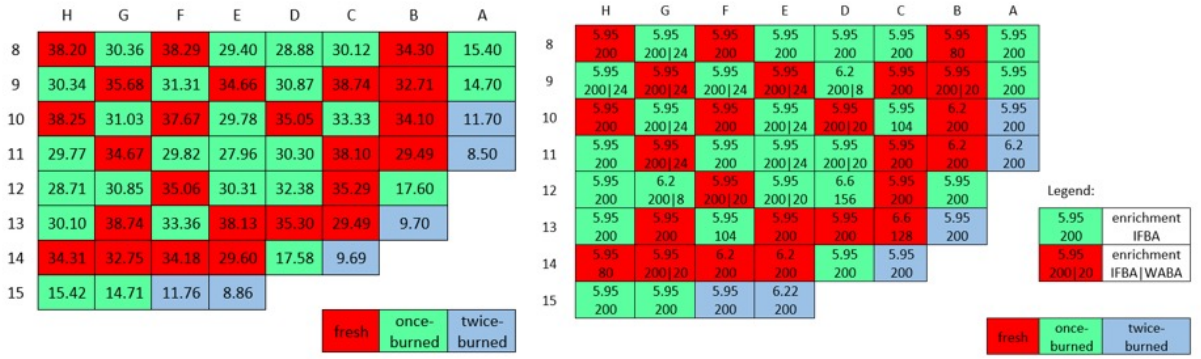

Figure 20. LEU+ Discharge Core Exposure Map (Left) and Enrichment Map (Right).

Time-to-Boil Results

- Time-to-boil is calculated for:
  - 1 + 1/3 LEU core + representative LEU fuel in SFP
  - 1 + 1/3 LEU+ core + representative LEU fuel in SFP (represents first LEU+ discharge core)
  - 1 + 1/3 LEU+ core + representative LEU+ fuel in SFP

	LEU Core and LEU SFP	**LEU+ Core and LEU+ SFP**	**LEU+ Core and LEU SFP**
Qgen, SFP (Btu/hr)	6.61E+06	9.99E+06	6.61E+06
Qgen, Total (Btu/hr)	6.77E+07	7.28E+07	6.94E+07
TTB (hr)	4.58	4.26	4.46

Time-to-Boil Conclusions

- Impact of LEU+ core on time-to-boil is very small
  - At such low cooling times, the impact of increased decay heat is not significant
  - Decay heat of SFP assemblies is small compared to discharge core decay heat