Topical Report BAW-10241 Discussion "The BHTP DNB Correlation With LYNXT"

Richard L. Harne
Framatome-ANP

Non-Proprietary Version

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FRAMATOME ANP

Agenda

- Purpose of the BAW-10241 Topical Report
- Description of the BHTP CHF Correlation
- Performance of the Correlation
- Application Limitations for the Correlation

Purpose of the BAW-10241 Topical Report

- **Background**
  - The magnitude of fuel rod failures, due to crossflow velocities through the slots and holes in the core baffle of B&W 177-FA plants, has warranted a change in the spacer grid design.
  - The resident Framatome-ANP fuel design at Crystal River-3 is the Mark-B10 with small contact points between the grids and fuel rods. Rod/assembly vibration has led to cladding erosion near such high crossflow velocities.

Mark-B Grid on Mark-B10 Fuel Design

Purpose of the BAW-10241 Topical Report

- **Background (cont'd)**
  - The formation of Framatome-ANP (joint venture of Framatome and Siemens) now allows the integration of proven hardware components across fuel design series for improved fuel reliability.
  - The HTP spacer grid design is a proven mechanically robust spacer grid design, with a line contact between the grids and fuel rods, that will significantly improve the fuel rod protection at the core periphery.

HTP Grid for Mark-B/HTP Fuel Design

Purpose of the BAW-10241 Topical Report

- **Background (cont'd)**
  - Progress Entergy desires to implement the HTP grid on the upcoming fresh fuel batch (Mark-B/HTP) for Crystal River-3. Startup: November 2003

Purpose of the BAW-10241 Topical Report

- **The HTP CHF correlation, applicable for the HTP spacer grid design, was developed using the XCOBRA-IIIC thermal-hydraulic code.**
  - XN-NF-75-21(P)(A) Revision 2, XCOBRA-IIIC: A Computer Code to Determine the Distribution of Coolant During Steady State and Transient Operation, Exxon Nuclear Company, January 1986.
- **The NRC-approved reload licensing tool set for Crystal River-3 reloads is the LYNXT thermal-hydraulic code.**
  - BAW-10179-A, Revision 4, Safety Criteria and Methodology for Acceptable Cycle Reload Analyses, Framatome-ANP, August 2001.
  - BAW-10156-A, Revision 1, LYNXT - Core Transient Thermal-Hydraulic Program, B&W Fuel Company, August 1993.

Purpose of the BAW-10241 Topical Report

- **The HTP grid designed for the Mark-B/HTP fuel design will have fuel design parameters that fall within the existing HTP correlation application range.**

	BHTP	HTP Approved Range
◆ Fuel Rod Diameter (in):	0.430	(0.360 - 0.440)
◆ Fuel Rod Pitch (in):	0.568	(0.496 - 0.580)
◆ Axial Spacer Span (in):	19.4	(10.5 - 26.2)
◆ Hydraulic Diameter (in):	0.525	(0.4571 - 0.5334)
◆ Heated Length (ft):	11.9	(9.8 - 14.0)

- **Application of the HTP correlation in LYNXT requires benchmarking of the correlation data base using the LYNXT code and NRC approval.**

Purpose of the BAW-10241 Topical Report

- Differences between XCOBRA-IIIC and LYNXT resulted in larger than desirable differences in the 95/95 DNB limit.
  - Water properties

- The coefficients in the correlation were adjusted to achieve a similar fit to the data with LYNXT and XCOBRA-IIIC

Purpose of the BAW-10241 Topical Report

- Application of the BHTP CHF correlation in Crystal River-3 reload analyses can be accomplished provided –
  - BAW-10241P, The BHTP DNB Correlation With LYNXT, is approved, and
  - BAW-10179P, Revision 5, Safety Criteria and Methodology for Acceptable Cycle Reload Analyses, Framatome-ANP is approved.

Contents of BAW-10241 Topical Report

- Introduction and Summary
  - Range of Applicability
  - Comparison of BHTP Correlation to Experimental Measurements
- The BHTP DNB Correlation
  - Base Correlation
  - Fuel Design Factor
  - Non-Uniform Axial Power Distribution Correction Factor
- Qualification of the BHTP DNB Correlation
  - Thermal-Hydraulic Models of Test Assemblies
  - Calculation Results and Analysis of Residuals
- Statistical Characterization of the BHTP DNB Correlation

Description of the CHF Correlations

- **BHTP CHF Documentation (under NRC review)**
  - BAW-10241P, BHTP DNB Correlation Applied With LYNXT, Framatome-ANP, December 2002.
- **HTP CHF Documentation**
  - EMF-92-153(P)(A) and EMF-92-153(P)(A) Supplement 1, HTP: Departure From Nucleate Boiling Correlation for High Thermal Performance Fuel, Siemens Power Corporation, March 1994.

Description of the CHF Correlations

- **HTP Data Base**
  - CHF data obtained at Columbia University's Heat Transfer Research Facility
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Description of the CHF Correlations

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Description of the CHF Correlations

- The differences between XCOBRA-IIIC and LYNXT resulted in different values for coefficients associated with enthalpy/mass flux/quality/pressure to yield desired empirical fits.

BHTP HTP

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Description of the CHF Correlations

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Performance of the BHTP CHF Correlation

- **A 95/95 safety limit for the BHTP correlation is 1.132** (compared to [ ] for the HTP correlation)

Performance of the BHTP CHF Correlation

- Comparison of the predicted DNB heat flux to the measured DNB heat flux for the entire data base

Performance of the BHTP CHF Correlation

- The frequency distribution of the predicted-to-measured DNB heat flux ratios for the entire database compared to a normal distribution

Performance of the BHTP CHF Correlation

- The residual analysis of the predicted-to-measured DNB heat fluxes showed no significant trends for the BHTP correlation.

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Application Limitations for the CHF Correlations

- **Coolant Ranges**

Variable	BHTP Minimum Value	BHTP Maximum Value	HTP Minimum Value	HTP Maximum Value
Pressure (psia)	1775	2425		
Local Mass Flux ($Mlb_m/hr\text{-}ft^2$)	0.897	3.549		
Inlet Enthalpy (Btu/lb_m)	383.9	644.3		
Local Quality	-0.130	0.344		

- **Fuel Design Parameters**

Parameter	Value
Fuel Rod Diameter (in)	0.360 – 0.440
Fuel Rod Pitch (in)	0.496 – 0.580
Axial Spacer Span (in)	10.5 – 26.2
Hydraulic Diameter (in)	0.4571 – 0.5334
Heat Length (ft)	9.8 – 14.0

Application Limitations for the BHTP CHF Correlation

- Code
  - BAW-10241 justifies the use of the BHTP correlation with the approved LYNXT code only.

Summary

- The BHTP correlation -
  - has been built upon the HTP correlation form and data base,
  - shows a similar performance level as the HTP correlation,
  - is identical to the HTP correlation with the exception of coefficients associated with enthalpy/pressure/mass flux/quality terms, and
  - has been justified for use with the LYNXT code.