VIPRE-D Topical Report
DOM-NAF-2
Information Meeting with NRC

Presenters

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Outline

I. Core Thermal-Hydraulics at Dominion

II. VIPRE-01 Licensing History

III. VIPRE-D is VIPRE-01

IV. DOM-NAF-2 Topical Philosophy

V. VIPRE-D Modeling

VI. Qualification of VIPRE-D Subchannel Model

VII. Standards for Core T/H Topical Reports

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I. Core Thermal Hydraulics at Dominion

- Current NRC-approved Code and Method
  - → COBRA-IIIC/MIT (VEP-FRD-33-A and VEP-NE-3-A)
  - → W-3 and WRB-1 CHF Correlations
- Current uses of COBRA-IIIC/MIT
  - → Statistical & Deterministic DNB FSAR Analyses
  - → Steady State & Transient DNB Evaluations
  - → Develop Reactor Core Safety Limits for DNB Protection
  - → Basis for Reactor Protection Setpoints (OTDT, OPDT, fdl)
  - → Code/correlation DNBR design limits
  - → North Anna and Surry Power Stations

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I. Core Thermal Hydraulics at Dominion

- Basis for switching to VIPRE-01
  - Fuel Vendor Independence
  - Industry-wide code with User's Group
  - Capable of analyzing PWRs
  - Capable of analyzing AOA/CIPS
  - Already approved for Westinghouse and AREVA fuel products and CHF correlations

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I. Core Thermal Hydraulics at Dominion

- Dominion Plan for VIPRE-01
  - Recover UFSAR Chapter 15 DNB analyses & RPS setpoint analyses for North Anna with AREVA fuel
  - Replace COBRA-IIIC/MIT for UFSAR Chapter 14 DNB & RPS setpoint analyses for Surry with Westinghouse fuel
  - Incorporate additional vendor CHF correlations for advanced fuel products
  - Use at other Dominion plants

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I. Core Thermal Hydraulics at Dominion

- Dominion Implementation of VIPRE-01
  - Compliance with Dominion's 10CFR50 Appendix B QA Program
  - Staff Qualification
    - → 20+ years of core T/H analysis experience
    - → Training on VIPRE-W with W-3 and WRB-1
    - → Training on thermal-hydraulic design bases at Westinghouse facilities
    - → In-house training on code enhancements

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II. VIPRE-01 Licensing History

- VIPRE-01 developed by Battelle for EPRI from COBRA codes (including COBRA-IIIC/MIT)
  - ➔NRC SER dated May 1986
- VIPRE-01 MOD-02
  - ➔Error corrections and enhancements 1 - 177
  - ➔Released April 1989
  - ➔NRC SER dated October 1993

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II. VIPRE-01 Licensing History

- VIPRE-01, MOD-02.1
  - → Error corrections and enhancements 178 - 231
  - → Released in May 2001
  - → No NRC review required
- Recent VIPRE-01 Approved Topicals
  - → Duke - VIPRE-01 + BWU CHF Correlations (2/97)
  - → Westinghouse - VIPRE-01 + WRB-1, WRB-2 and WRB-2M CHF Correlations (10/99)
  - → Kewaunee - VIPRE-01 + HTP CHF Correlation (9/01)

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III. VIPRE-D is VIPRE-01

- Dominion has made NO modifications to the NRC-approved constitutive models, equations, and algorithms in VIPRE-01
- Enhancements made to VIPRE-01 MOD 2.1 under 10CFR50 Appendix B
  - → Vendor Proprietary CHF Correlations
  - → Input/Output customizations to integrate VIPRE-01 with other codes
  - → Incorporate error corrections provided by code custodian after release of VIPRE-01, Mod. 2.1

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III. VIPRE-D is VIPRE-01

- Dominion verified that each enhancement did NOT affect any of the original internal models and algorithms present in VIPRE-01

- Dominion process to customize VIPRE-01 is identical to other approved topicals
  - → VIPRE-01 + CHF Correlations + Customizations
  - → Verify that additions do not affect any of the original internal models and algorithms

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III. VIPRE-D is VIPRE-01

- CHF Correlations
  - AREVA BWU-Z (DOM-NAF-2 Appendix A)
  - AREVA BWU-ZM (DOM-NAF-2 Appendix A)
  - AREVA BWU-N (DOM-NAF-2 Appendix A)
  - AREVA BWU-I
  - Westinghouse W-3
  - Westinghouse WRB-1

III. VIPRE-D is VIPRE-01

- Code Customizations
  - Option to apply each CHF correlation at its applicable axial location
  - Checks hot channel parameters against range of validity for each CHF correlation
  - Increased stacked cases from 30 to 1000
  - Increased # of axial nodes from 80 to 201
  - Ability to adjust radial power distribution according to partial power multiplier when iterating on power for a given MDNBR

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IV. DOM-NAF-2 Topical Structure

- Non-proprietary
  - Vendor CHF test data already at NRC
  - Fuel specific parameters omitted (FLC, $F_{\Delta H_E}$)
- Level of detail comparable to approved VIPRE-01 topicals
- Divided in two parts:
  - Main body - VIPRE-01 modeling choices
  - Appendixes - code/correlation DNBR design limits for fuel vendor CHF correlations

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IV. DOM-NAF-2 Topical Structure

- Intended Uses (Section 2.1)
  - Statistical & Deterministic DNB FSAR Analyses
  - Steady State & Transient DNB Evaluations
  - Development of Reactor Core Safety Limits
  - Basis for Reactor Protection Setpoints
  - Code/correlation DNBR design limits
  - Analysis of 14x14, 15x15 and 17x17 fuel in PWR reactors
    - → North Anna, Surry and plants of similar design

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IV. DOM-NAF-2 Topical Structure

- Compliance with VIPRE-01 SER (Section 2.2)

1. PWR licensing calculations with heat transfer regime up to CHF
2. CHF correlations reviewed and approved by NRC. DNBR design limits will be derived and submitted to NRC for review and approval.
3. Justification for all modeling assumptions
4. Appropriate time steps selected for transient analyses
5. Code maintained within Dominion's 10CFR50 Appendix B Quality Assurance program.

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IV. DOM-NAF-2 Topical Structure

- VIPRE-D Code Description (Section 3)
- VIPRE-D Modeling (Section 4)
- Qualification of Subchannel Model (Section 5)
- Appendix A: DNBR Design Limits for BWU CHF Correlations

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V. VIPRE-D Modeling

- Modeling choices described in Section 4 are consistent with industry practice and satisfy SER Restriction #3
- User instructions are not part of a Topical
  - VIPRE-01 User Manual fully applicable
  - VIPRE-D manual constructed to describe code enhancements (e.g., how to select the BWU-Z CHF correlation)

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V. VIPRE-D Modeling

VIPRE-01 MODEL	SELECTION	DOM-NAF-2
Turbulent Mixing	No momentum mixing ABETA = 0.038	Section 4.5
Axial Friction Losses	McAdams Correlation	Section 4.6
Crossflow Resistance	Idel-Chik Correlation	Section 4.6
Two Phase Flow and Heat Transfer	EPRI Correlations Dittus-Boelter Correlation	Sections 4.8 & 5.4
Run Control Parameters	Default Options with Courant > 1 for transients	Section 4.12

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V. VIPRE-D Modeling

- Fuel Specific Parameters
  - Radial Nodalization - Section 4.1 method applicable to 14x14, 15x15 and 17x17 fuel
  - Radial Power Distribution - Section 4.4 method applicable to 14x14, 15x15 and 17x17 fuel
  - Axial Nodalization
  - Fuel Rod Modeling (dummy rod model)
  - Form Loss Coefficients (vendor proprietary)
  - CHF Correlation (vendor proprietary)
  - Engineering Factors (vendor proprietary)

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VI. Qualification of VIPRE-D Subchannel Model

- 173 Statepoints from UFSAR Chapter 15 (Section 5.1)
  - → Reactor Core Safety Limits
  - → Axial Offset Envelopes
  - → Rod Withdrawal at Power
  - → Rod Withdrawal from Subcritical
  - → Control Rod Misalignment
  - → Loss of Flow Accident
  - → Locked Rotor
- Main Steam Line Break (Section 5.2)

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VI. Qualification of VIPRE-D Subchannel Model

- Exercise DNB sensitivity to
  - ➔Power level, pressure and temperature
  - ➔Axial power shapes
  - ➔Elevated Hot Rod Power
  - ➔Low Flow

VARIABLE	RANGE
Pressure [psia]	1860 to 2400
Power [%]	66 to 135
Inlet Temperature [°F]	506.6 to 626.2
Flow [%]	64 to 100
FΔH	1.49 to 1.945
Axial Offset [%]	-48.7 to 57.9

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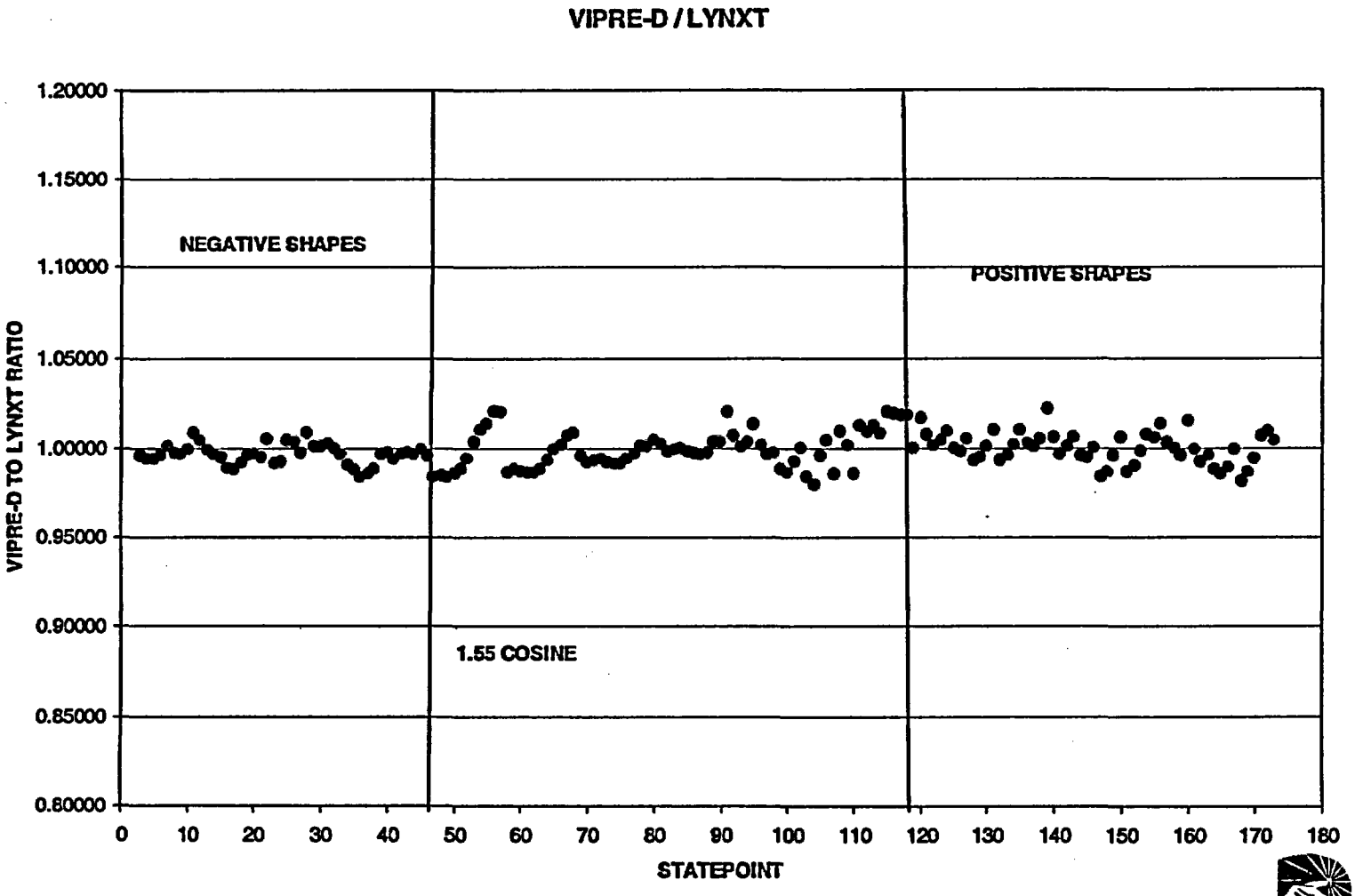
VI. Qualification of VIPRE-D Subchannel Model

- Benchmarked to the AREVA LYNXT code
  - Average Deviation in MDNBR of 0.14%
  - Maximum Deviation in MDNBR of 2.2%
  - Within 5% uncertainty associated to thermal-hydraulic codes

VI. Qualification of VIPRE-D Subchannel Model



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VI. Qualification of VIPRE-D Subchannel Model

- Transient calculations (Section 5.3)
  - VIPRE-01 transients in EPRI NP-2511-CCM still applicable
  - VIPRE-D - demonstrate model integrity and code capability to process forcing functions
  - LOFA and RWAP examples
  - Transient MDNBR was rerun as a steady-state statepoint condition --> same result

VII. Standards for Core T/H Topical Reports

- VIPRE-D is VIPRE-01: VIPRE-01 qualification is fully applicable
- DOM-NAF-2 includes expected uses and compliance with VIPRE-01 SER
- Dominion qualification of subchannel models consistent with approved VIPRE-01 topicals
- DOM-NAF-2 format and level of detail consistent with approved VIPRE-01 topicals

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VII. Standards for Core T/H Topical Reports

- Dominion develops DNBR design limits from test section data
  - COBRA/WRB-1
  - VIPRE-D/BWU (Appendix A)
- NRC expectations for qualification of CHF correlations (Appendix A)

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