Discussion on WCAP-12472, Addendum 2, "BEACON Core Monitoring & Operation Support System" (Slide Presentation of June 25, 2001), (Proprietary)

June 2001

NRC / Westinghouse / CCNPP

BEACON Discussions

June 25, 2001

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Agenda

- Introductions
- BEACON Overview Presentation
- Review/Discussion of Preliminary NRC Questions
- Next Steps / Wrap-up

Monitor Functions

- Monitor Core Power Distributions
- Directly Monitor PLHR
- Prompt Anomaly Detection
- On-line Display of
  - Current Operating Conditions
  - 24 Hour Data Trend
  - Xenon Distribution and Worth
  - Soluble Boron Concentration (including B_{10} depletion)
  - Quadrant Power Tilt Ratio
- With Plant Specific licensing, can be used for power distribution surveillances

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BEACON Power Distribution Measurement Methodology

- BEACON can use Moveable Incore Detectors (MIDs) or Fixed Incore Detectors (FID's)
- On-Line Nodal Model Provides 3D Power Distributions and Associated Detector Reaction Rates
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- Nodal Calibration Factors are Used to Infer Measured Power From Predicted Power

Measurement Data Utilized

- Loop inlet temperatures
- Control rod positions
- Reactor power
- Boration and Water Flow Rates
- Incore detector signals for FID plants

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BEACON FID Methodology

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BEACON FID Methodology

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BEACON FID Methodology

- Predicted Power Distribution
  - Predicted by the BEACON neutronics model at the current core conditions
  - Uses current measured core parameters
    - Power level
    - Rod Insertion
    - Temperature
  - Incorporates as-operated burnup history

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BEACON Rh FID Methodology

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BEACON Rh FID Methodology

- Microscopic Cross Sections Obtained from PHOENIX-P
- Instrumentation Thimble Flux Obtained from ANC Pin Power Reconstruction Methodology

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BEACON Vd FID Methodology

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BEACON Vd FID Methodology

- Microscopic Cross Sections Obtained from PHOENIX-P
- Instrumentation Thimble Flux Obtained from ANC Pin Power Reconstruction Methodology

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BEACON Pt FID Methodology

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BEACON Pt FID Methodology

- Gamma and Neutron response functions obtained from PHOENIX-P
- Fuel Pin Weighting factors obtained from MCNP
- Assembly pin powers obtained from ANC Pin Power Reconstruction Methodology

Advantages Pt and Vd Detectors

- Rh detectors have a relatively short life (2-3 fuel cycles because of:
  - depletion of material
  - cracking of detector material or sheathing
- Both issues addressed by either Pt or Vd detectors
  - very slow depletion due to low absorption
  - more ductile than Rh
- Expected lifetime 15-20 years
- Long lifetime demonstrated in operating reactors

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Uncertainty Methodology

- Discussed in Addendum 1
- Strongly a function of
  - detector variability
  - number/location of detectors
- Detector variability strongly dependent on detector material and length of detectors
- Number / location of detectors is plant/vendor dependent

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Example F_{DH} (F_R) Uncertainty

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Example F_Q (kw/ft) Uncertainty

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Detector Configuration

- Detectors typically consist of strings of 4 to 7 detectors per string
- Specific characteristics vary among plants / vendors
  - length of individual detectors
  - use of background wires / live tails
  - diameter of detector wires
  - characteristics of sheathing
  - etc.

Detector Configuration

- It is not the intent of the BEACON Topical Report Addenda to address all the physical configuration of the detectors
- Addenda primarily focus on:
  - the ability of BEACON to predict the detector current given a specified detector material (Rh, Pt, Vd)
  - the uncertainty in the power distribution measurement given the detector variability

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Detector Configuration

- BEACON Addenda have covered a wide range of detector configurations addressing:
  - detector material (Rh, Vd, Pt)
  - number of detectors per string (4-7)
  - number / location of detectors within the core (CE, B&W, VVER design reactors)
  - physical characteristics of the detector detector including new axial layout (OPARSSELS)
- Combinations of these features are possible

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OPARSSEL Detector

- Optimized Proportional Axial Region Signal Separation, Extended Life (OPARSSEL) detector used for Vd demonstration strings
- Five Over-Lapping, Sequentially Increasing Length Vanadium Elements
- By subtraction, results in the equivalent of 5 detectors each covering 20% of the core height
- Provides higher signal strength and lower variability

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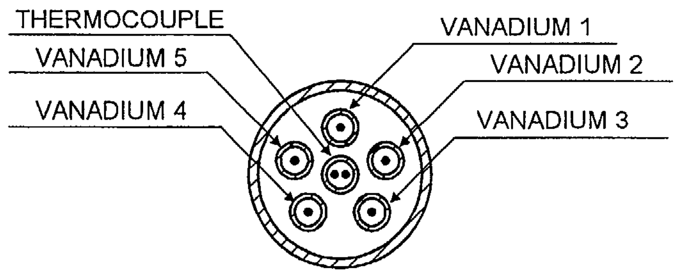

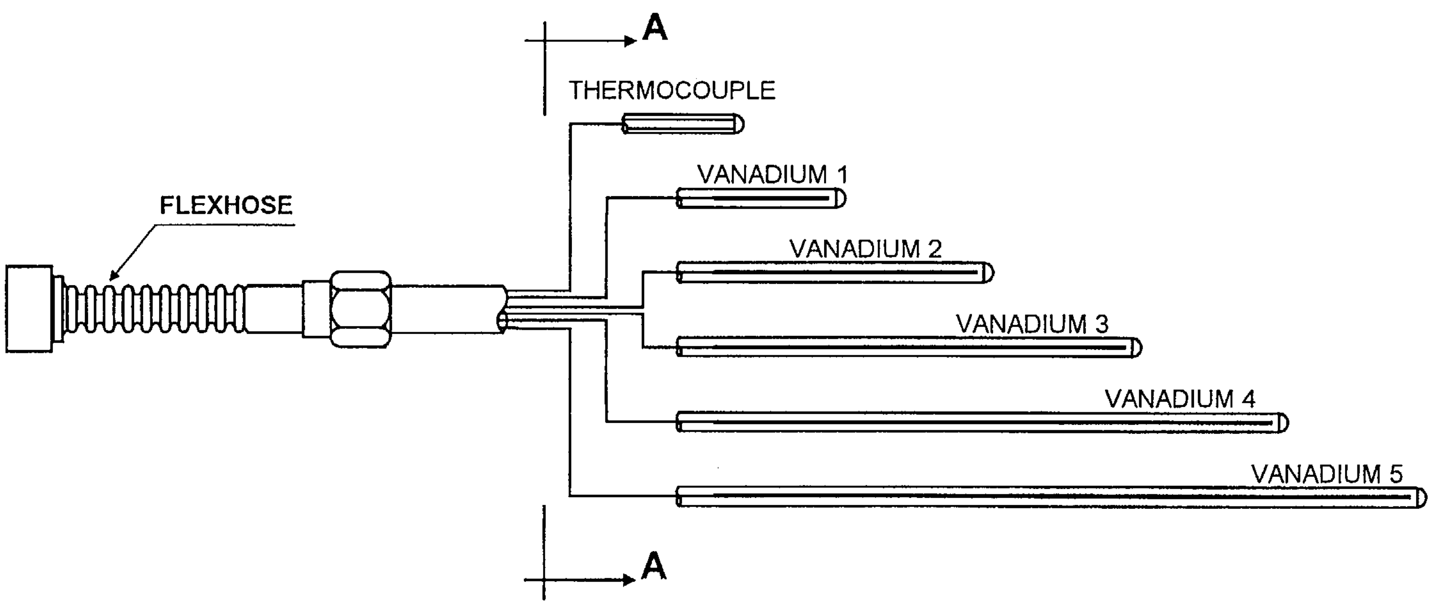

OPARSSEL SELF-POWERED NEUTRON DETECTOR GENERAL ARRANGEMENT

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Summary

- BEACON methodology has been developed for FID based monitoring using SPDs
- Methodology has been confirmed through years of in-plant demonstration
- Addendum 2 extends methodology to address both Pt and Vd based detectors