Safety and Performance in Current NPPs

Application of Advanced Technology to Improve Plant Performance

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A Gold Mine is Hidden in Every Nuclear Power Plant

- What is it?
- Where is it?
- How to get to it?
Opportunities

• Improve safety, reliability, availability, and productivity
• Optimize maintenance, predict when equipment may fail, or if the process has anomalies
• Support aging management, license renewal, long life operation
• Contribute to power uprates, shorter outages, and longer cycles

All These Can Be Done Passively, Remotely, and While the Plant is Operating!
Terminology/Analogy

- Instrumentation
- Visual Inspection
- Acoustic Monitoring

Calibration
Prognostics

Feeling Good

Normal

Back at Work
What is the Gold Mine?

DATA

Applies to Conventional & Advanced LWRs, HWRs, HTGRs, LMFBRs, Gen IV, and even Research Reactors
What Does It Look Like?

Flow vs. Time

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What Can We Do With It?

- Measure vibration of reactor internals
- Identify blockages, voids, and leaks
- Detect venturi fouling
- Verify the calibration and response time of I&C systems
- Develop passive fluid flow measurement system
- Monitor for degradation of neutron instrumentation systems
- Determine core stability margin
- Identify temperature coefficient of reactivity
- Detect water chemistry changes and valve problems
Reactor Internal Vibration Measurement by Neutron Noise Analysis

- Reactor vessel
- RX coolant pump
- Core barrel shell mode
- Core barrel beam mode
- Thermal shield
- Fuel assembly
- Thermohydraulic fluctuations

Graph showing APSD (Power Spectral Density) with vertical bars and a line graph. The horizontal axis represents time (0-30) and the vertical axis represents the APSD scale (1E-9 to 1E-1). The diagram includes labels for different components of the reactor and its environment.
Sensing Line Blockages Can Be Dangerous

![Graph showing PSD vs. Frequency for Blocked and Cleared Pressure Transmitter Sensing Lines.]

- **Blocked Pressure Transmitter Sensing Line**
- **Cleared Pressure Transmitter Sensing Line**

Partially Blocked

Completely Blocked

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Detect RCP Leak

Chemical and Volume Control System (CVCS)
Venturi Fouling is Detectable and Quantifiable

Venturi Fouling Can Waste More than 2% of the Reactor Power

Venturi Fouling
Challenges

• Sufficient data is not always available from existing sensors
• Process sensors do not always have high fidelity
• Advanced sensors and techniques are not yet widely available for in-situ or on-line monitoring of material degradation (vessel, cables, etc.)
What Is The Lesson?

- Sample Data Fast (e.g. 1000 Hz) and store it
- Add wireless sensors
- Build these technologies in NPPs of today and tomorrow
- Work on sensors and technology for material degradation monitoring
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• Compliance

• Non Compliance