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Scientech User Group Meeting



Wireless Technology Implementation in Nuclear Power Plants

Overview of Wireless Technology Implementation

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What is going on with Wireless

- Shift in focus from condition monitoring to the mobile workforce
- Ongoing work on industry wireless protocols
- New engineers expect mobility
- Most applications based on Wi-Fi technology





Nuclear Guidance on Wireless Technology

- IEC TR 62918 Ed. 1.0 Released July 2014
 - General Overview of Wireless Technologies
 - Description of Existing Wireless Installations
- EPRI TR-102323 Rev 4 Released Dec 2013
 - Address Exclusion Zones
 - Spectrum Management
- Miscellaneous Documents
 - NRC: Applications and Coexistence
 - EPRI: General Guidance and Implementation



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Guidance Under Development

- IEC Wireless Standard Development
 - Build upon IEC Report
- IAEA Coordinated Research Project
 - Report of Wireless Technology
- NRC Reg. Guide 1.180 Revision 2
 - EMC Wireless Guidance: Exclusion Zones
- EPRI TR-102323 Revision 5
 - EMC Wireless Guidance: Exclusion Zones
 - Build upon Appendix
- IEC 62003 Ed. 2
 - EMC Standard



Applications of Wireless Technology in Nuclear Power Plants

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On-line Monitoring – Wireless Applications

Arkansas Nuclear One (ANO)

- Containment Cooling Fans
- CEDM Cooling Fans
- Oil Collection Tanks



High Flux Isotope Reactor (HFIR)

- Cooling Tower Fans
- Cold Source Expansion Engines



Benefits:

- Automatically Perform Routine Surveillance Testing on Equipment
- Enables Monitoring in Hard to Access or Hazardous Locations
- Provides Solution to the High Cost of Running Cable



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NPP Application: ANO Containment Fans

- Purpose: Circulate and cool containment air maintaining uniform ambient temperature, preventing localized 'hot spots'
- Significance: Failure of a single fan causes unit to shut down if repair takes longer than 72 hours
- Current data collection: Every 9 months
- Failure history: 1 fan failure every 4 years
- Average downtime due to fan failure: 5 days





In-Containment Specifications

Requirements	Description
EMI/RFI	System must not interfere with existing equipment, nor be impacted by the target environment; communication frequency must be 2.4 GHz.
Cyber Security	System must incorporate Wi-Fi Protected Access II (WPA2) security features
Fire Load	System must not add appreciable combustible material to containment
Secure Anchoring	System must be anchored such that it cannot be dislodged and swept into the sump system
Ambient Environment	System must survive at 95°F, relatively low humidity, and low levels of radiation (e.g., <1 mrem/hr)



ANO Containment Wireless Cooling Fan Vibration & Tank Level

Unit 1 Cooling Fans





Unit 2 Cooling Fans





Unit 1 Oil Tank Level







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WiFi Data displayed in ANO Plant Computer





HFIR System Description





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Vibration Analysis at HFIR Expansion Engines

- Analysis shows smooth operation of 3 engines
- 4th engine shows erratic and high vibration levels
- Engine failed in service in the next operational cycle





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EMI has Hindered Wireless





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What is the Issue?

- Most equipment was not qualified
- Equipment that was qualified was only tested to 1 GHz
- Qualification testing may not have replicated the plant installation
 - Door may have been closed
 - Cabling my not have matched plant wiring
 - Configuration may not have replicated installation
- Assumption is made that 4 V/m is tolerable by plant equipment
 - In some cases this may be overly conservative but in other cases it may not be adequate
 - This really only applies to equipment that was tested to 10 V/m (8dB greater)
- EPRI and NRC both provide an equation for calculating the exclusion distance that is based on free space propagation



Radio Exclusion Zone Equation

Exclusion Zone distance is dependent upon transmitter power and antenna gain.

$$d = \frac{\sqrt{30P_tG_t}}{E} (meters)$$

Where:

(in Volts/meter)





Can you hear me now?





Don't forget the antenna

Omni-Directional Antenna



Directional Antenna









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Frequency DOES MATTER





Limitations of exclusion zones

- Adequate/Clear Signage
- Knowledgeable Personnel
- Varying output power of different devices
- Inadequate clearance
- Improperly applied
- Based upon an assumed level of immunity
- Continuously updated for new equipment









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Example Exclusion Zones from a Nuclear Utility

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- Laptop computer/VoIP communication devices
 - Exclusion distance = 32"
- Tablet computer such as the iPad (without integrated cell phone – recommended - or cell disabled) and other handheld logging devices (use iPad mini distance);
 - Exclusion distance for iPad 2 = 4 FT
 - Exclusion distance for iPad mini / iPad Air = 6 FT
 - Exclusion distance for iPad 4 = 8 FT
- Wireless vibration monitoring probe
 - Exclusion distance = 24"
- Wireless dosimetry
 - Exclusion distance = 12"



Methods for Overcoming Exclusion Zone Limitations

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- Hope for the best
- Perform an engineering evaluation of the equipment to assess its vulnerabilities to wireless
- Harden equipment against wireless signals
- Perform qualification testing of similar equipment at the manufacturer's facility/warehouse/training center/simulator
- Perform in-situ immunity testing of the plant equipment
- Install new equipment with demonstrated immunity to wireless
- Reduce output power of wireless devices



Diablo Canyon Investigating Wireless

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- Fire sparked need for evaluating impact of wireless devices on plant equipment
- Implementation Project
 - Walkdown of Equipment
 - Characterize Electromagnetic Environment
 - Immunity testing of plant equipment





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Immunity Test Diagram





Plant Equipment Tested for Slide 24 of 27 Immunity

- Various Barton and Rosemount Pressure, Level, and Flow Transmitters
- Various Relays and Modules associated with 4160V Vital Bus
- Seismic Trigger Instrumentation
- Digital Feedwater Control System Development Simulator
- Turbine Control System Development Simulator
- Source Range Nuclear Instrumentation System Training Drawer
- Intermediate range Nuclear Instrumentation System Training Drawer
- Solid State Protection System Training Cabinet
- Radiation Monitors

These devices tested represent a total of 1702 installed devices in the plant.



Identification of Vulnerable Equipment

- Barton 763 Pressure
 Transmitter
- Barton 368 & 369 Pressure Transmitters
- Victoreen Radiation Monitor model 876A:
- Rochester Position Transmitter Model SC-1300R
- Victoreen radiation detector and preamplifier assembly model 943-25T





Summary

- Wireless technology can be successfully used in a nuclear power plant
- The risks and concerns can be addressed and mitigated
- Guidance and OE is being gathered and developed
- How can wireless benefit you?





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Thank You



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