Non-Invasive Digitization of Existing Nuclear Plants

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Southern Nuclear CYPRESS ENVIROSYSTEMS

Problem: Most Plant Data is NOT Digitized

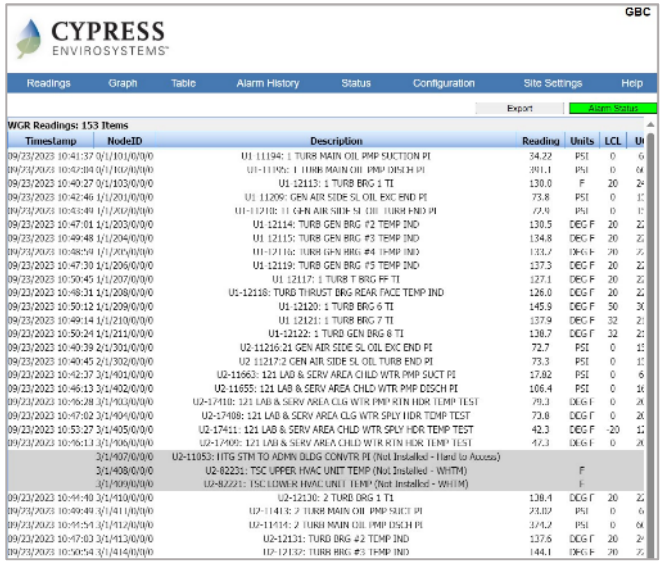
Safety, Reliability, Efficiency and AI: Requires more data, more frequently

Solution: Non-Invasive Sensors – 5 Minute Install

Connection via
RESTful API or OPC

Historian

HMI



"Digital Overlays": Wireless, battery operated, does not touch plant process: ~10% the cost of traditional instrumentation

Southern Nuclear

CYPRESS ENVIROSYSTEMS

ANS

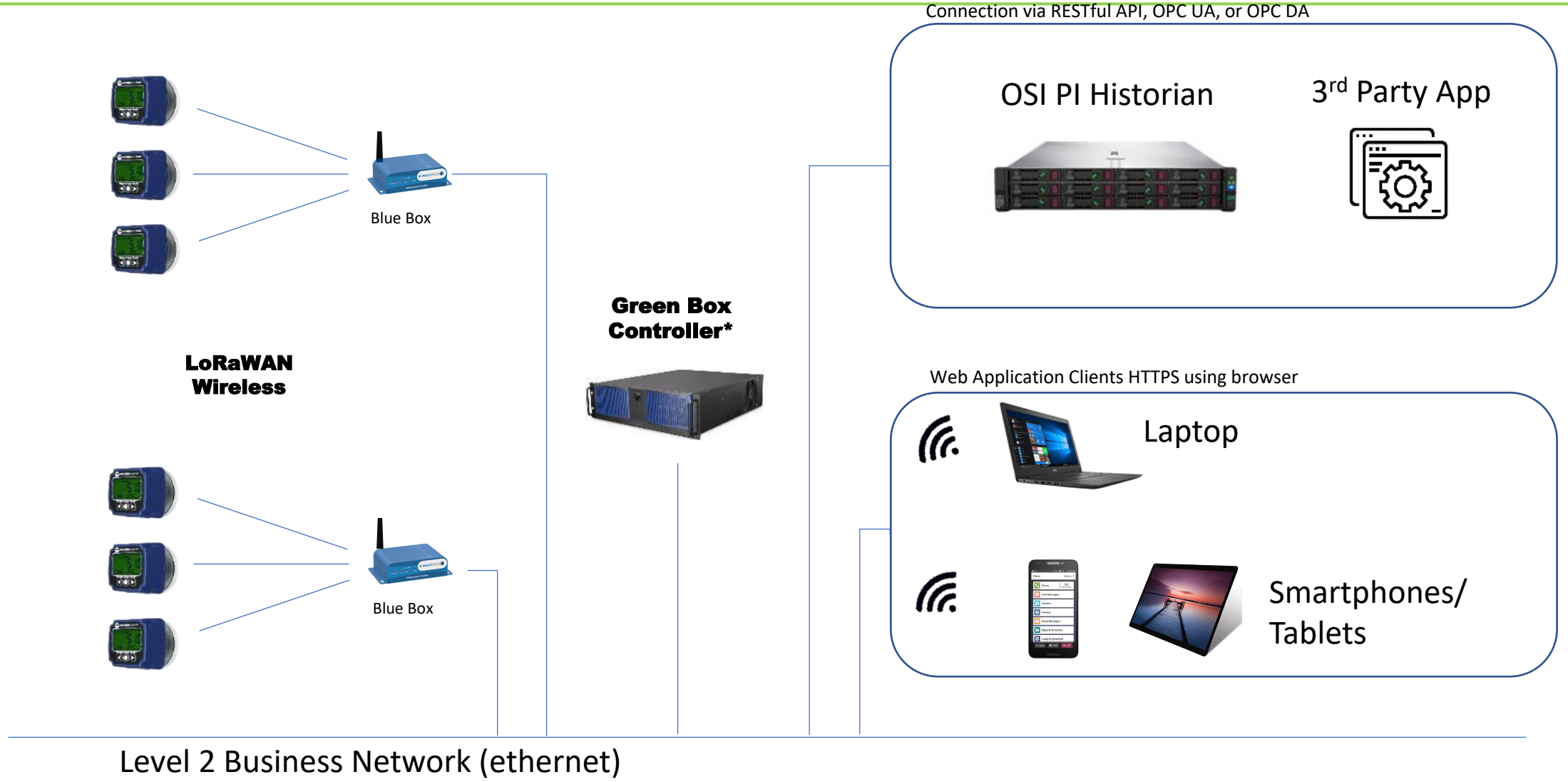
Typical Installation

Minimal disruption to existing operator rounds

Typical Installation – cont'd

Outdoors, Radiologically Controlled Area, Safety Related, Seismic Related

Integration with Plant Data Network – Cyber Approved



Non-Invasive Sensors – “Digital Overlays”

Wireless Gauge Reader

Cycle Isolation Valve Monitor

Wireless Temperature and Humidity Monitor

Wireless Rad Monitor

Webcam Digitization
(machine vision)

Vibration Sensors

Wireless Transducer Reader
(thermocouples, 4-20mA, 0-5V, dry contacts, RS-232 etc.)

Magnetic Mount Thermocouple

Void Detection

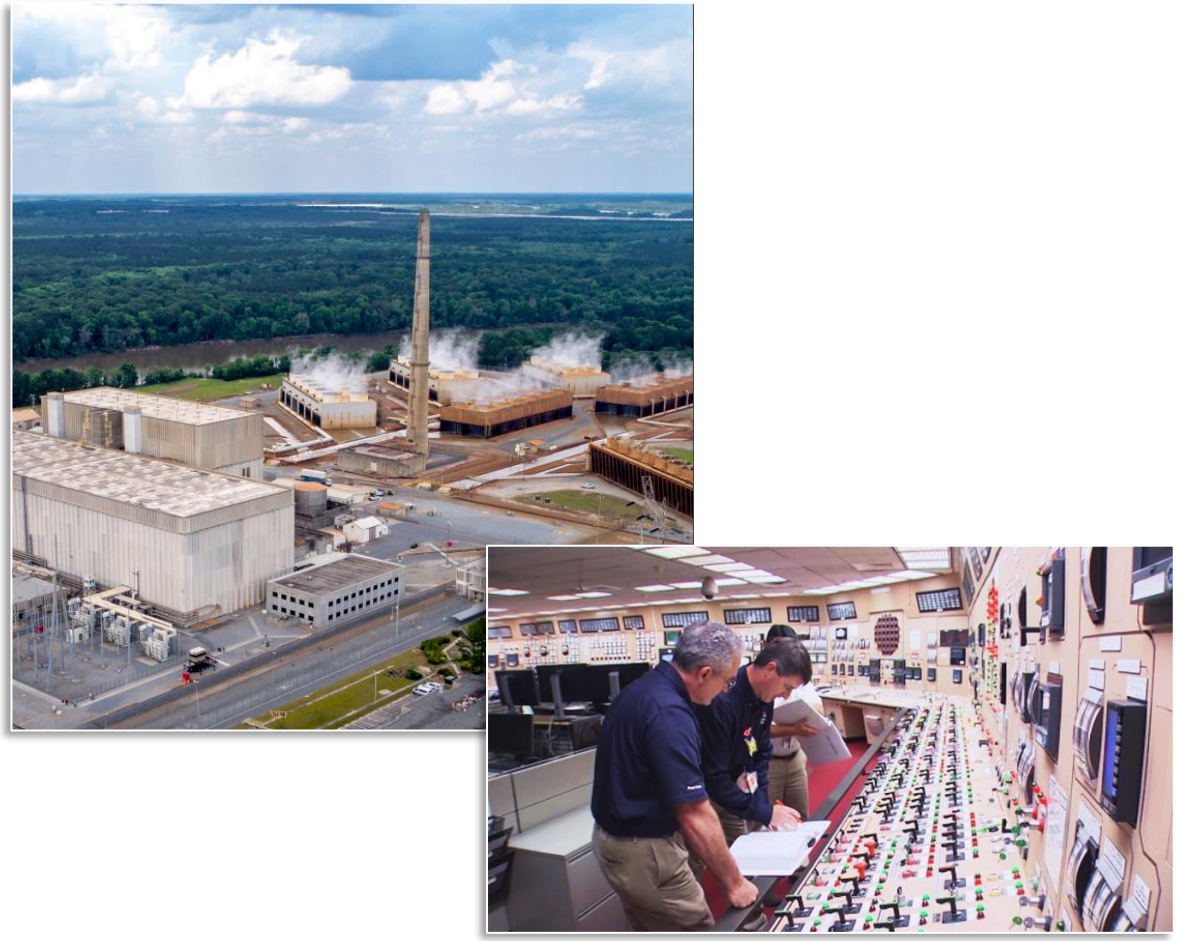
Drone Integration
(machine vision)

Wireless, Battery Operated, Non-Invasive, Install in Minutes
10% Cost of Traditional Approaches

Non-Invasive Digitization Deployment at:

Southern Nuclear Company Plant Hatch, Baxley, Georgia United States

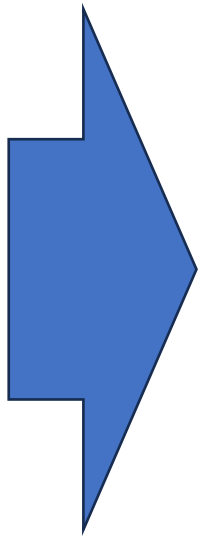
Reactor Type:	GE BWR-4
Units Operational:	2 x 900 MW
Start Operations:	1975 (Unit 1)
	1979 (Unit 2)



Plant-wide Engagement – Broad benefits

DEPARTMENT:

- Operations
- Maintenance
- Engineering
- Chemistry
- Radiation Protection
- Monitoring & Diagnostics Center



BENEFITS:

- Improve operator efficiency
- Equipment fault detection/reduce unplanned downtime
- Reduce maintenance cost – enable condition-based maintenance
- Optimizing plant thermal performance
- Improve worker safety – ALARA, heat stress
- Troubleshooting via crash cart, emergent needs

Long Term Trending: Turbine Valve Actuator Temperatures

Need:

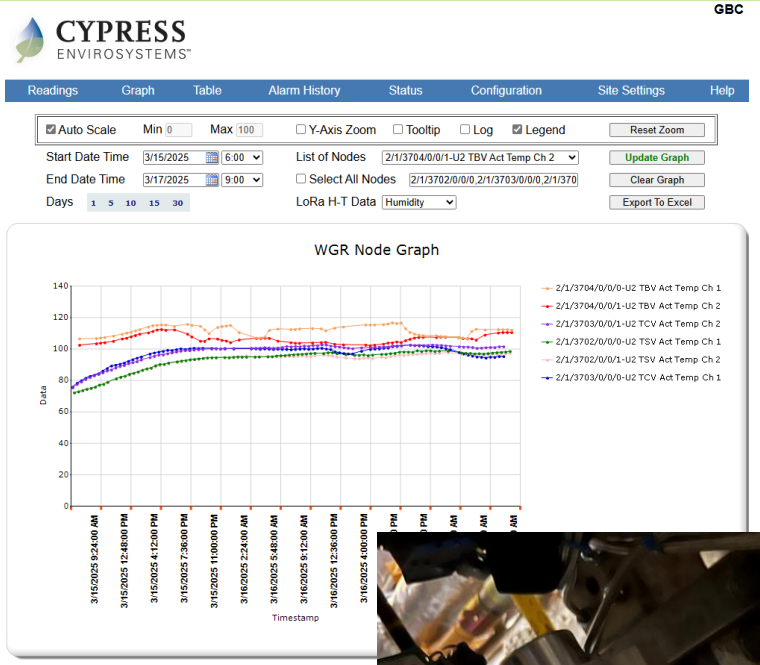
- Long term temperature trending to monitor for EHC fluid degradation due to temperature

Solution:

- Install magnetic thermocouples to each Turbine Valve Actuator

Benefit:

- Real time temperature monitoring without entry into Condenser Bay
- Eliminate Radiation dose and heat stress to personnel
- Avoid Turbine Valve failures due to EHC fluid degradation



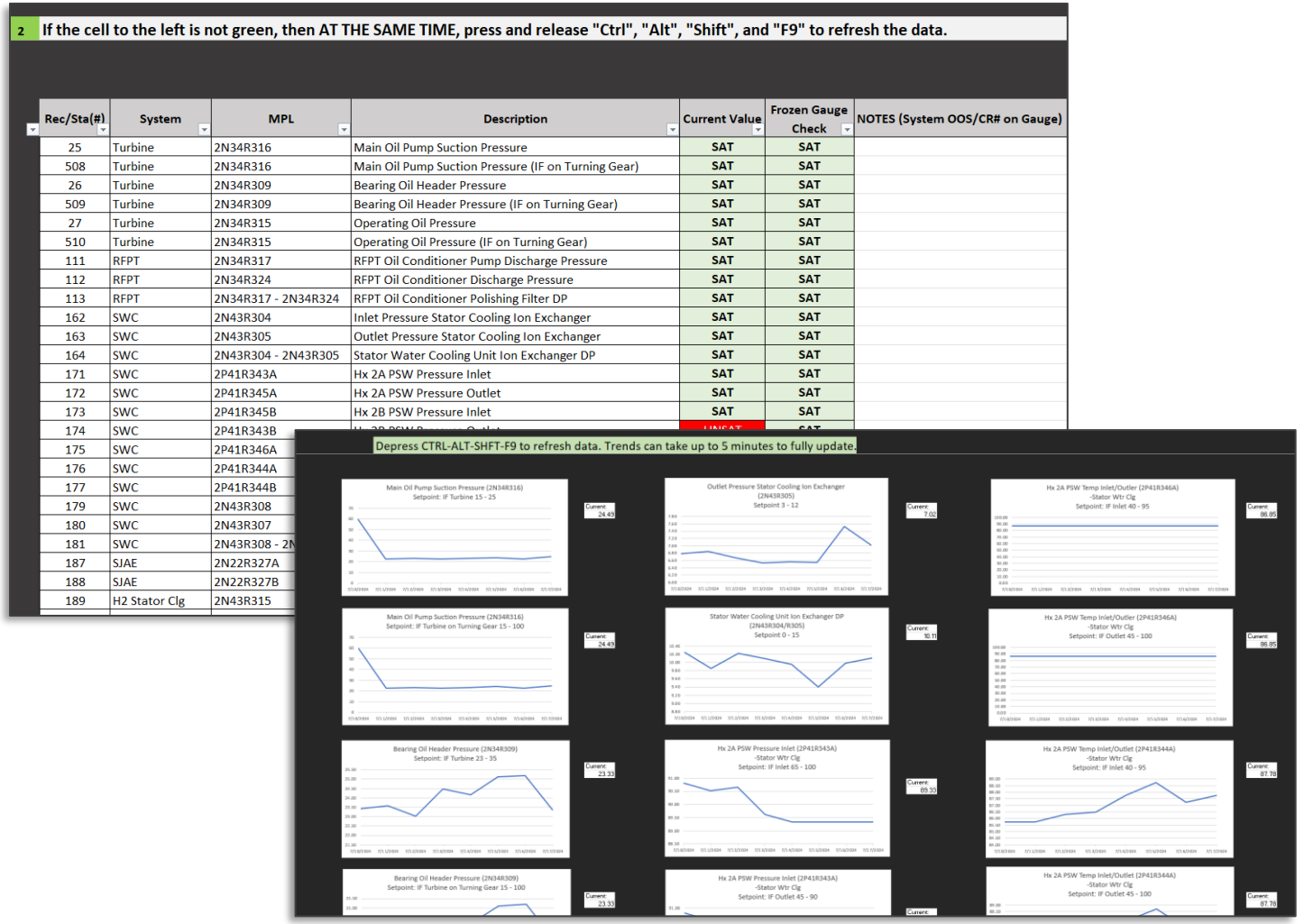
Operator Rounds Dashboard

Concept:

- Collect rounds data throughout day using WGRs
- Operators can review trends and identify abnormalities at start of shift
- Plan and prioritize work more efficiently

Benefit:

- Reduce operator time by 2 hours per shift
- Faster response to excursions / emergent issues



2 If the cell to the left is not green, then AT THE SAME TIME, press and release "Ctrl", "Alt", "Shift", and "F9" to refresh the data.

Rec/Sta(#)	System	MPL	Description	Current Value	Frozen Gauge Check	NOTES (System OOS/CR# on Gauge)
25	Turbine	2N34R316	Main Oil Pump Suction Pressure	SAT	SAT	
508	Turbine	2N34R316	Main Oil Pump Suction Pressure (IF on Turning Gear)	SAT	SAT	
26	Turbine	2N34R309	Bearing Oil Header Pressure	SAT	SAT	
509	Turbine	2N34R309	Bearing Oil Header Pressure (IF on Turning Gear)	SAT	SAT	
27	Turbine	2N34R315	Operating Oil Pressure	SAT	SAT	
510	Turbine	2N34R315	Operating Oil Pressure (IF on Turning Gear)	SAT	SAT	
111	RFPT	2N34R317	RFPT Oil Conditioner Pump Discharge Pressure	SAT	SAT	
112	RFPT	2N34R324	RFPT Oil Conditioner Discharge Pressure	SAT	SAT	
113	RFPT	2N34R317 - 2N34R324	RFPT Oil Conditioner Polishing Filter DP	SAT	SAT	
162	SWC	2N43R304	Inlet Pressure Stator Cooling Ion Exchanger	SAT	SAT	
163	SWC	2N43R305	Outlet Pressure Stator Cooling Ion Exchanger	SAT	SAT	
164	SWC	2N43R304 - 2N43R305	Stator Water Cooling Unit Ion Exchanger DP	SAT	SAT	
171	SWC	2P41R343A	Hx 2A PSW Pressure Inlet	SAT	SAT	
172	SWC	2P41R345A	Hx 2A PSW Pressure Outlet	SAT	SAT	
173	SWC	2P41R345B	Hx 2B PSW Pressure Inlet	SAT	SAT	
174	SWC	2P41R343B		UNSAT		
175	SWC	2P41R346A				
176	SWC	2P41R344A				
177	SWC	2P41R344B				
179	SWC	2N43R308				
180	SWC	2N43R307				
181	SWC	2N43R308 - 2N				
187	SJAE	2N22R327A				
188	SJAE	2N22R327B				
189	H2 Stator Clg	2N43R315				

Depress CTRL-ALT-SHFT-F9 to refresh data. Trends can take up to 5 minutes to fully update.

Credit: Operator Dashboard developed by J. Plumb, Operator at Duke Energy, Oconee Nuclear Plant

Dry Well Temp / Humidity Monitoring

Need:

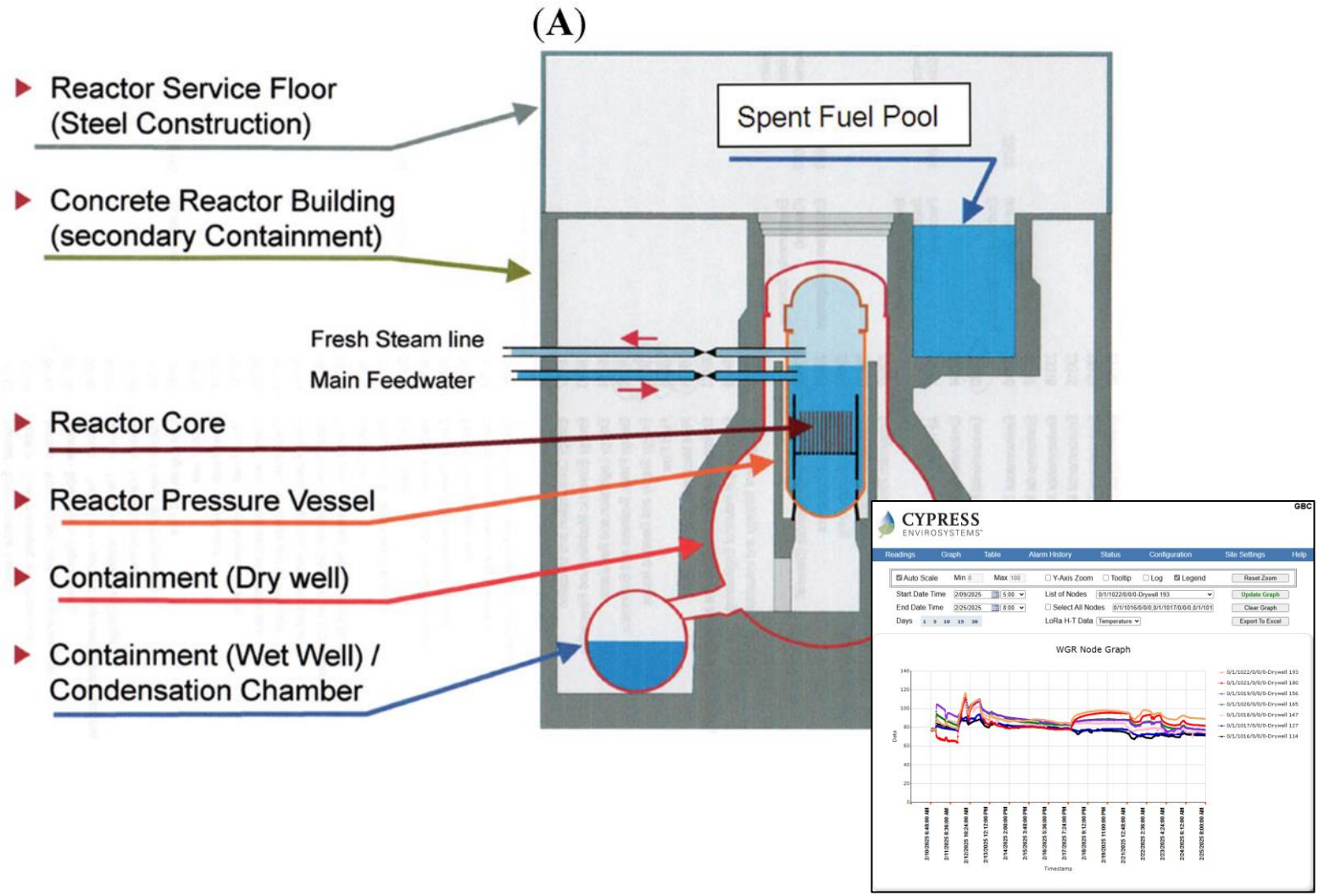
- During outage: Monitor temperature and humidity for worker safety (heat stress).
- Minimize time and dosage exposure for RP Tech to gather data each shift.

Solution:

- Use magnetic mount temporary non-invasive Wireless Temperature and Humidity Monitors.

Benefit:

- Save 1.5 Man-hours/day, 45 Man-hours outage total
- Reduce 8 mrem/day, 240 mrem outage total radiation exposure
- Reduced Industrial Safety exposure



Crash Cart for Emergent Issues

Need:

- Plant needs data quickly to troubleshoot, diagnose and correct emergent issues.

Concept:

- Use Crash Cart with non-invasive sensors to collect data
- Pre-approved, ready to install in 30 minutes.

Benefit:

- Avoid lengthy engineering reviews and approvals to add sensors
- Minimize operator man-hours
- Reduce plant downtime

Early Fault Detection: Condenser Tube Leaks

Need:

- Remotely monitor Condenser Hotwell Sodium and Conductivity to detect tube leaks

Concept:

- Use Wireless Digit Readers to monitor installed Sodium and Conductivity instruments

Benefit:

- Early detection of tube leaks prior to impacting Reactor Chemistry
- Ability to trend chemistry data
- Remote monitoring versus having a technician gathering data

Enhance Design Modifications: Condensate Booster Pump Seal Continuous Monitoring

Application:

- Design Mod to upgrade Unit 2 condensate booster pump seals
- Added six WGRs as low-cost method to digitize/enable continuous monitoring of seal pressures.

Benefit:

- Minimize design time and cost to allow continuous monitoring.
- Enable automated equipment health monitoring and fault-detection.

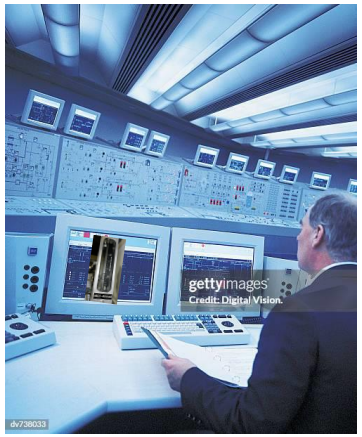
Machine Vision Webcam Digitization

Application:

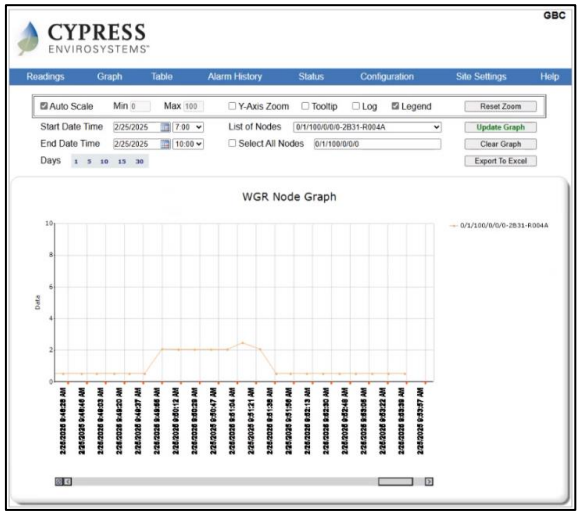
- Support design mod to reactor recirc pump seal purge filter.
- Monitor purge flow during post install testing.
- Normally requires operator watching webcam display.
- Replace with machine vision.

Benefit:

- Reduce operator time.
- Quickly detect excursions.
- Ability to collect, trend and analyze historical data.
- Non-invasive – no EC's required, minimal cybersecurity impact.



Webcam with Operator monitor



Automated Digitized Collection of Data

Valve Cycle Isolation Monitoring

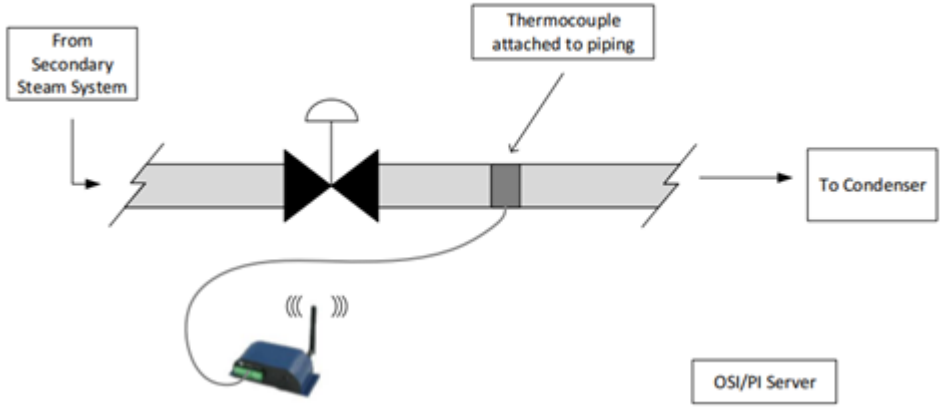
Need:

- Detect valve cycle isolation faults.
- Minimize cost and process disruption.

Benefit:

- Stop leaks, save MW's (est. up to 2MW per malfunctioning valve).
- Save operator time to monitor valves

Detect Leaking Valves



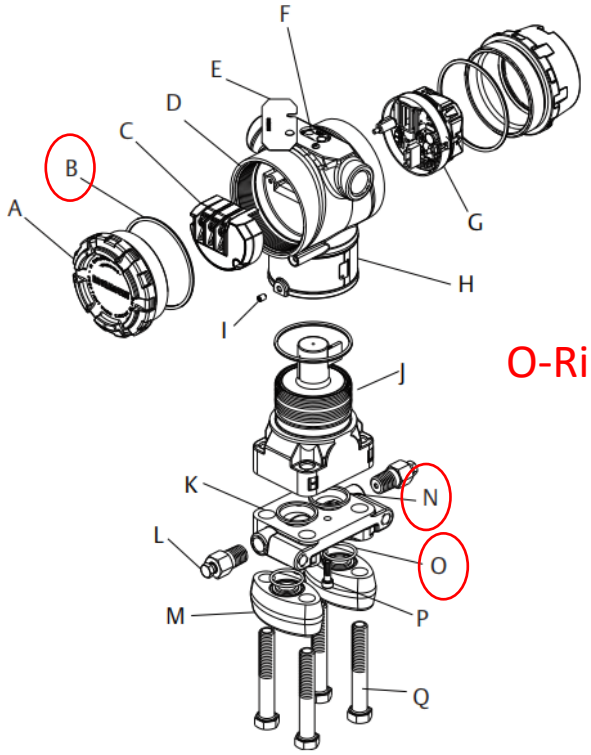
Local area temperature monitoring for Environmental Qualification life extensions

Duke Fleetwide

Concept:

- In many cases the EQ qualified life calculations assume the worst-case condition ambient temperatures.
- These temperatures usually have a significant amount of conservatism in them. Using actual temperature data could potentially result in decreasing the frequency of component replacements.
- This can have a significant cost savings to the plant due to the cost of nuclear qualified electrical components.
- Cypress WHTM's provide temperature data to allow for extension of EQ qualified life. It is expected that an investment of $200,000 can save over $2M through 20-year span of plant operation (PWR).

Example of devices / components affected

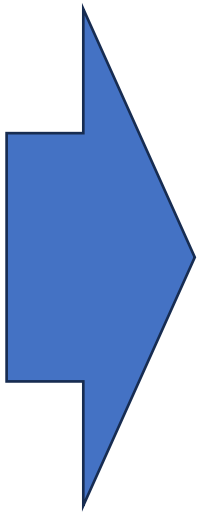


O-Rings (PFTE)

A. Cover
B. Cover O-ring
C. Terminal block
D. Electronics housing
E. Configuration buttons cover
F. Local configuration buttons
G. Electronics board
H. Name plate
I. Housing rotation set screw (180 degree maximum rotation without further disassembly)
J. Sensor module
K. Coplanar flange
L. Drain/vent valve
M. Flange adapters
N. Process O-ring
O. Flange adapter O-ring
P. Flange alignment screw (not pressure retaining)
Q. Flange bolts

Enhancement - Wireless Remote Radiation Monitor

Commercially Available
Radiation Meter

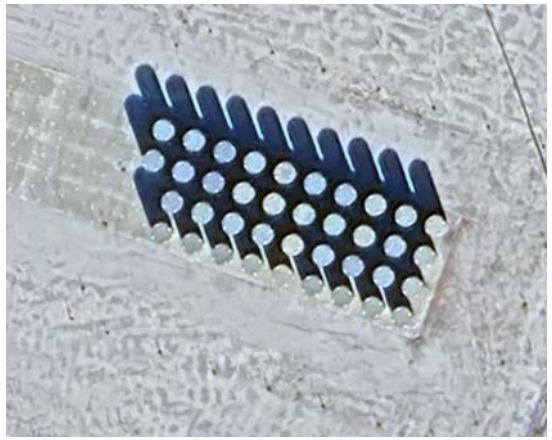


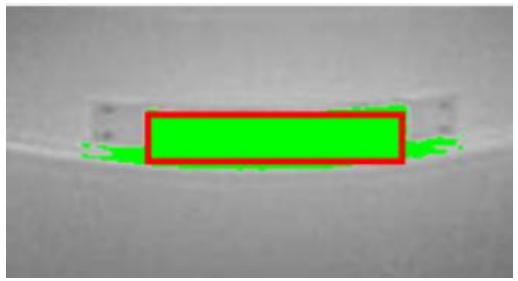
External
Battery Pack

Add-on
Wireless Digit Reader

- Real-time wireless mobile radiation dose rate monitor
- Battery operated: does not require power nor communications wires
- No need to install additional wireless network (uses Blue Box Gateway and GBC)
- Data via OPC or RESTful API available to PI Historian, 360 Plant Walkthru Software etc.

In-Progress: Drone + Machine Vision Dry Cask Inspection





Skydio Drone

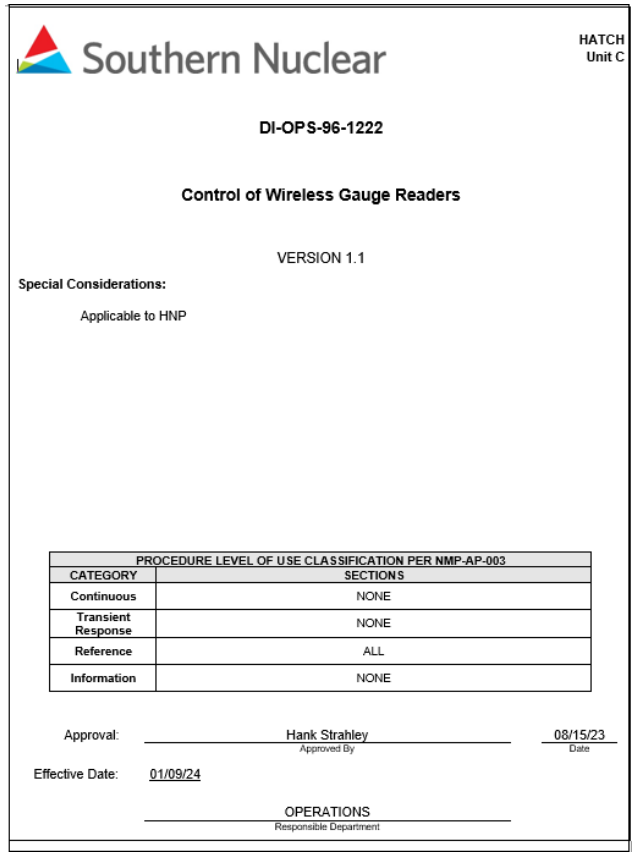
- May be piloted
- Or autonomous

Skydio Dock

- “Garage” protection
- Recharging
- Data download

Stakeholder Engagement, Sustainable Adoption

- Clear procedures for tasks, roles, and ownership.
- Lots of training.
- Users Group to share OE and best practices – Industry wide group plus Southern chapter.
- Create library of Use Cases with documented benefits.
- PROACTIVE - DO NOT TAKE ADOPTION FOR GRANTED.



Southern Nuclear

HATCH
Unit C

DI-OPS-96-1222

Control of Wireless Gauge Readers

VERSION 1.1

Special Considerations:

Applicable to HNP

PROCEDURE LEVEL OF USE CLASSIFICATION PER NMP-AP-003	
CATEGORY	SECTIONS
Continuous	NONE
Transient Response	NONE
Reference	ALL
Information	NONE

Approval: Hank Strahley (Approved By) 08/15/23 (Date)

Effective Date: 01/09/24

OPERATIONS (Responsible Department)

Digital Overlays as Part of I&C Modernization Strategy

- "Digital Overlays" is faster, lower cost method to expose plant data for AI and advanced software tools.
- Deploy instead of replacing existing analog, pneumatic, or hydraulic infrastructure with fully digital systems (which are costly and disruptive).
- Extract data from current instruments without interfering with plant operations or control systems.
- Benefits:
  - **Lower Cost:** Avoids the expense of full system replacement.
  - **Minimized Disruption:** No major shutdowns or operational interruptions.
  - **Fewer Regulatory Hurdles:** Since the core control systems remain unchanged, regulatory approval is simpler and faster.
  - **Reduced Cybersecurity Risk:** Digital overlays do not introduce new control pathways, so cybersecurity requirements are less stringent.
  - **Enables AI and Advanced Software:** Plants can still use tools like CBM/OLM, digital twins, and asset management systems to improve safety, reliability, and efficiency.

Deployments – N. America Nuclear Fleet (34 plants)

- Duke Energy (Fleetwide: Oconee, Robinson, Brunswick, Harris, Catawba, McGuire)
- Southern (Fleetwide: Farley, Hatch, Vogtle)
- Xcel Energy (Fleetwide: Prairie Island, Monticello)
- PSEG (Fleetwide: Salem, Hope Creek)*
- Bruce Power (Canada)
- Constellation Energy (Calvert, Braidwood, Clinton, JAF, Nine Mile Point, Limerick, Ginna, Peach Bottom)
- NextEra (Fleetwide: Turkey Point, St. Lucie, Point Beach, Seabrook)
- Vistra (Comanche Peak, Davis Besse, Beaver Valley)
- STP Nuclear (South Texas)
- Nebraska Public Power District (Cooper)
- Arizona Public Service (Palo Verde*)
- Entergy Vermont Yankee (1 unit – decommissioned)
- EPRI Charlotte - Nuclear Applications Center (installed)
- France EDF (pilot deployment)

* Pending Installation

International Atomic Energy Agency Innovation Award 2024

"The ISOP Innovation Awards aim to highlight and recognize innovative use cases within the nuclear power industry. This programme showcases practical applications of cutting-edge technologies and solutions that have been successfully implemented in operating nuclear power plants."

IAEA
International Atomic Energy Agency

Southern Nuclear

American Nuclear Society

Paper will also be presented at 2025 ANS Annual Conference, Chicago

Q&A

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- Prior experience:
  - System Operations Manager, Plant Hatch
  - Licensed Senior Reactor Operator
    Nine Mile Point Nuclear Plant, Exelon
  - Nuclear submarine service, US Navy
- US Navy Nuclear Power Program

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- Founder, inventor & patent holder
- Prior experience:
  - VP Honeywell Automation Control
  - Payload Director, NASA STS-40 Mission
- MBA Insead, France
- MS+BS Electrical & Mech Engineering,
  Control Systems, Stanford University