

# Non-Invasive Digitization of Nuclear Plants

*September 3, 2025 - Vienna*



Technical Meeting on  
Operating Experience on the Use of Digital Technologies  
for Instrumentation and Control Systems  
EVT2402789

# Presenters



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Website: [www.duke-energy.com](http://www.duke-energy.com)

- Innovation leader, Duke nuclear fleet
- Prior experience – Catawba Nuclear Station:
  - Operations Manager
  - Safety Assurance Manager
  - Engineering Manager
- BS Mechanical Engineering, N. Carolina State Univ



## Hank Strahley

Operations Support Supervisor,  
Southern Nuclear

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- Operations leader, Plant Hatch
- 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



## Harry Sim

CEO, Cypress Envirosystems Inc.

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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

# Problem: Most Plant Data is NOT Digitized



## Solution: Non-Invasive Sensors – 5 Minute Install

Connection via  
RESTful API or OPC

## Historian



# HMI



CYPRSS ENVIRSYS <sup>SM</sup>							GBC		
Readings	Graph	Table	Alarm History	Status	Configuration	Site Settings	Help		
							Export	Print Screen	
WGR Readings: 153 Items									
Timestamp	NodeID	Description				Readings	Units	LCL UM	
08/23/2023 10:41:37.011/01/01	01	11104-1	TURB MAIN GEN BOLD				34.29	PSI	0
08/23/2023 10:52:04.010/16/01	01	11109-1	TURB MAIN GEN BOLD				26.11	PSI	0
08/23/2023 10:40:20.013/03/01	01	12111-1	TURB ENG 1 T				138.0	F	20
08/23/2023 10:42:46.112/01/01	01	11209-1	GEN AIR SIDE SLC EHC ENG 1				73.8	PSI	0
08/23/2023 10:43:49.111/01/01	01	11102-1	GEN AIR SIDE SLC EHC ENG 1				17.06	PSI	0
08/23/2023 10:45:11.121/02/01	01	12114-1	TURB GEN GEN 2 TEMP IND				138.5	DEG C	20
08/23/2023 10:40:48.111/04/01	01	12115-1	TURB GEN GEN 3 TEMP IND				134.8	DEG C	20
08/23/2023 10:40:50.111/05/01	01	11113-1	TURB GEN GEN 4 TEMP IND				135.7	DEG C	20
08/23/2023 10:47:30.120/06/01	01	12117-1	TURB GEN GEN 5 TEMP IND				137.3	DEG C	20
08/23/2023 10:50:40.111/07/01	01	12117-1	TURB GEN GEN 5 TEMP IND				137.1	DEG C	20
08/23/2023 10:48:21.111/08/01	01	12118-1	TURB TURBO ENG 6 AIR SIDE TEMP IND				126.0	DEG C	20
08/23/2023 10:50:12.120/09/01	01	12120-1	TURB ENG 7 T				145.9	DEG C	50
08/23/2023 10:49:14.121/10/01	01	12121-1	TURB ENG 7 T				137.9	DEG C	32
08/23/2023 10:50:21.121/11/01	01	12122-1	TURB GEN GEN 8 T				138.6	DEG C	32
08/23/2023 10:49:29.120/12/01	01	12126-1	GEN AIR SIDE SLC EHC ENG 1				72.2	PSI	0
08/23/2023 10:49:42.121/01/01	01	12127-1	GEN AIR SIDE SLC EHC ENG 1				71.3	PSI	0
08/23/2023 10:42:37.120/02/01	01	10160-1	121 LND & SERV AREA COLD WTR PRP SUCT FC				27.82	PSI	0
08/23/2023 10:46:13.121/03/01	01	11055-1	121 LND & SERV AREA COLD WTR PRP DISCH FC				106.4	PSI	0
08/23/2023 10:46:28.120/04/01	01	10110-1	121 LND & SERV AREA COLD WTR PRP 4TH HOK TEMP TEST				79.3	DEG C	10
08/23/2023 10:47:42.121/05/01	01	10110-1	121 LND & SERV AREA COLD WTR PRP 4TH HOK TEMP TEST				79.2	DEG C	10
08/23/2023 10:52:37.121/06/01	01	10161-1	121 LND & SERV AREA COLD WTR PRP 4TH HOK TEMP TEST				79.2	DEG C	10
08/23/2023 10:46:13.120/07/01	01	10190-1	121 LND & SERV AREA COLD WTR PRP 4TH HOK TEMP TEST				47.3	DEG C	10
08/23/2023 10:46:13.120/08/01	01	10115-1	121 LND TO ADMIN BLDG CONTR PRP (Not Installed - Item to be Added)						
08/23/2023 10:46:13.120/09/01	01	10122-1	121 UPPER HVAC UNIT CONTR PRP (Not Installed - Item to be Added)						
08/23/2023 10:46:13.120/10/01	01	10122-1	121 UPPER HVAC UNIT CONTR PRP (Not Installed - Item to be Added)						
08/23/2023 10:46:13.120/11/01	01	10123-1	2 TURB GEN 1 T				138.4	DEG C	20
08/23/2023 10:48:49.101/12/01	01	10141-1	TURB MAIN GEN BOLD				26.09	PSI	0
08/23/2023 10:49:51.101/01/01	01	10141-1	TURB MAIN GEN BOLD				26.09	PSI	0
08/23/2023 10:49:53.101/02/01	01	10112-1	TURB GEN GEN 2 TEMP IND				137.4	DEG C	20
08/23/2023 10:50:54.101/03/01	01	10123-1	TURB GEN GEN 3 TEMP IND				134.8	DEG C	20
08/23/2023 10:50:54.101/04/01	01	10124-1	TURB GEN GEN 4 TEMP IND				135.7	DEG C	20
08/23/2023 10:50:54.101/05/01	01	10125-1	TURB GEN GEN 5 TEMP IND				137.3	DEG C	20

**Wireless, battery operated, does not touch plant process:  
~10% the cost of traditional instrumentation, 5 minute install**



# Installation Example

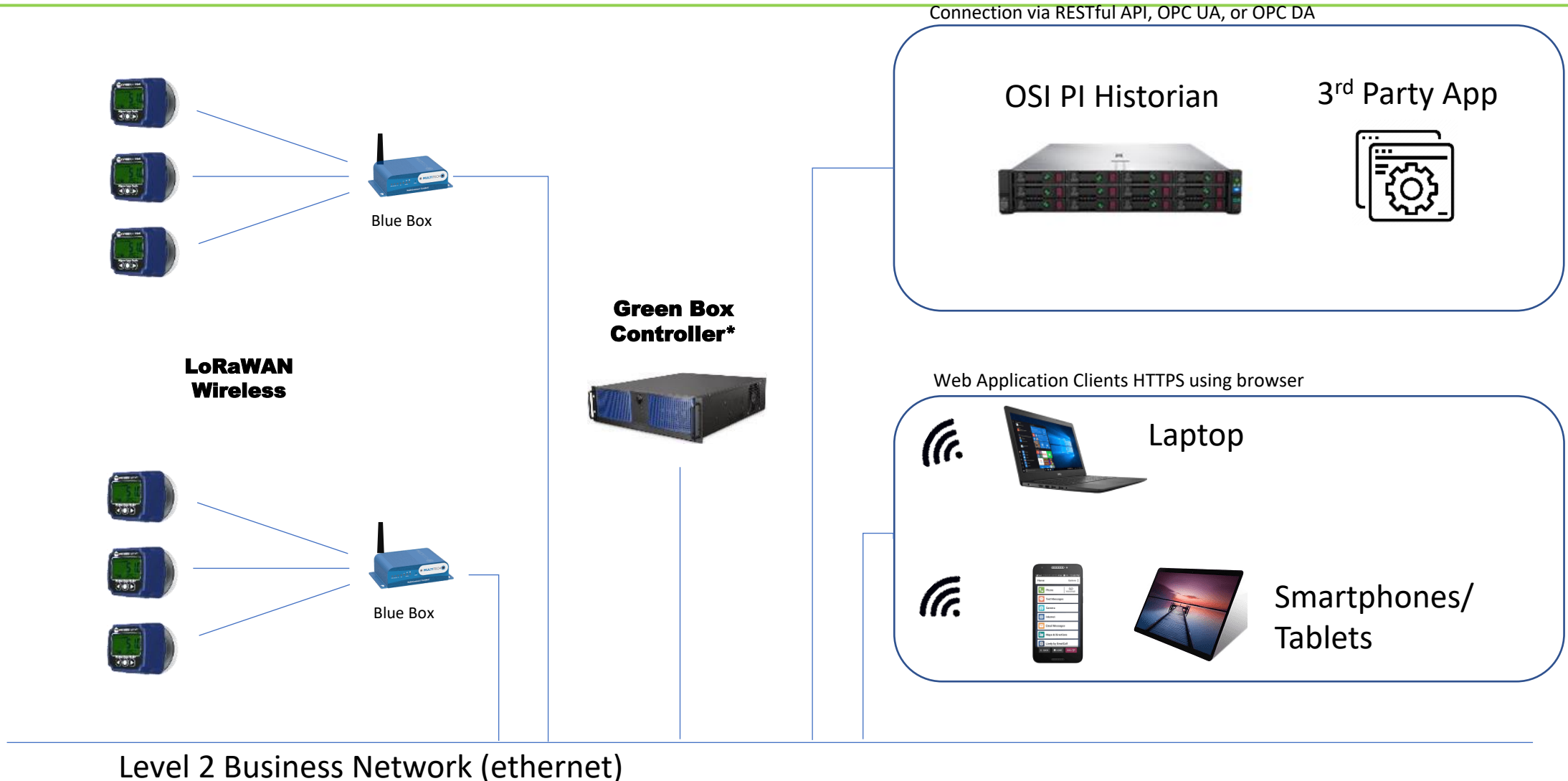


# Outdoors, RCA, Seismic, Safety Related Areas





# Integration with Plant Data Network – Cyber Approved



# Non-Invasive Digitization Solutions

Cycle  
Isolation  
Valve  
Monitor



Wireless Temperature  
and Humidity Monitor



Wireless Rad  
Monitor



Vibration  
Sensors



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



Void Detection



Webcam Digitization  
(machine vision)



Drone Integration  
(machine vision)



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



# Operational Experience and Use Cases



## **Nuclear Fleet:**

- Hatch, 2 reactors, BWR, Georgia, USA
- Vogtle, 4 reactors, PWR, Georgia, USA
- Farley, 2 reactors, PWR, Alabama, USA



## **Nuclear Fleet:**

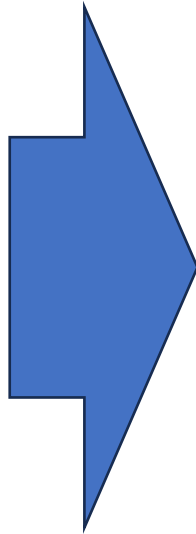
- Harris, 1 reactor, PWR, N. Carolina, USA
- McGuire, 2 reactors, PWR, N. Carolina, USA
- Catawba, 2 reactors, PWR, S. Carolina, USA
- Robinson, 1 reactor, PWR, S. Carolina, USA
- Brunswick, 2 reactors, BWR, N. Carolina, USA
- Oconee, 3 reactors, PWR, S. Carolina, USA

# Plant-wide Engagement – Broad benefits

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## 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 crash cart, emergent needs

# Operator Efficiency: Operator Rounds Dashboard



## Concept:

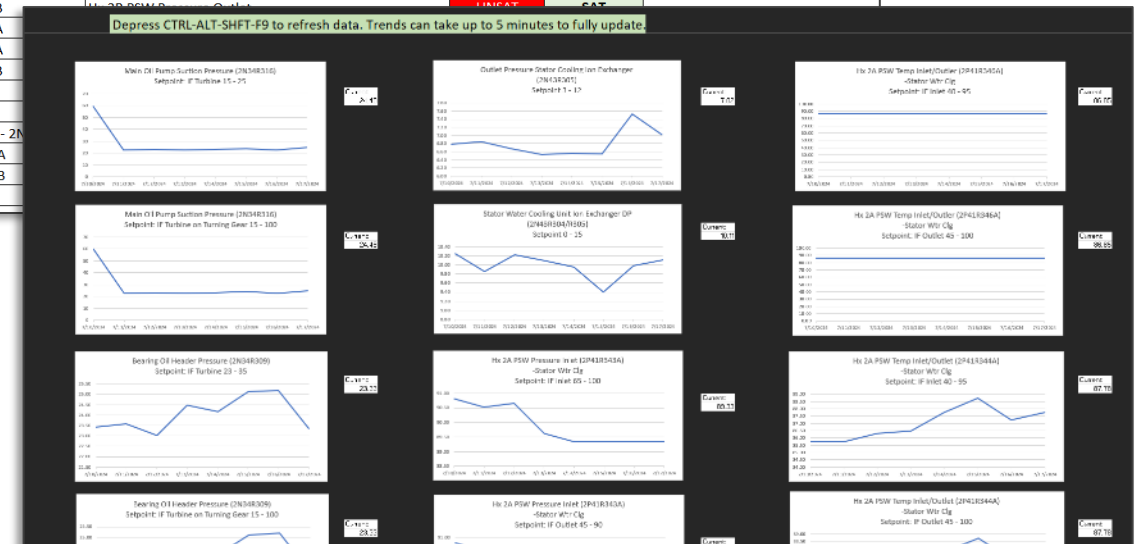
- Collect rounds data throughout day using WGRs
- Operators can review trends and identify abnormalities at start of shift
- Plan and prioritize work more efficiently

## 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	Hx 2B PSW Pressure Outlet	SAT	SAT	
175	SWC	2P41R346A	Hx 2B PSW Temp Inlet/Outlet (2P41R346A)	SAT	SAT	
176	SWC	2P41R344A	Hx 2B PSW Temp Inlet/Outlet (2P41R344A)	SAT	SAT	
177	SWC	2P41R344B	Hx 2B PSW Temp Inlet/Outlet (2P41R344B)	SAT	SAT	
179	SWC	2N43R308	Bearing Oil Header Pressure (2N43R308)	SAT	SAT	
180	SWC	2N43R307	Bearing Oil Header Pressure (2N43R307)	SAT	SAT	
181	SWC	2N43R308 - 2N43R307	Bearing Oil Header Pressure (2N43R308 - 2N43R307)	SAT	SAT	
187	SJAE	2N22R327A	Raw Oil Header Pressure (2N22R327A)	SAT	SAT	
188	SJAE	2N22R327B	Raw Oil Header Pressure (2N22R327B)	SAT	SAT	
189	H2 Stator Clg	2N43R315	Raw Oil Header Pressure (2N43R315)	SAT	SAT	



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



# Condition Based Maintenance: Pump Seals

- Automated remote monitoring of reactor recirculation pump seals
- WGR used to collect analog gauge readings for upper and lower seal pressures to assist in fault detection
- Benefits:
  - Reduce operator time to necessary to read gauges
  - Faster identification and troubleshooting of problems
  - Minimize down-time
  - Reduce dose exposure (in BWR)



# Operator Efficiency: Feedwater Level – Machine Vision



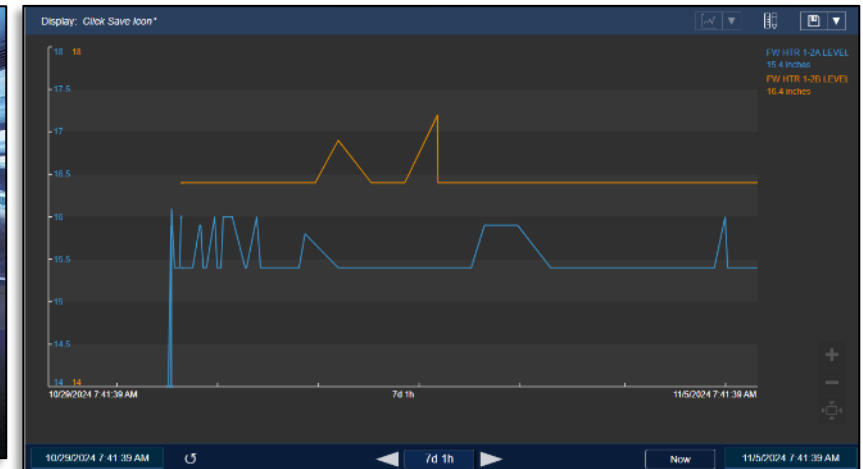
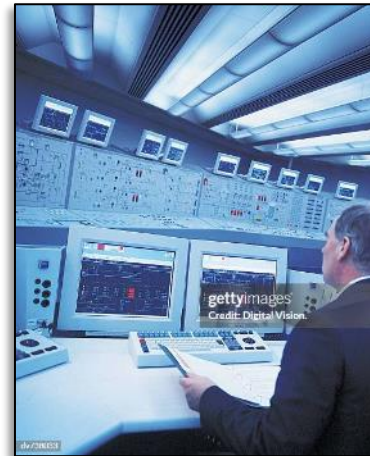
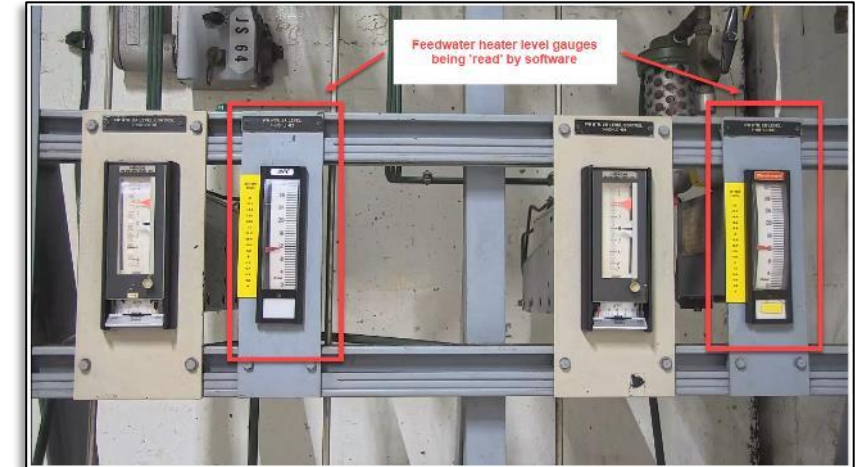
*Duke Brunswick*

## Need:

- Automate data collection from feedwater heater including heater level.
- Prior issue resulted in heater taken offline for repairs.
- Must rely on vertical gauge local indicator.

## Solution:

- Install Panasonic IP camera, use GBC machine vision capability to digitize image.
- Data can be stored in PI Historian.
- Operator can look at digitized trend data on PI Vision instead of just watching webcam video.



**Data collected and displayed  
via PI Historian**

# Environmental Monitoring: Sump Pump Hour Meters

- As part of a Groundwater Protection Plan, Cypress installed wireless gauge readers on sump pump hour meters to track electrical manhole sump pump run-time.
- No current method to monitor sump levels automatically.
- If tritium is detected the sump pump runtime data may be useful to determine where it came from.
- Catch two types of faults:
  - Pumps not running when they should (sump level too high)
  - Pumps running too much (must be a leak)





# Thermal Performance: Valve Cycle Isolation Monitoring

## Need:

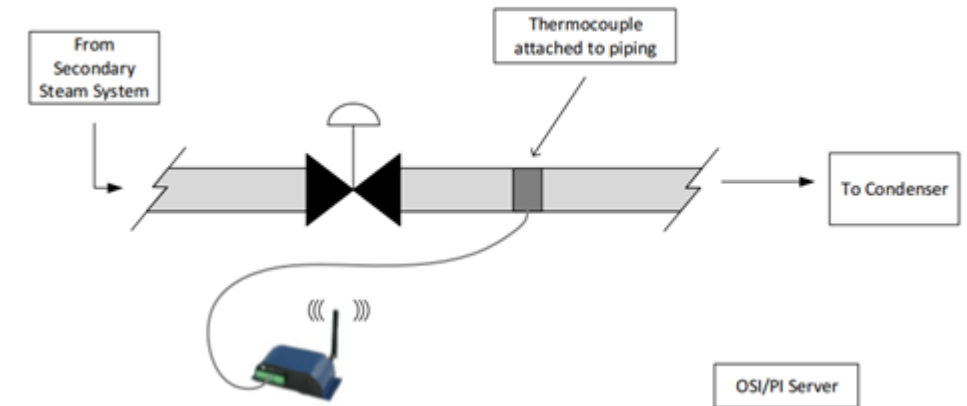
- Detect valve cycle isolation faults.
- Minimize cost and process disruption.

## Benefit:

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



## Detect Leaking Valves



# Minimize Downtime: Crash Cart for Emergent Issues

*Southern Hatch*

## **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



# ALARA/Safety: Dry Well Temp & Humidity Monitoring

## Need:

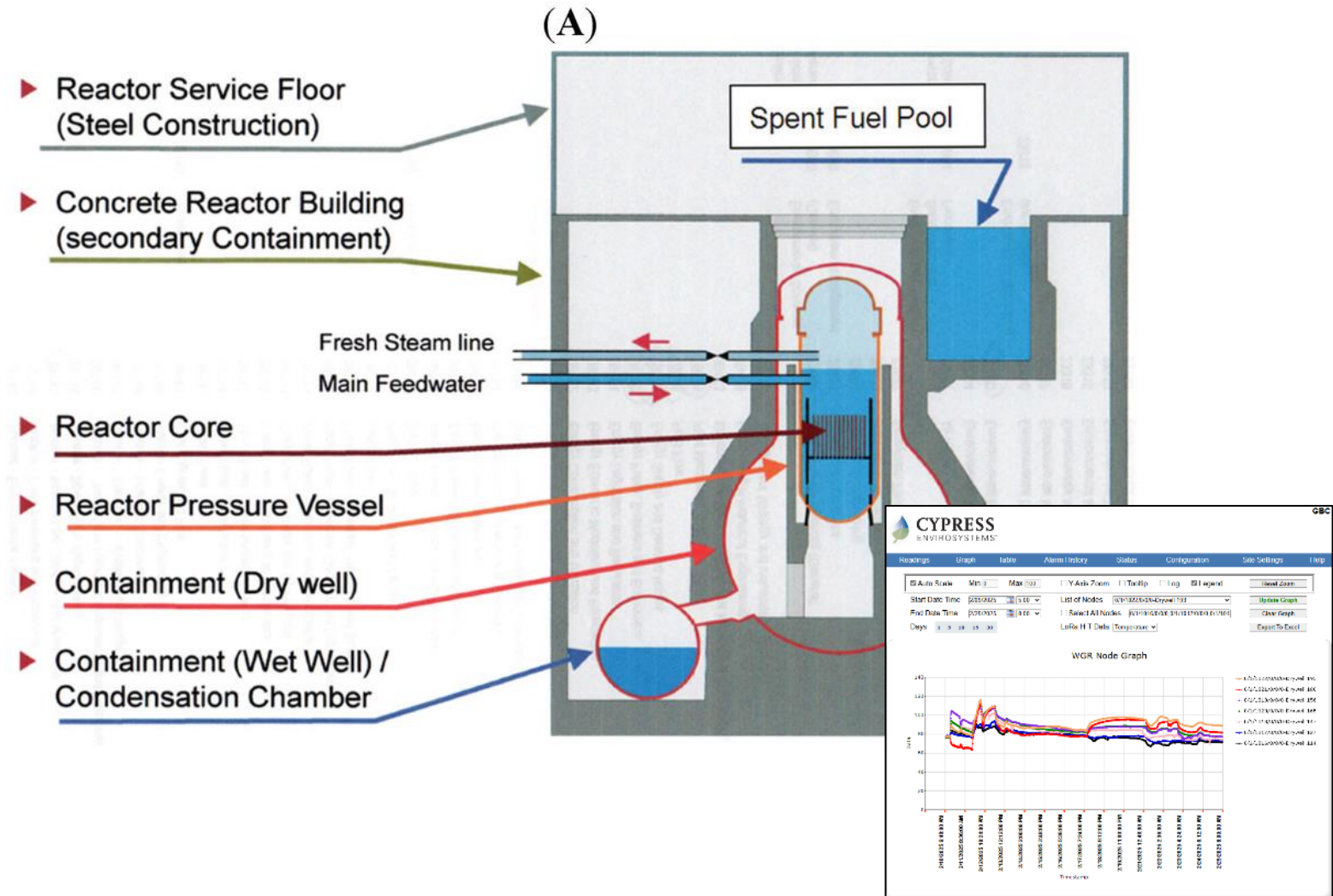
- During outage: Monitor temperature and humidity for worker safety (heat stress).
- Minimize time and dosage exposure for RP Tech to gather data each shift.

## Solution:

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

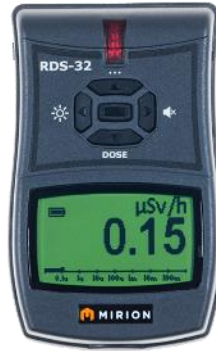
## Benefit:

- 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

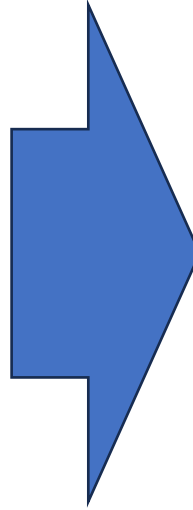




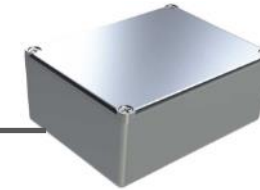
# Enhancement - Wireless Remote Radiation Monitor



Commercially Available  
Radiation Meter



Add-on  
Wireless Digit Reader



External  
Battery Pack

- 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.

# Design Modifications: Condensate Booster Pump Seal Continuous Monitoring

*Southern Hatch*

## Application:

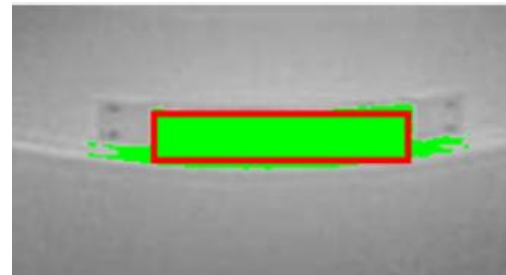
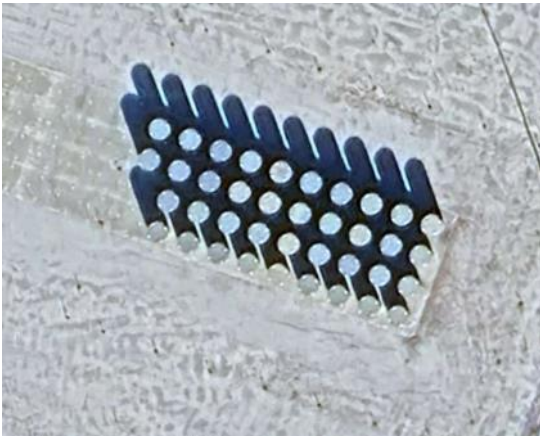
- Design Mod to upgrade Unit 2 condensate booster pump seals
- Added six WGRs as low-cost method to digitize/enable continuous monitoring of seal pressures.

## Benefit:

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



# 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 08/15/23  
Approved By Date

Effective Date: 01/09/24

OPERATIONS  
Responsible Department

# WGR Deployments – 33 Nuclear Plants

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- 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, 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.”*



**American Nuclear Society**

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



# Q & A