



14th International Topical Meeting on
Nuclear Plant Instrumentation, Control &
Human-Machine Interface Technologies

Non-Invasive Digitization of Existing Nuclear Plants

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EMBEDDED TOPICAL CONFERENCE AT THE
 **ANS**® 2025 ANNUAL
CONFERENCE

Problem: Most Plant Data is NOT Digitized



Use of AI, cost reduction: Requires more data, more frequently

Solution: Non-Invasive Sensors – 5 Minute Install



Connection via
RESTful API or OPC

Historian



HMI

CYPRESS ENVIROSYSTEMS[®]

Readings Graph Table Alarm History Status Configuration Site Settings Help

Export **Summary**

WGR Readings: 153 Items

Timestamp	NodeID	Description	Reading	Units	LCL	U
09/23/2023 10:41:37 3/1/10/0/0/0	U1-11194: 1	TURB MAIN OIL PMP SUCTION PI	34.22	PSI	0	6
09/23/2023 10:42:04 3/1/10/0/0/0	U1-11192: 1	TURB MAIN OIL PMP DISCH PI	39.11	PSI	0	6
09/23/2023 10:42:27 3/1/103/0/0/0	U1-12113: 1	TURB BRG 1 TI	130.0	F	20	24
09/23/2023 10:42:46 1/1/201/0/0/0	U1-11209: 1	GEN AIR SIDE SL OIL EXC END PI	73.8	PSI	0	11
09/23/2023 10:43:49 1/1/100/0/0/0	U1-11210: 1	GEN AIR SIDE SL OIL TURB END PI	73.9	PSI	0	11
09/23/2023 10:47:01 1/1/203/0/0/0	U1-12114: 1	TURB GEN BRG #2 TEMP IND	130.5	DEG F	20	22
09/23/2023 10:49:48 1/1/204/0/0/0	U1-12115: 1	TURB GEN BRG #3 TEMP IND	134.8	DEG F	20	22
09/23/2023 10:49:58 1/1/100/0/0/0	U1-12116: 1	TURB GEN BRG #4 TEMP IND	133.7	DEG F	20	22
09/23/2023 10:47:30 1/1/206/0/0/0	U1-12119: 1	TURB GEN BRG #5 TEMP IND	137.3	DEG F	20	22
09/23/2023 10:50:45 1/1/207/0/0/0	U1-12117: 1	TURB T BRG #6 TI	127.1	DEG F	20	21
09/23/2023 10:48:21 1/1/208/0/0/0	U1-12118: 1	TURB THRUST BRG REAR FACE TEMP IND	126.0	DEG F	20	22
09/23/2023 10:50:12 1/1/209/0/0/0	U1-12120: 1	TURB BRG 6 TI	145.9	DEG F	50	32
09/23/2023 10:49:14 1/1/210/0/0/0	U1-12121: 1	TURB BRG 7 TI	137.9	DEG F	32	21
09/23/2023 10:50:24 1/1/211/0/0/0	U1-12122: 1	TURB GEN BRG 6 TI	138.7	DEG F	32	21
09/23/2023 10:40:59 2/1/301/0/0/0	U2-11216: 2	GEN AIR SIDE SL OIL EXC END PI	72.7	PSI	0	11
09/23/2023 10:40:45 2/1/302/0/0/0	U2-11217: 2	GEN AIR SIDE SL OIL TURB END PI	73.3	PSI	0	11
09/23/2023 10:42:27 3/1/103/0/0/0	U2-11663: 1	LAB & SERV AREA CHLD WTR PMP SUCT PI	12.82	PSI	0	6
09/23/2023 10:46:13 3/1/402/0/0/0	U2-11655: 1	LAB & SERV AREA CHLD WTR PMP DISCH PI	166.4	PSI	0	6
09/23/2023 10:46:28 3/1/100/0/0/0	U2-17410: 1	LAB & SERV AREA CLG WTR PMP RIN HDR TEMP TEST	70.3	DEG F	0	28
09/23/2023 10:47:02 3/1/100/0/0/0	U2-17408: 1	LAB & SERV AREA CLG WTR SPLY HDR TEMP TEST	73.8	DEG F	0	28
09/23/2023 10:53:27 3/1/405/0/0/0	U2-17411: 1	LAB & SERV AREA CHLD WTR PMP HDR TEMP TEST	42.3	DEG F	-20	11
09/23/2023 10:46:13 3/1/100/0/0/0	U2-17409: 1	LAB & SERV AREA CHLD WTR RIN HDR TEMP TEST	47.3	DEG F	0	28
3/1/407/0/0/0	U2-11053: 1	HTS SHFT HDN BLDG CONTR PI (Not Installed - Hard to Access)		F		
3/1/408/0/0/0	U2-8223: 1	TSC UPPER HVAC UNIT TEMP (Not Installed - WH1M)		F		
3/1/309/0/0/0	U2-8222: 1	ISCL LOWER HVAC UNIT TEMP (Not Installed - WH1M)		F		
09/23/2023 10:41:50 3/1/110/0/0/0	U2-12130: 2	TURB BRG 1 TI	138.4	DEG F	20	22
09/23/2023 10:49:49 3/1/111/0/0/0	U2-11413: 2	TURB MAIN OIL PMP SUCT PI	23.02	PSI	0	6
09/23/2023 10:41:54 3/1/112/0/0/0	U2-11414: 2	TURB MAIN OIL PMP DISCH PI	31.12	PSI	0	6
09/23/2023 10:47:03 3/1/113/0/0/0	U2-12131: 1	TURB BRG #2 TEMP IND	137.6	DEG F	20	22
09/23/2023 10:50:54 3/1/114/0/0/0	U2-12132: 1	TURB BRG #3 TEMP IND	144.1	DEG F	20	22

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

Typical Installation



Outdoors, Radiologically Controlled Area, Safety Related, Seismic Related

Typical Installation-2



Minimal disruption to existing operator rounds

Family of Non-Invasive Monitoring Solutions

Valve Cycle Isolation Monitor



Steam Trap Monitor



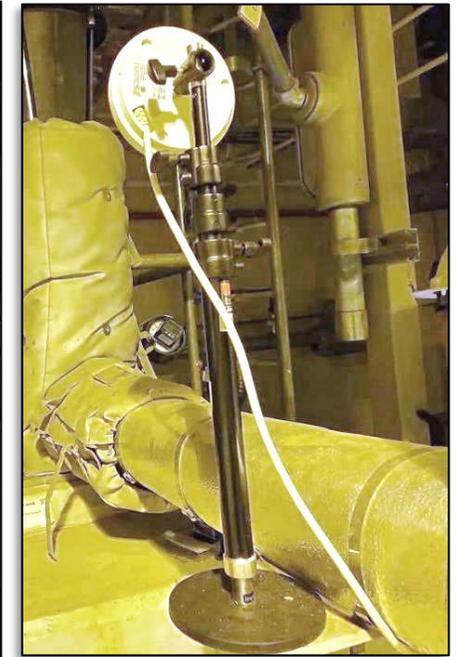
Wireless Temperature and Humidity Monitor



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

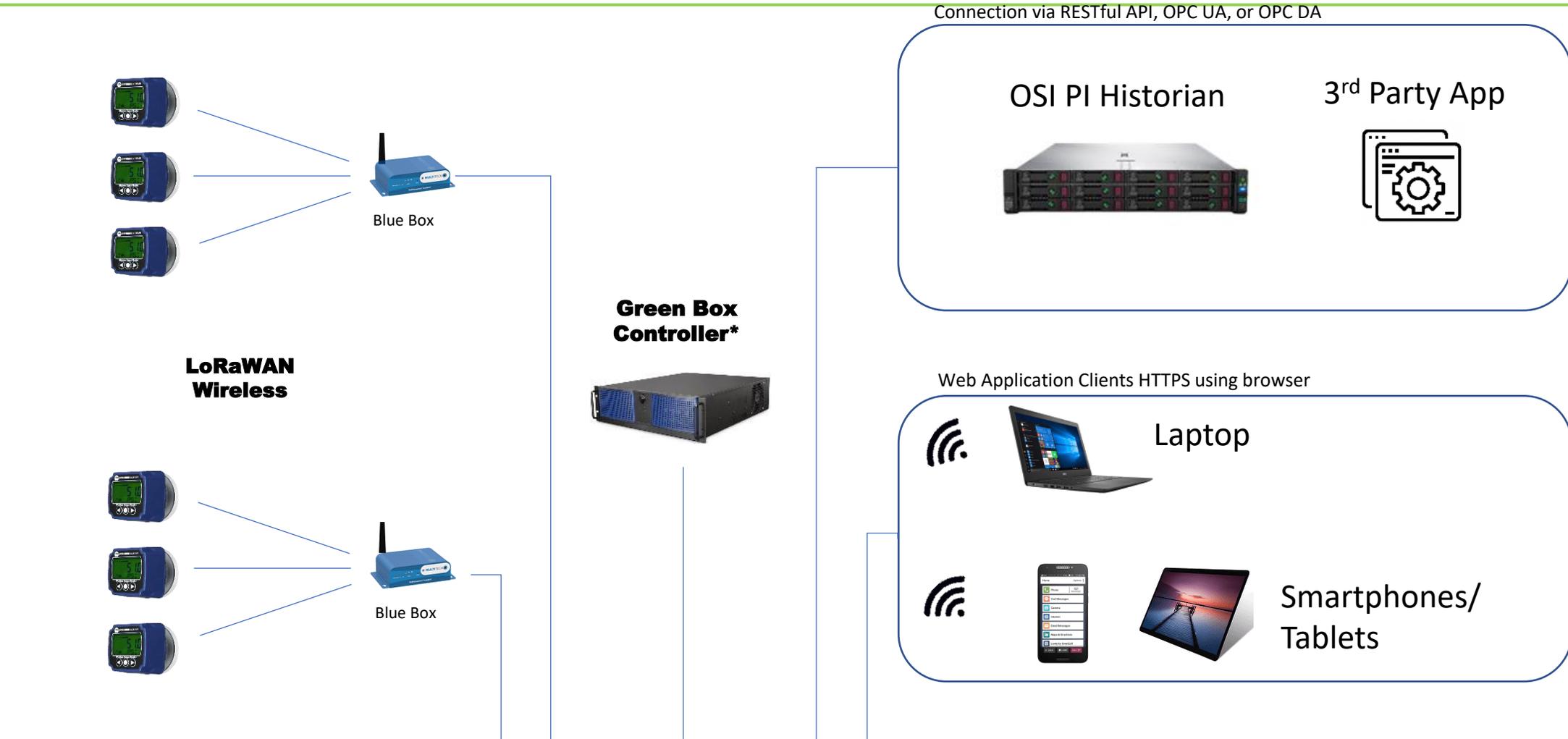


Webcam Digitization
(machine vision)



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

Network Architecture – Cyber Approved



Seamlessly integrates with existing plant IT infrastructure

*Non-Invasive Digitization
Deployment at:*

Southern Nuclear Company Plant Hatch, Baxley, Georgia United States

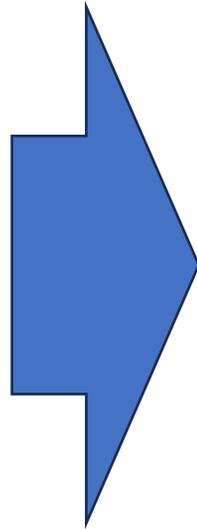
Reactor Type: GE BWR-4
Units Operational: 2 x 900 MW
Start Operations: 1975 (Unit 1)
1979 (Unit 2)



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:

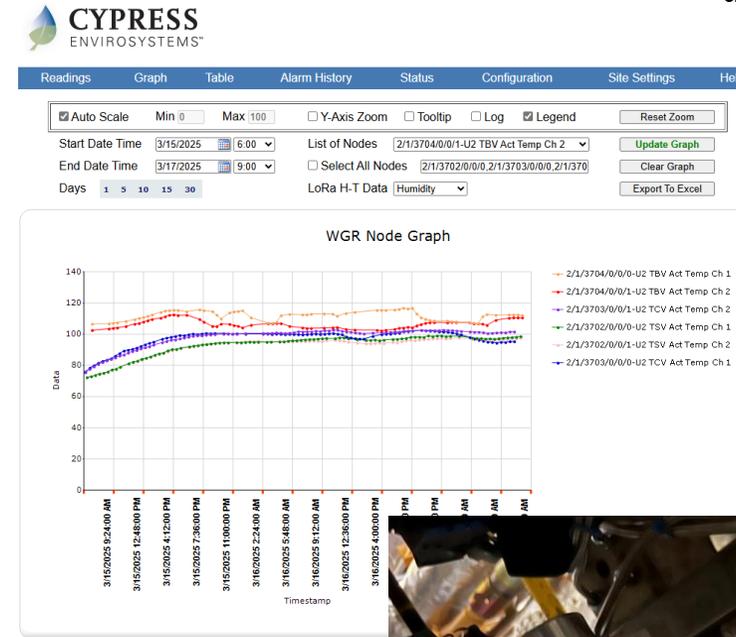
- Long term temperature trending to monitor for EHC fluid degradation due to temperature

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:

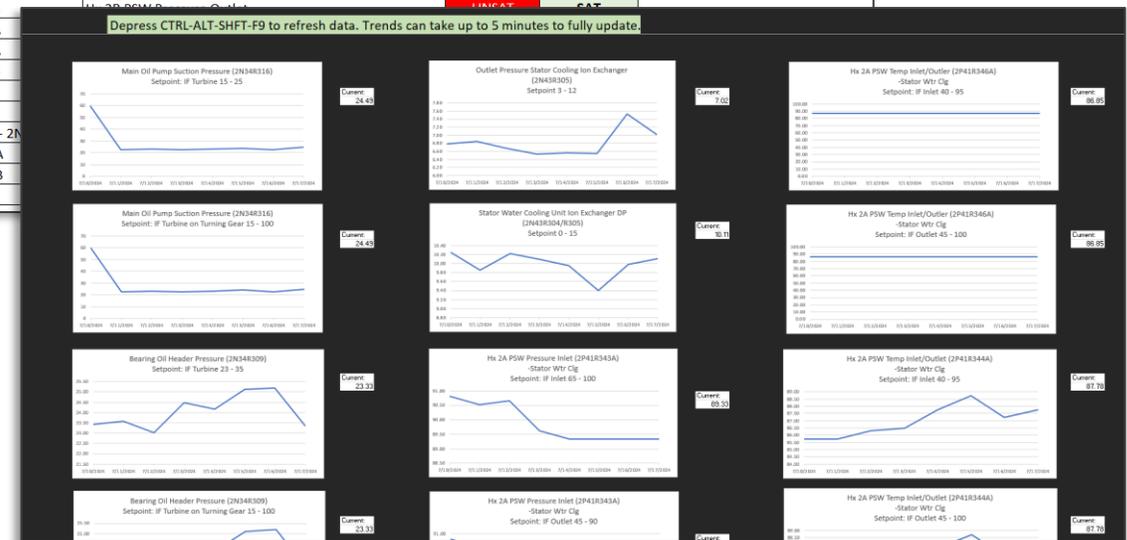
- Collect rounds data throughout day using WGRs
- Operators can review trends and identify abnormalities at start of shift
- Plan and prioritize work more efficiently

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



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

Dry Well Temp / Humidity Monitoring

Need:

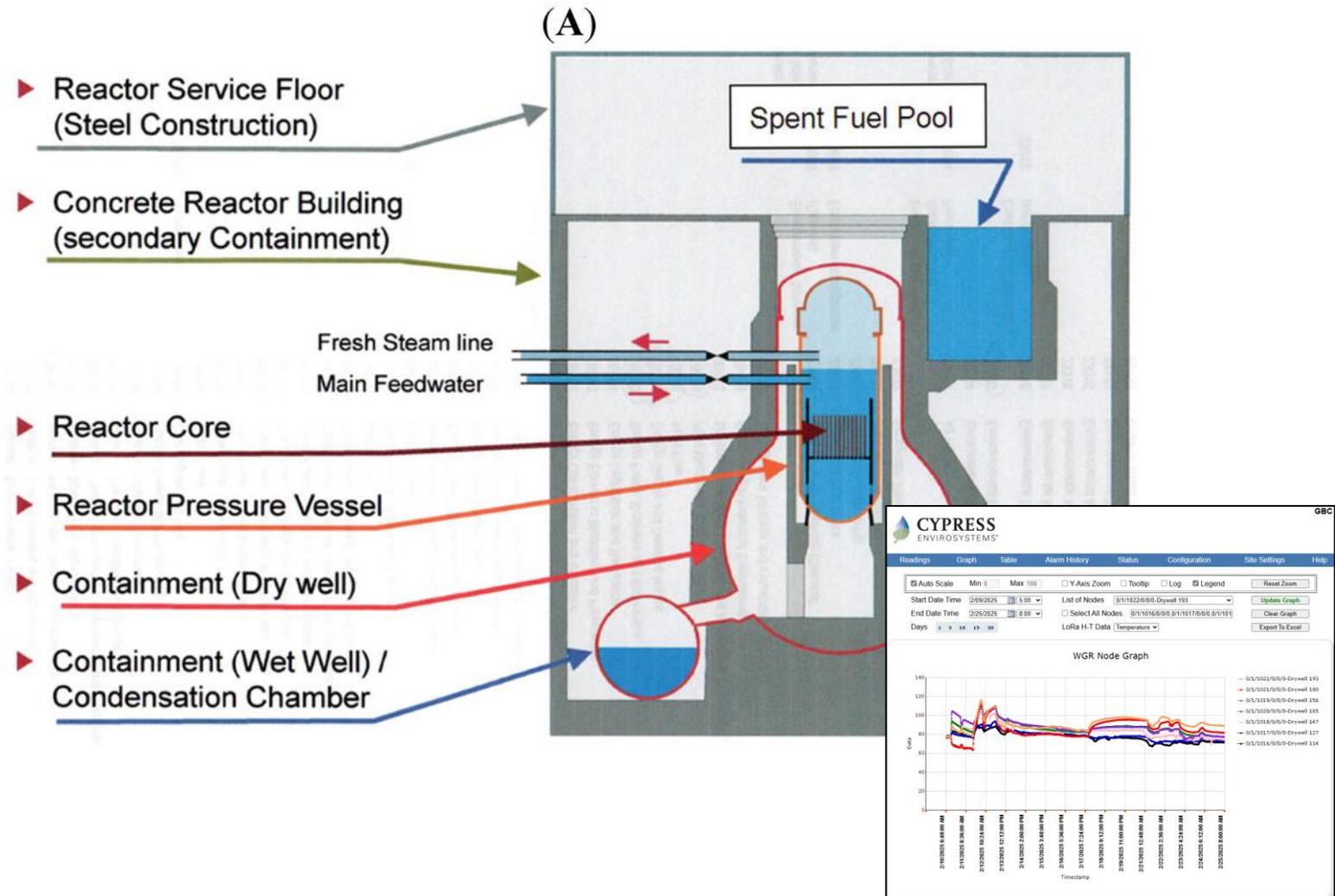
- During outage: Monitor temperature and humidity for worker safety (heat stress).
- Minimize time and dosage exposure for RP Tech to gather data each shift.

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:

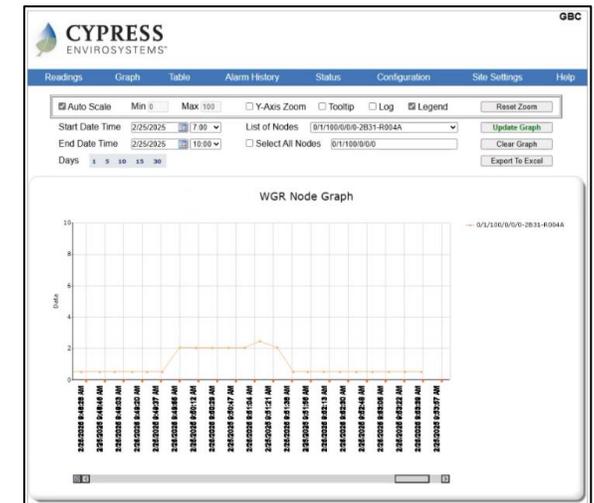
- Support design mod to reactor recirc pump seal purge filter.
- Monitor purge flow during post install testing.
- Normally requires operator watching webcam display.
- Replace with machine vision.

Benefit:

- Reduce operator time.
- Quickly detect excursions.
- Ability to collect, trend and analyze historical data.



Webcam with Operator monitor



Automated Digitized Collection of Data

Valve Cycle Isolation Monitoring

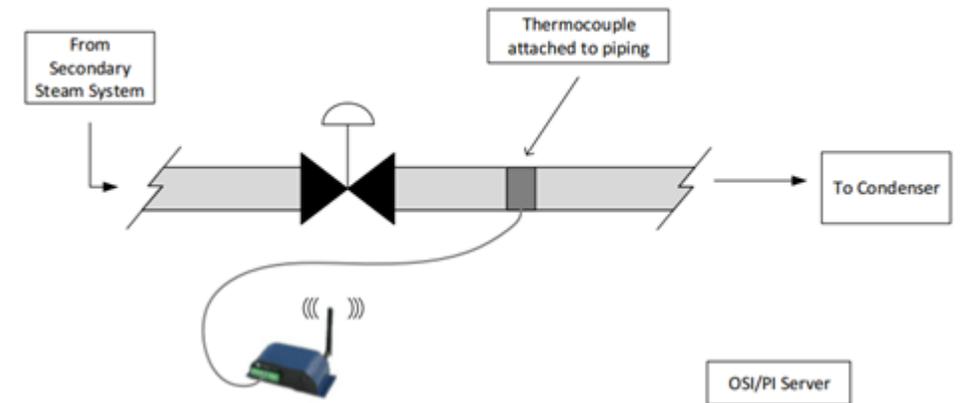
Need:

- 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



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

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)
- 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

Q & A

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