

Non-Invasive Digitization of Nuclear Plants

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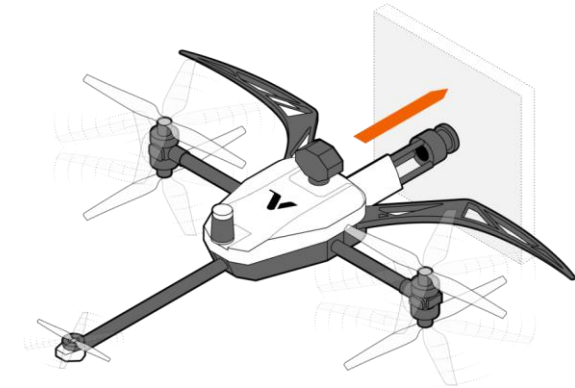
Technical Meeting on Operating Experience on the Use of Digital
Technologies for Instrumentation and Control Systems

Vienna, September 2-4, 2025

Fantastic to explore new technologies, a reality...



AI for fault
detection and
optimization



Also reality: most plant data is not even digitized



Upgrade / Digitization Challenges

- Disruptive to operations – downtime needed
- Lengthy review and approval cycle (EC's)
- High cost and long payback

Solution: Non-Invasive Sensors – 5 Minute Install



Connection via
RESTful API or OPC

Historian



HMI

CYPRESS ENVIROSYSTEMS™										GBC
Readings										
Graph										
Table										
Alarm History										
Status										
Configuration										
Site Settings										
Help										
Export										
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 1/1/200/0/0/0	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 PP TI	127.1	DEG F	20	22				
09/23/2023 10:48:24 1/1/208/0/0/0	U2-12118: 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 8 TI	138.7	DEG F	32	21				
09/23/2023 10:40:39 2/1/201/0/0/0	U2-11216: 2	GEN AIR SIDE SL OIL EXC END PI	72.7	PSI	0	11				
09/23/2023 10:40:45 2/1/202/0/0/0	U2-11217: 2	GEN AIR SIDE SL OIL TURB END PI	73.3	PSI	0	11				
09/23/2023 10:42:27 3/1/101/0/0/0	U2-11963: 1	LAB & SERV AREA CHLD WTR PMP SUCT PI	17.82	PSI	0	6				
09/23/2023 10:46:13 3/1/102/0/0/0	U2-11955: 1	LAB & SERV AREA CHLD WTR PMP DISCH PI	166.4	PSI	0	24				
09/23/2023 10:46:28 3/1/103/0/0/0	U2-17410: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST	79.3	DEG F	0	24				
09/23/2023 10:47:02 3/1/104/0/0/0	U2-17408: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST	73.8	DEG F	0	24				
09/23/2023 10:53:27 3/1/105/0/0/0	U2-17411: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST	42.3	DEG F	-20	11				
09/23/2023 10:46:13 3/1/106/0/0/0	U2-17409: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST	47.3	DEG F	0	24				
3/1/107/0/0/0	U2-11953: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST								
3/1/108/0/0/0	U2-11954: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST								
3/1/109/0/0/0	U2-11955: 1	LAB & SERV AREA CHLD WTR PMP KRN HOR TEMP TEST								
09/23/2023 10:41:30 3/1/110/0/0/0	U2-12130: 2	TURB BRG 1 TI	138.4	DEG F	20	22				
09/23/2023 10:40:49 3/1/111/0/0/0	U2-11413: 2	TURB MAIN OIL PMP SUCT PI	21.02	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-1



Minimal disruption to existing operator rounds

Typical Installation - 2



Outdoors, Radiologically Controlled Area, Safety Related, Seismic Related

Family of Non-Invasive Monitoring Solutions

Cycle
Isolation
Valve
Monitor



Steam Trap
Monitor



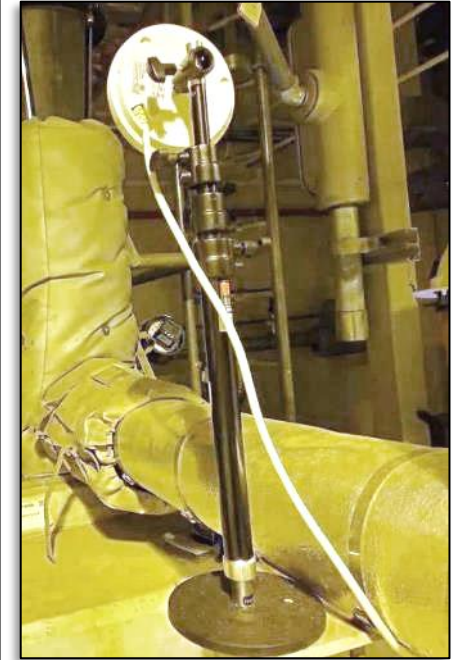
Wireless Temperature
and Humidity Monitor



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

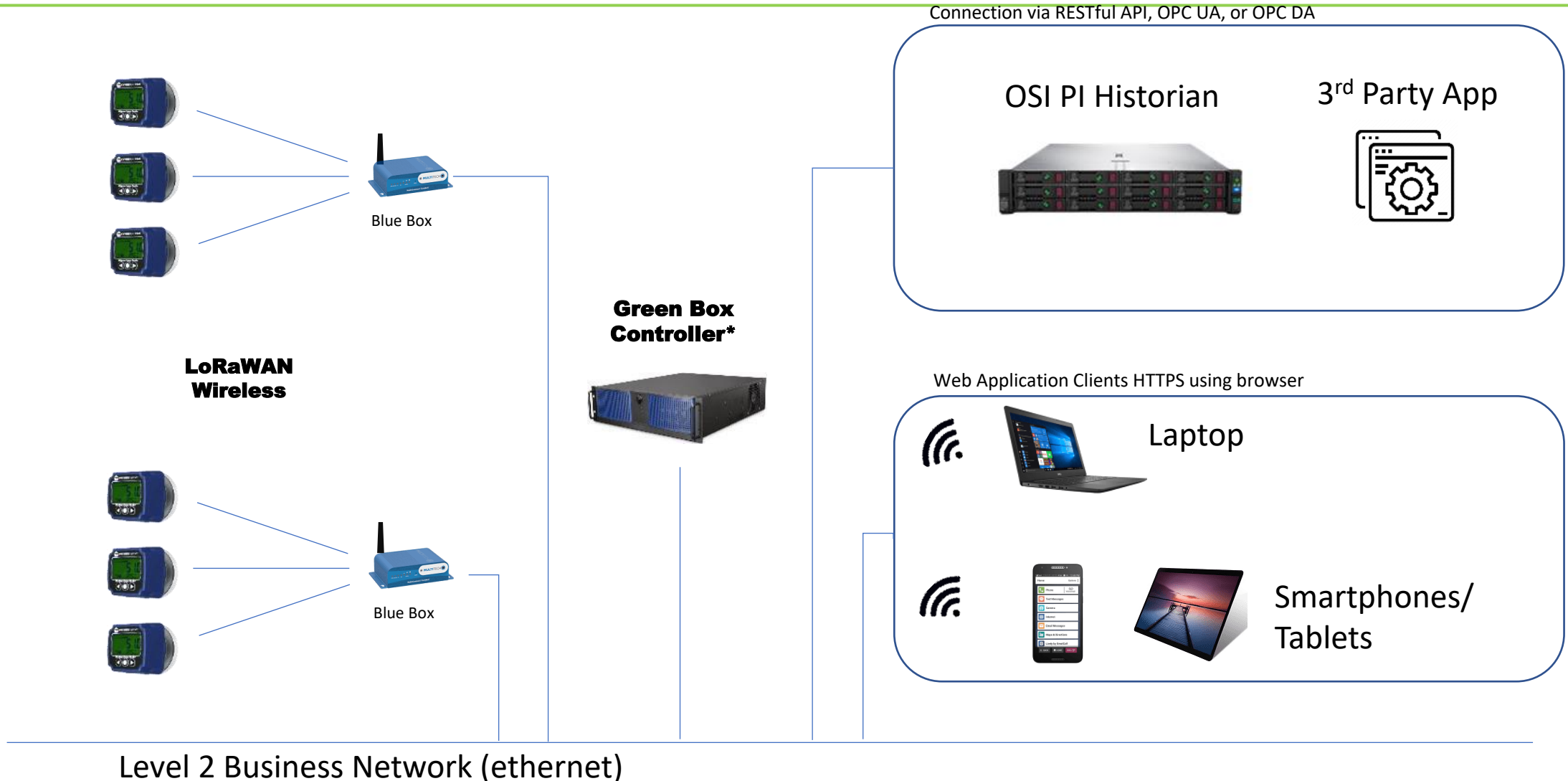


Webcam Digitization
(machine vision)



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

Network: Cybersecurity approved for nuclear plants



3rd Party Sensors - Vibration Monitoring

- Honeywell partnership with Cypress
- Vibration sensor, 3-axis
- RMS velocity and acceleration
- FFT calculated for 12 “frequency bins”
- 3-year battery life (typical)
- Mounting options: Stud, Magnetic, Adhesive
- Compatible with Cypress LoRaWAN Blue Box, GBC
- Data available to PI Historian



HONEYWELL VERSATILIS TRANSMITTER

Multi-Variant Sensing

Honeywell Versatilis™ Transmitter is a multi-variant sensing platform based on the latest LoRaWAN® protocol communication technology. Its inherently low-power compact design coupled with quick & easy installation, and commission helps manufacturers to deploy them at scale with the lowest CAPEX and negligible OPEX. These sensors are designed to monitor and predict the health of rotating equipment like motors, pumps, blowers, fans, compressors, and gearboxes. In addition, they can be deployed to remotely monitor the position of manual valves, the health of steam traps, and the surface temperature of static process equipment. They can also be deployed to monitor environmental conditions in life science facilities.

MEASUREMENT PARAMETERS:

Surface Temperature	Ambient Humidity	Ambient Pressure
Vibration	Audio Acoustics	Ambient Temperature



Figure 1 – Honeywell Versatilis Transmitter

SENSORS AND COMMUNICATIONS:

The Honeywell Versatilis platform contains a suite of sensors encompassing versatile sensing parameters such as pressure, temperature, humidity, triaxial accelerometer, and audio acoustics MEMS to provide insightful measurements. Sensors on the platform are selected to cover a broad frequency spectrum enabling adequate sensing coverage of process and physical phenomena. Sensor fusion analysis on the acquired measurements can be performed. Any specific parameter is customizable in either software or hardware according to the requirement of a specific application. Each measured parameter contributes a unique dimension thereby augmenting the system into a multi-dimension sensing platform. Sensor data can be transferred over the LoRaWAN® network which is protected through secure key authentication. The Honeywell Versatilis Transmitter can be configured to notify the application through Event Triggers and FFT (Fast Fourier Transform) Triggers.

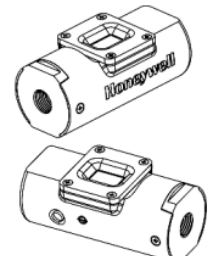


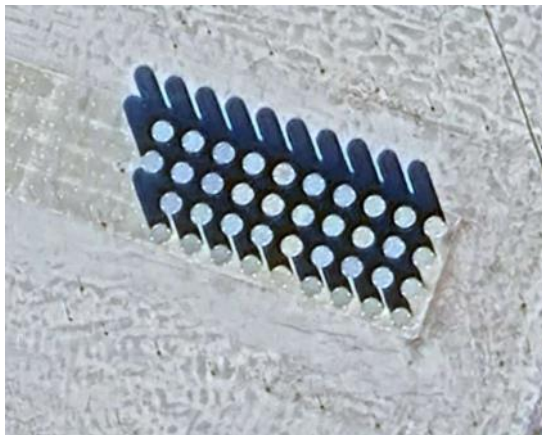
Figure 2 – Assembly

Honeywell

Honeywell Versatilis™ Transmitter Technical Specification

Honeywell Proprietary

Drone Integration: Dry Cask Inspection



Skydio Drone

- May be piloted
- Or autonomous



Skydio Dock

- "Garage" protection
- Recharging
- Data download

Installed at 32 nuclear plants in N. America

- 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*)

* 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



Use Case Library - Update

otform

Tables

Use Case Library - Non-Invasive Nuclear Plant Digitization

Last updated at 18 Apr 2023 8:08 AM C

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WGR Case Studies - Reports

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Form

Download

Title of Use Case	Utility	Plant	T...	Depart...	Plant Location	Plant System or Sub-System	What improvements/benefits come from the data?		
Enable condition Based Maintenance for condensate polisher filters	Constellation	Clinton	BWR	Maintenance	Turbine Building	Condensate Polishing System	Operator Efficiency	ALARA reducing dosage exposure	Maintenance
Fault detection for Air Operated Valves for Feedwater Heaters	Constellation	Calvert Cliffs	PWR	Engineering	Turbine Building	Feedwater Tanks Air Operated Valves	Operator Efficiency	Fault Detection	Maintenance Effort/Consumable
Fault Detection for Stator Cooling Water Control Valves	Southern Company	Hatch	BWR	Operations	Turbine Building	Generator Stator	Operator Efficiency	Fault Detection	Maintenance Effort/Consumable
Improve efficiency of Operator rounds	Duke Energy	Oconee	PWR	Operations	Multiple		Operator Efficiency	ALARA reducing dosage exposure	
Fault Detection for Reactor Recirculation Pump Seals	Duke Energy	Brunswick	BWR	Engineering	Reactor Building	Reactor cooling	Fault Detection		
DRAFT - Enhance operator efficiency for thermal performance monitoring	PSEG	Hope Creek	BWR	Operations	Turbine Building	Feedwater Heaters	Operator Efficiency	Fault Detection	
Fault Detection for Transformers	Constellation	Calvert Cliffs	PWR	Engineering	Other	Transformers	Operator Efficiency	Fault Detection	
Ensure personnel safety - Temperature and Humidity Monitoring	Constellation	Calvert Cliffs	PWR	Operations	Turbine Building	Work and storage environment	Operator Efficiency	Safety (e.g. Heat Stress, Confined Space etc.)	
Improve groundwater management monitoring	Duke Energy	Brunswick	BWR	Chemistry	Other	Sump Pumps	Operator Efficiency	Fault Detection	Compliance (e.g. Environmental
Implement Condition Based Maintenance of Condensate Polisher Demin	Energy Harbor	Davis Besse	PWR	Chemistry	Turbine Building	Condensate Polishing System	Operator Efficiency	Maintenance Effort/Consumables	
Enhance Operator Efficiency for Monitoring Intake Screen	Constellation	Nine Mile Pt	BWR	Operations	Intake	Intake screens	Operator Efficiency		
Improve personnel safety for negative pressure compliance monitoring	Constellation	Nine Mile Pt	BWR	Other	Multiple	Negative pressure locations	Operator Efficiency	Safety (e.g. Heat Stress, Confined Space etc.)	
DRAFT - Condition based monitoring of lube oil filters	Constellation	Nine Mile Pt	BWR	Engineering	Turbine Building	Lubricating oil system	Fault Detection		
Fault Detection - Cycle Isolation Valve Temperature Monitoring	Duke Energy	Harris	PWR	Engineering	Turbine Building	Cycle isolation valves	Thermal Performance	Improves efficiency of the Thermal Performance	
Feedwater Heater Temperature Monitoring	Duke Energy	Robinson	PWR	Engineering	Turbine Building	Heater Drain	Troubleshooting/Emergent Issues		
DRAFT - Fault detection for condensate vacuum pumps and valves	PSEG	Salem	PWR	Engineering	Turbine Building	Condensate pumps and valves	Operator Efficiency	Fault Detection	Maintenance Effort/Consumable
DRAFT - Fault detection & troubleshooting for containment moisture rem...	Bruce Power	Bruce A	CANDU	Engineering	Other	Dryer system for containment moist...	Operator Efficiency	Fault Detection	Maintenance Effort/Consumable
DRAFT - Safety Surveillance Monitoring remote monitoring	Luminant	Comanche Peak	PWR	Operations	Multiple	Safety related systems	Operator Efficiency	Fault Detection	
Operator Efficiency - Automating Webcam Monitoring	Southern Company	Vogtle	PWR	Operations	Turbine Building		Operator Efficiency	Fault Detection	Maintenance Effort/Consumable

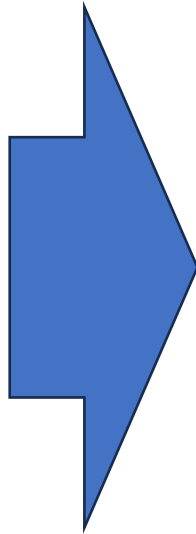
WGR Users Group 2025

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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

Condition Based Monitoring – FRF Filters

Bruce Power

Need:

- Apply Condition Based Monitoring to FRF filters. Replace consumables only when data shows it is necessary.
- Note: FRF Filters remove impurities which can cause damage or malfunction to the hydraulic system.

Solution:

- Use WGR's to monitor and trend delta pressure across FRF filters.
- Replace filters at designated delta P.

Benefit:

- Save filter consumables.
- Avoid system damage or downtime due to undetected filter rupture or clog.



Operator Rounds Dashboard

*Southern Hatch
Duke Oconee*

Concept:

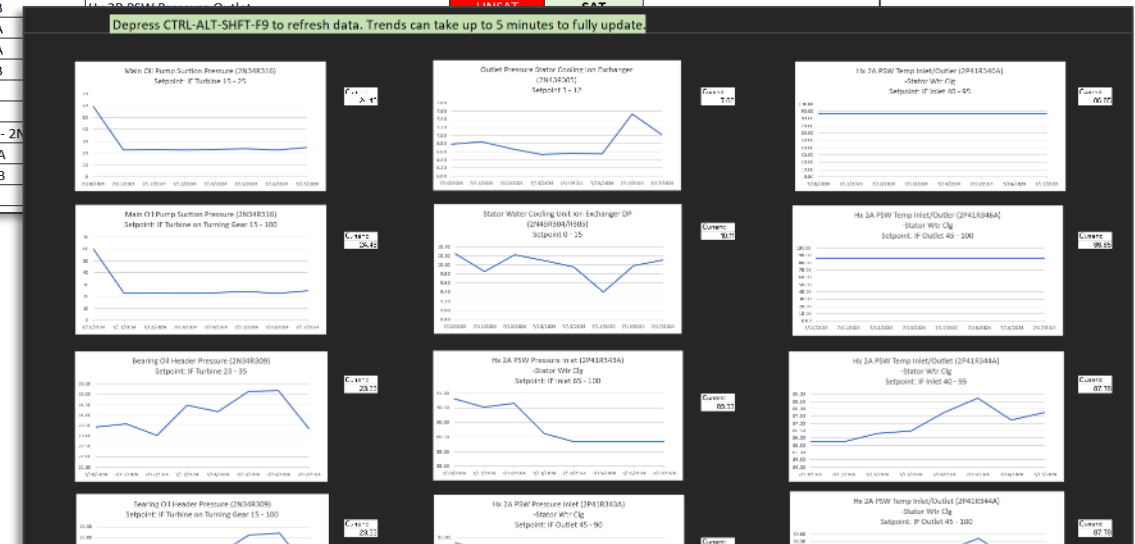
- Collect rounds data throughout day using WGRs
- Operators can review trends and identify abnormalities at start of shift
- Plan and prioritize work more efficiently

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 (2P41R344A)	SAT	SAT	
176	SWC	2P41R344A	Hx 2A PSW Temp Inlet/Outlet (2P41R344A)	SAT	SAT	
177	SWC	2P41R344B	Hx 2A PSW Temp Inlet/Outlet (2P41R344A)	SAT	SAT	
179	SWC	2N43R308	Bearing Oil Header Pressure (2N43R309)	SAT	SAT	
180	SWC	2N43R307	Bearing Oil Header Pressure (2N43R309)	SAT	SAT	
181	SWC	2N43R308 - 2N43R307	Bearing Oil Header Pressure (2N43R309)	SAT	SAT	
187	SJAE	2N22R327A	RFPT Oil Header Pressure (2N34R309)	SAT	SAT	
188	SJAE	2N22R327B	RFPT Oil Header Pressure (2N34R309)	SAT	SAT	
189	H2 Stator Clg	2N43R315	Operating Oil Pressure (2N34R315)	SAT	SAT	



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

Crash Cart for Emergent Issues

Southern Hatch

Need:

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

Concept:

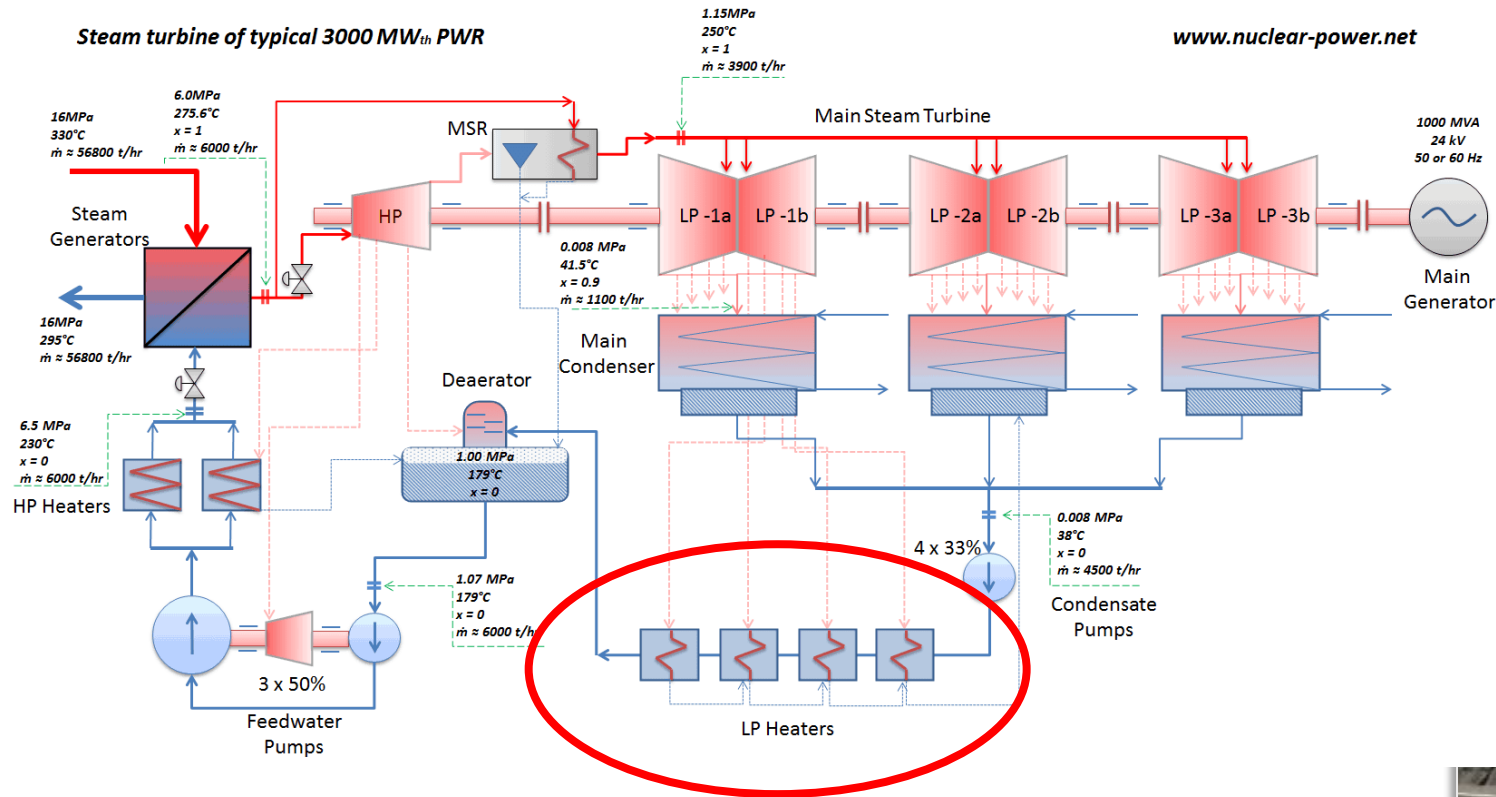
- Use Crash Cart with non-invasive sensors to collect data
- Pre-approved, ready to install in 30 minutes.

Benefit:

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



Feedwater Heater Level Fault Detection



Feedwater Heater Level - Webcam Digitization

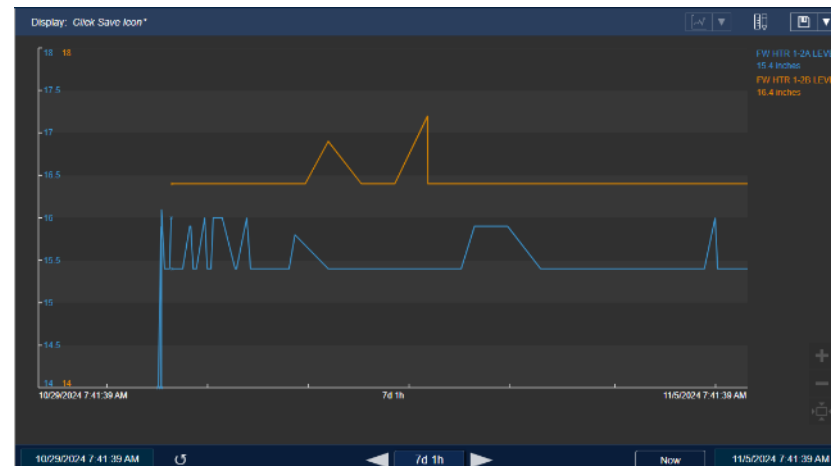
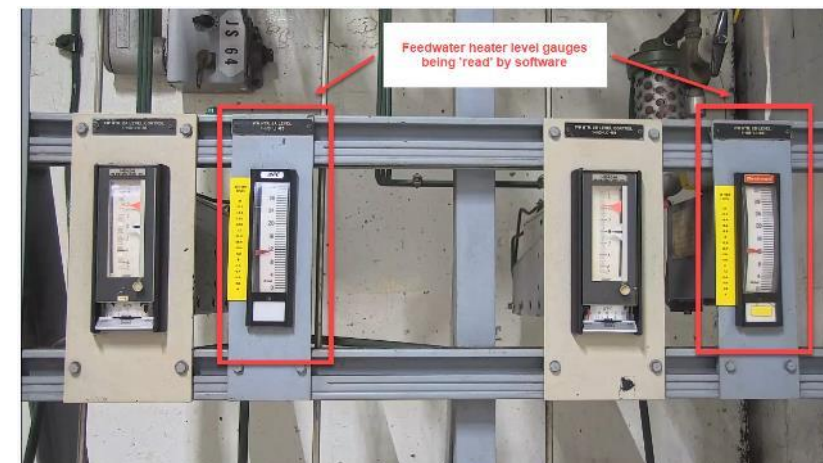
Duke Brunswick

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.

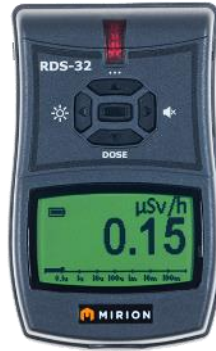
Solution:

- 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.

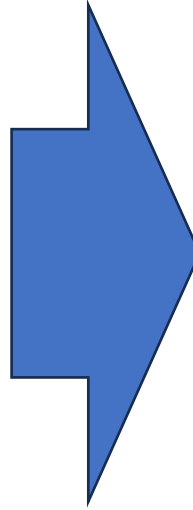


**Data collected and displayed
via PI Historian**

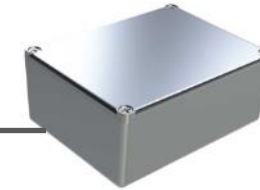
Wireless Remote Radiation Monitor



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.

Valve Cycle Isolation Monitoring

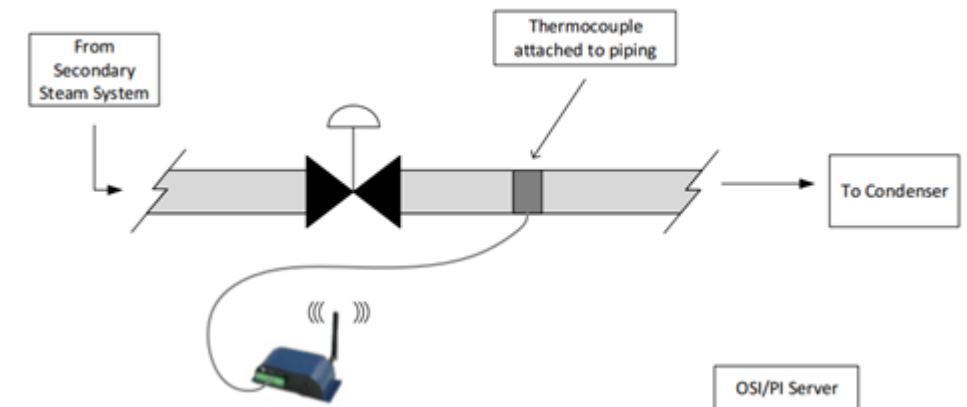
Need:

- 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



Q & A