Non-Invasive Digitization of Nuclear Plants

Applications and ROI
Version 10 – July 2025

CYPRESS ENVIROSYSTEMS™

WGR Deployments – 34 Nuclear 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, Ginna, Peach Bottom)
- NextEra (Fleetwide: Turkey Point, St. Lucie, Point Beach, Seabrook)
- Vistra (Comanche Peak, Davis Besse, Perry, 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

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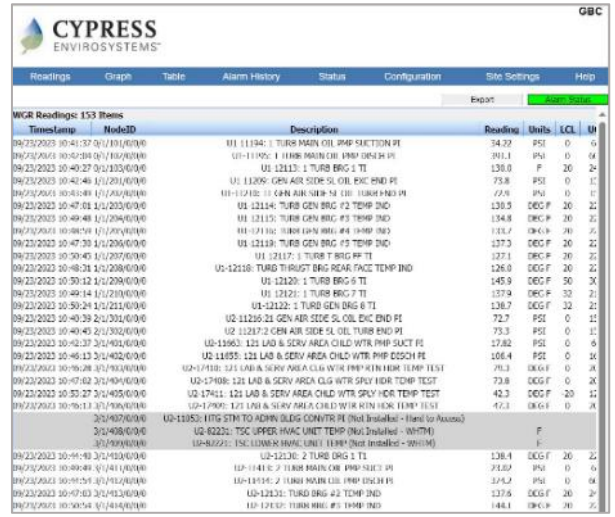
Problem: Most Plant Data is NOT Digitized

Solution: Non-Invasive Sensors – 5 Minute Install

Connection via
RESTful API or OPC

Historian

HMI



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

Where are they installed?

Outdoors, RCA, Seismic Structures, Safety Related

(Non-CDA, Non Tech Spec, Trending /Analysis only)

Variety of Mounting Methods per Operational Need

- Use of flip doors with gas struts provide hands-free maximum visibility of original gauge

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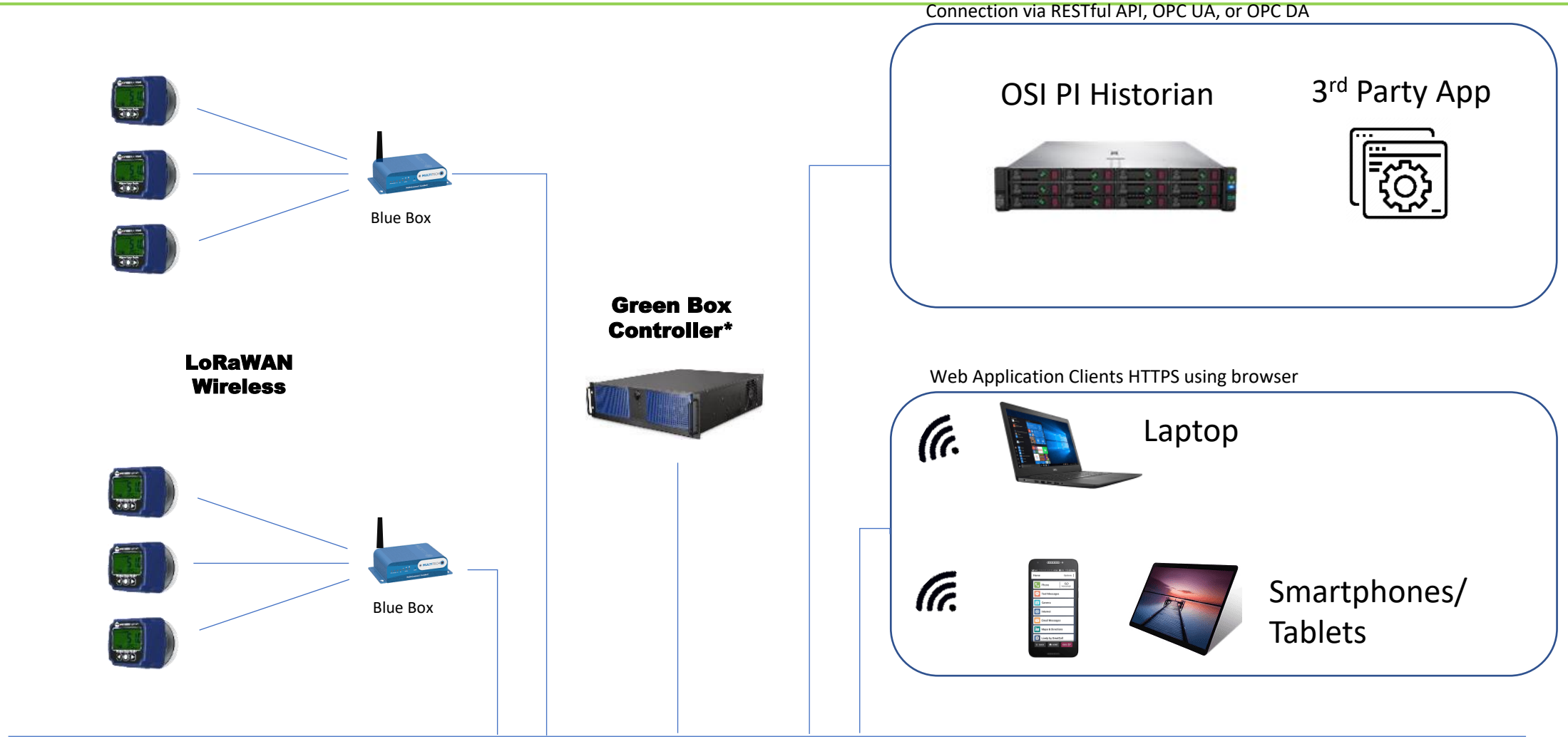
Typical Deployment Architecture



Data Visibility on Tablets or Plant Historian

GBC

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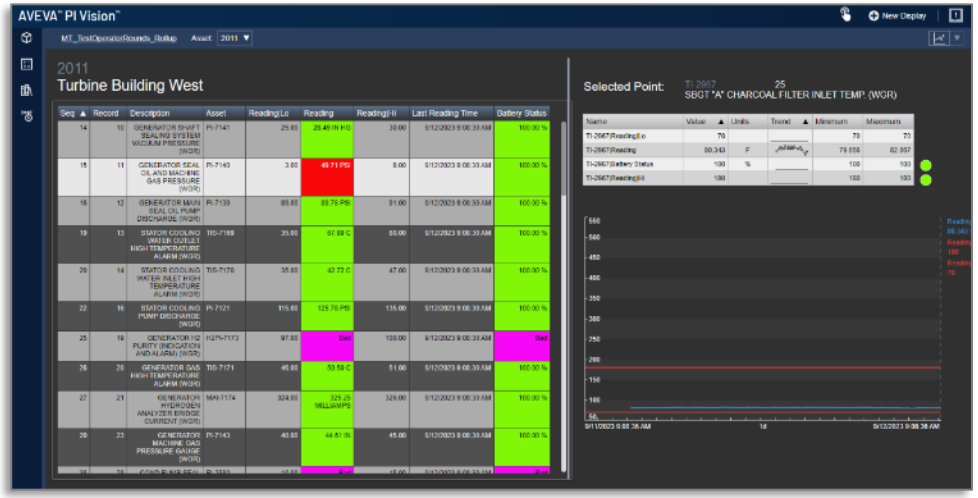
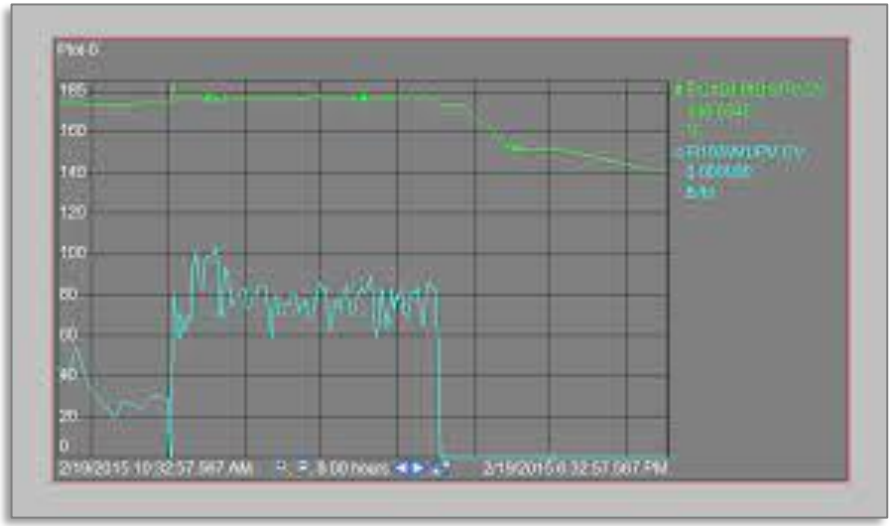
Readings | Graph | Table | Alarm History | Status | Configuration | Site Settings | Help

Export | Alarm Status

WGR Readings: 153 Items

Timestamp	NodeID	Description	Reading	Units	LCL	UC
09/23/2023 10:41:37	0/1/101/0/0/0	U1-11194: 1 TURB MAIN OIL PMP SUCTION PI	34.22	PSI	0	6
09/23/2023 10:42:04	0/1/102/0/0/0	U1-11195: 1 TURB MAIN OIL PMP DISCH PI	391.1	PSI	0	6(
09/23/2023 10:40:27	0/1/103/0/0/0	U1-12113: 1 TURB BRG 1 TI	130.0	F	20	2(
09/23/2023 10:42:46	1/1/201/0/0/0	U1-11209: GEN AIR SIDE SL OIL EXC END PI	73.8	PSI	0	1(
09/23/2023 10:43:49	1/1/202/0/0/0	U1-11210: 11 GEN AIR SIDE SL OIL TURB END PI	72.9	PSI	0	1(
09/23/2023 10:47:01	1/1/203/0/0/0	U1-12114: TURB GEN BRG #2 TEMP IND	130.5	DEG F	20	2(
09/23/2023 10:49:48	1/1/204/0/0/0	U1-12115: TURB GEN BRG #3 TEMP IND	134.8	DEG F	20	2(
09/23/2023 10:48:59	1/1/205/0/0/0	U1-12116: TURB GEN BRG #4 TEMP IND	133.7	DEG F	20	2(
09/23/2023 10:47:30	1/1/206/0/0/0	U1-12119: TURB GEN BRG #5 TEMP IND	137.3	DEG F	20	2(
09/23/2023 10:50:45	1/1/207/0/0/0	U1-12117: 1 TURB T-BRG FF TI	127.1	DEG F	20	2(
09/23/2023 10:48:31	1/1/208/0/0/0	U1-12118: TURB THRUST BRG REAR FACE TEMP IND	126.0	DEG F	20	2(
09/23/2023 10:50:12	1/1/209/0/0/0	U1-12120: 1 TURB BRG 6 TI	145.9	DEG F	50	3(
09/23/2023 10:49:14	1/1/210/0/0/0	U1-12121: 1 TURB BRG 7 TI	137.9	DEG F	32	2(
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	2(
09/23/2023 10:40:39	2/1/301/0/0/0	U2-11216:21 GEN AIR SIDE SL OIL EXC END PI	72.7	PSI	0	1(
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	1(
09/23/2023 10:42:37	3/1/401/0/0/0	U2-11663: 121 LAB & SERV AREA CHLD WTR PMP SUCT PI	17.82	PSI	0	6
09/23/2023 10:46:13	3/1/402/0/0/0	U2-11655: 121 LAB & SERV AREA CHLD WTR PMP DISCH PI	106.4	PSI	0	1(
09/23/2023 10:46:28	3/1/403/0/0/0	U2-17410: 121 LAB & SERV AREA CLG WTR PMP RTN HDR TEMP TEST	79.3	DEG F	0	2(
09/23/2023 10:47:02	3/1/404/0/0/0	U2-17408: 121 LAB & SERV AREA CLG WTR SPLY HDR TEMP TEST	73.8	DEG F	0	2(
09/23/2023 10:53:27	3/1/405/0/0/0	U2-17411: 121 LAB & SERV AREA CHLD WTR SPLY HDR TEMP TEST	42.3	DEG F	-20	1:
09/23/2023 10:46:13	3/1/406/0/0/0	U2-17409: 121 LAB & SERV AREA CHLD WTR RTN HDR TEMP TEST	47.3	DEG F	0	2(
	3/1/407/0/0/0	U2-11053: HTG STM TO ADMN BLDG CONVTR PI (Not Installed - Hard to Access)				
	3/1/408/0/0/0	U2-82231: TSC UPPER HVAC UNIT TEMP (Not Installed - WHTM)		F		
	3/1/409/0/0/0	U2-82221: TSC LOWER HVAC UNIT TEMP (Not Installed - WHTM)		F		
09/23/2023 10:44:40	3/1/410/0/0/0	U2-12130: 2 TURB BRG 1 T1	138.4	DEG F	20	2(
09/23/2023 10:49:49	3/1/411/0/0/0	U2-11413: 2 TURB MAIN OIL PMP SUCT PI	23.02	PSI	0	6
09/23/2023 10:44:54	3/1/412/0/0/0	U2-11414: 2 TURB MAIN OIL PMP DSCH PI	374.2	PSI	0	6(
09/23/2023 10:47:03	3/1/413/0/0/0	U2-12131: TURB BRG #2 TEMP IND	137.6	DEG F	20	2(
09/23/2023 10:50:54	3/1/414/0/0/0	U2-12132: TURB BRG #3 TEMP IND	144.1	DEG F	20	2(





CYPRESS ENVIROSYSTEMS™

Cypress Family of Non-Invasive Digitization Solutions

Non-Invasive Sensors

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

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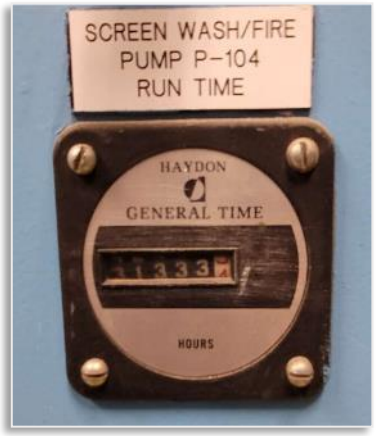
Wireless Digit Reader

- Reads numeric indicators
- Exactly same form factor as Wireless Gauge Reader
- Should not require additional engineering review/approval
- Has different firmware than WGR
- Wireless transmission duty cycle is higher - battery life about 30% of WGR. Use slower sample rate to compensate



Wireless Pipe Temperature Monitor

- Clamp on Type K thermocouples to pipe wall
- Thermocouples may also be inserted between pipe insulation and pipe wall
- Small form factor, slim profile – can fit in tight spaces
- Low weight – less than 1 lb – reduces civil and seismic concerns.
- 500 deg F maximum temperature at thermocouple
- Electronics module max temperature of 158 F. Thermocouple wires may be up to 100 ft long.
- Battery life of 3+ years at 15 minute sample rate
- Optional IP67 enclosure available

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Wireless Steam Trap/Pipe Wall Temp Monitor

Leaking Traps Waste Energy

Typical Steam Trap

- Traps are a necessary part of the steam distribution system, usually hundreds of units per site
- 15-20% average failure rate; leaks steam
- Failed traps lose $5,000 per year (1/8” orifice)
- Manual inspection typically done annually – labor intensive, do not catch problems in timely manner
- Solution: Wireless steam trap monitor detects faults and alarms on error, avoiding expensive leak loss
- Non-invasive installation: no breaking seals, wireless, integrates with BMS
- Battery life of 3+ years at typical sample rates
- IP65/NEMA 4 rated for outdoor use
- One year payback on investment

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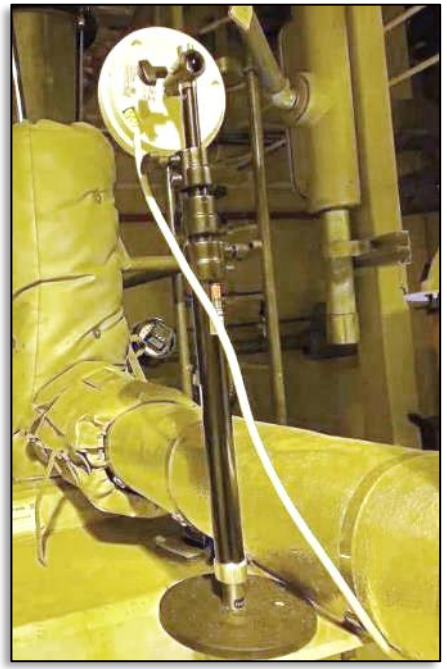
Wireless Transducer Reader

- Software configurable I/O and signal conditioning
- Enables wireless remote monitoring of virtually any analog transducer or instrument with the following outputs: 4-20mA, 0-5V, or 0-10V, RS-232, RS-485, thermocouple, thermistor, dry contacts
- 2 channels per device
- Configurable sample rates from three seconds to four hours
- Compatible with most existing flow meters, current meters, particle counters, thermocouples, weigh scales, etc.
- Battery life of 3+ years at 15 minute sample rate, also accepts 110VAC line power
- IP 67 protection
- Enables data logging to enable trend analysis, notification, or statistical process control

Wireless Humidity, Temperature, Wet Bulb Monitor

- -20 ºC to +70 ºC (-4 ºF to 158 ºF) Temperature Range
- 0 – 100% Relative Humidity Range
- Displays Temperature, Relative Humidity, and Wet Bulb Temperature (optional)
- Used for worker heat stress management, materials life tracking etc.
- Magnetic Mounting for steel walls or columns
- Adhesive Mounting for other surfaces
- Battery life of 3+ years at 15 minute sample rate
- IP56/NEMA 4 rated for outdoor use

IP Camera Monitoring Automation



- Capture images from 3rd party IP Cameras
- Use GBC machine vision engine to automatically convert to digital value and store for history, trending, alarming
- No need for human operator to always check camera feed
- Leverage existing approved data architecture

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Wireless Liquid Level Monitor – mobile application

INSTALLED

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Vibration Monitoring

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.

Figure 1– Honeywell Versatilis Transmitter

MEASUREMENT PARAMETERS:

Surface Temperature	Ambient Humidity	Ambient Pressure
Vibration	Audio Acoustics	Ambient Temperature

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.

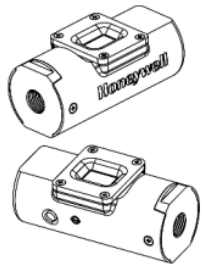

Figure 2– Assembly

Honeywell

Honeywell Versatilis™ Transmitter Technical Specification Honeywell Proprietary

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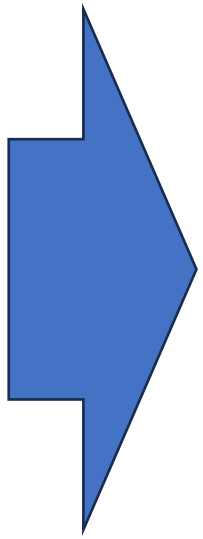
Return on Investment
Use Cases

Plant-wide Engagement – Broad benefits

DEPARTMENT:

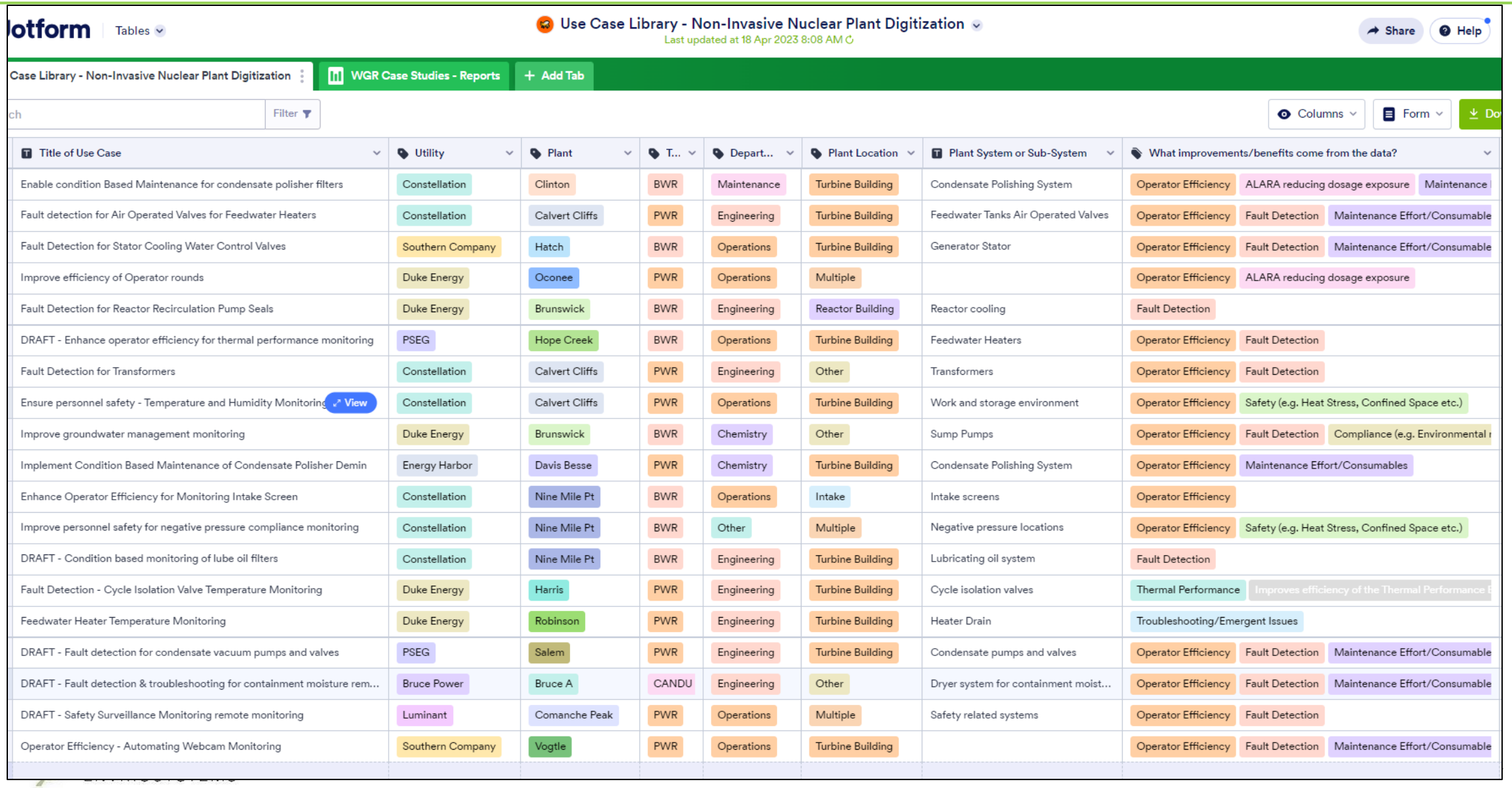
- Operations
- Maintenance
- Engineering
- Chemistry
- Radiation Protection
- Monitoring & Diagnostics Center



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

Use Case Library – Available to WGR Users Group



jotform | Tables

Use Case Library - Non-Invasive Nuclear Plant Digitization

Last updated at 18 Apr 2023 8:08 AM

Share | Help

Case Library - Non-Invasive Nuclear Plant Digitization | WGR Case Studies - Reports | + Add Tab

ch | Filter | Columns | Form | Do

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 View	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

Best Practices Library – Available to WGR Users Group

Jotform | Tables

WGR Users Group Repository
Last updated at 03 May 2023 10:31 AM

WGR Users Group Repository | + Add Tab

Search | Filter | Columns

	Title	Organization	Plant	Type of document / su...	Description		Submitter Name	Submitter Email	Submitter Phone	Submission
1	Constellation Fleet Admin Proc...	Constellation	Multiple Plants	Procedure	Fleet administrative proce...		Bill Ansley	William.Ansley@constellat...	(856) 981-1348	Oct 18, 2023
2	WGR Battery Replacement Trai...	Cypress Envirosystems	Other or N/A	Training	Training document to sho...	PDF	Harry Sim	harry.sim@cypressenviros...	(408) 307-0922	Oct 18, 2023
3	NITSL Paper 2023 - Non-Invasi...	Southern Company	Multiple Plants	Technical Paper	Technical paper presented...	PDF	Josh Patrick	jbpatric@southernco.com	(912) 531-3394	Oct 18, 2023
4	Specification: Equipment Monit...	Duke Energy	Multiple Plants	Specification	Fleet specification for inst...	PDF	Steve Putnam	Steven.Putnam@duke-ene...	(704) 770-8415	Oct 18, 2023
5	Members Contact List	Cypress Envirosystems	Other or N/A	Meeting Minutes / Materials	List of Users Group Memb...	PDF	Harry Sim	harry.sim@cypressenviros...	(408) 307-0922	May 3, 2023
6	Tech spec for wireless devices	PSEG	Multiple Plants	Specification	Equipment installed under ...	PDF	Emmanuel Darko	Emmanuel.Darko@pseg.c...	(540) 424-6582	May 2, 2023
7	April users group meeting minu...	Cypress Envirosystems	Other or N/A	Meeting Minutes / Materials	Discussion package and a...	PDF	Harry Sim	harry.sim@cypressenviros...	(408) 307-0922	Apr 18, 2023
8	Magnehelic Gauge adapter for ...	Constellation	Nine Mile Pt	Best practice	Magnehelic gauges have a...	PDF	Sila Hoffstaetter	Silas.Hoffstaetter@constel...	(607) 229-2491	Apr 18, 2023
9	Duke - Fleet Specification	Duke Energy	Other or N/A	Specification	Duke Fleet Specification c...	PDF	Steve Putnam	Steven.Putnam@duke-ene...	(704) 770-8415	Apr 17, 2023
10	Duke - WGR Installation Guidel...	Duke Energy	Other or N/A	Best practice	This document contains th...	DOCX PD	Steve Putnam	Steven.Putnam@duke-ene...	(704) 770-8415	Apr 14, 2023
11	Charlotte Meeting Package	Cypress Envirosystems	Other or N/A	Meeting Minutes / Materials	Discussion package from ...	PDF	Aline Sim	aline.sim@cypressenviros...	(408) 219-1657	Apr 12, 2023
12	WGR Training Manual	Cypress Envirosystems	Other or N/A	Training	WGR Installation and Cali...	PDF	Harry Sim	harry.sim@cypressenviros...	(408) 307-0922	Apr 12, 2023

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

Condition Based Monitoring – FRF Filters

Bruce Power

Need:

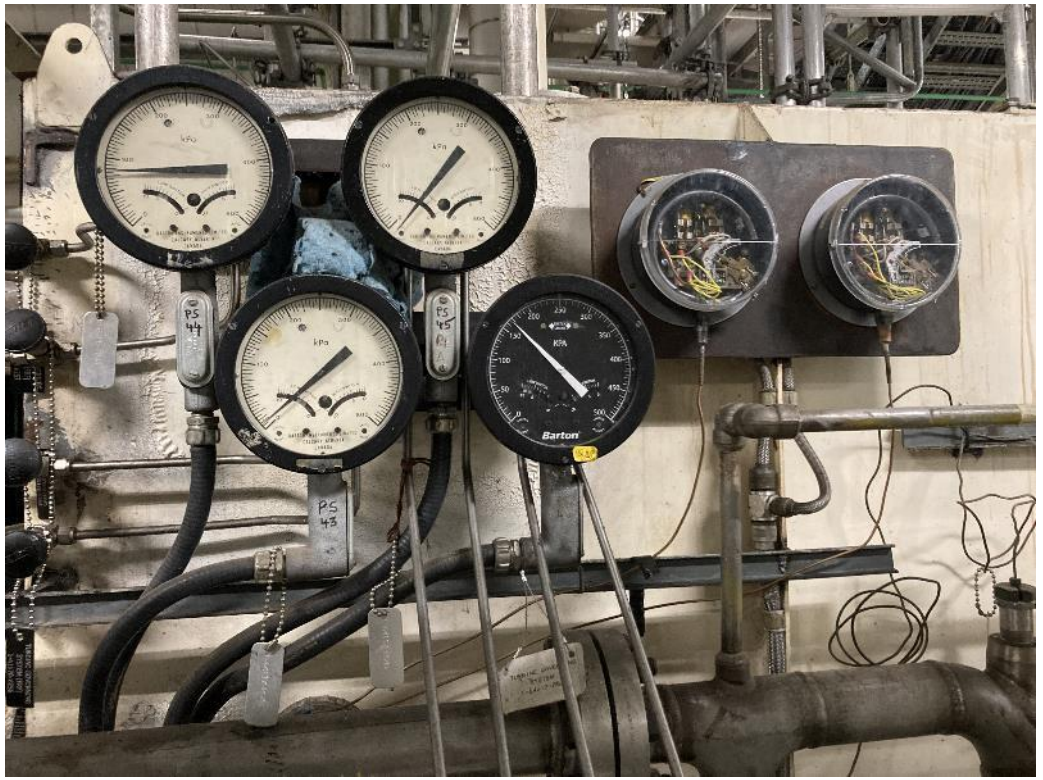
- Apply Condition Based Monitoring to FRF filters. Replace consumables only when data shows it is necessary.
- Note: FRF Filters remove impurities which can cause damage or malfunction to the hydraulic system.

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.



Feedwater Heater Level - Webcam Digitization

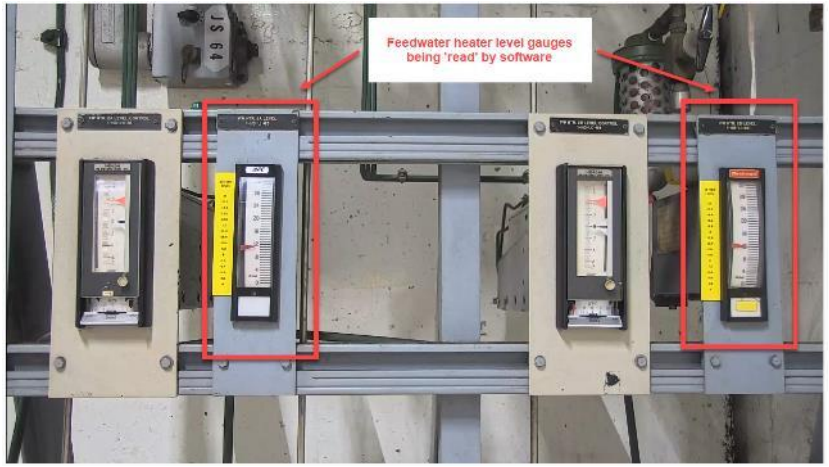
Duke Brunswick

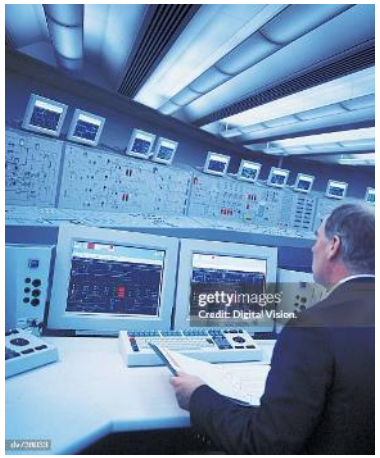
Need:

- 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

Operator Rounds Dashboard

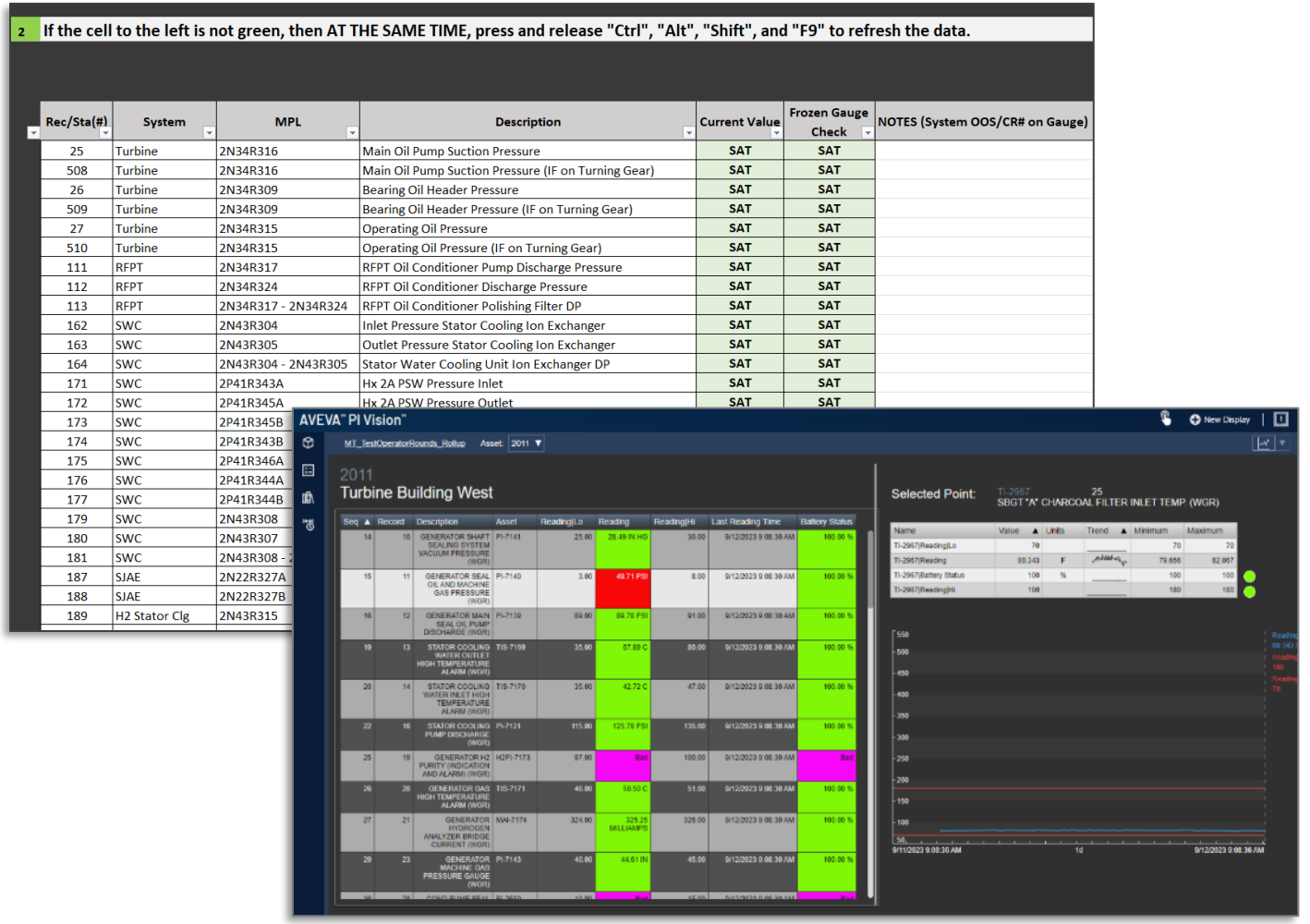
Southern Hatch
Duke Oconee

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

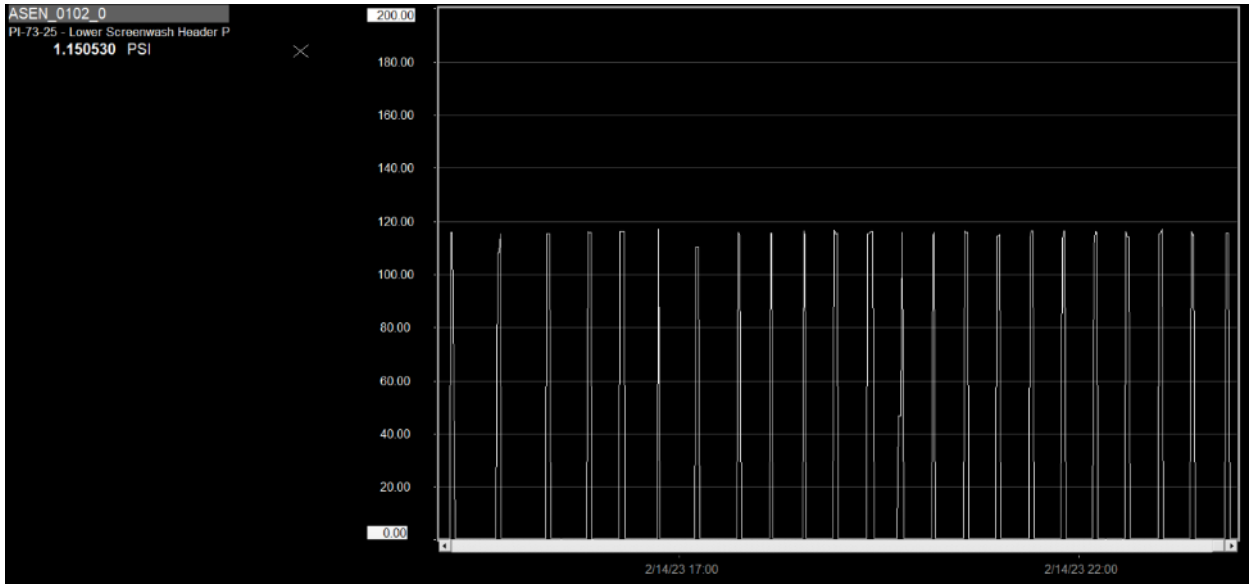


2 If the cell to the left is not green, then AT THE SAME TIME, press and release "Ctrl", "Alt", "Shift", and "F9" to refresh the data.

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				
174	SWC	2P41R343B				
175	SWC	2P41R346A				
176	SWC	2P41R344A				
177	SWC	2P41R344B				
179	SWC	2N43R308				
180	SWC	2N43R307				
181	SWC	2N43R308 -				
187	SJAE	2N22R327A				
188	SJAE	2N22R327B				
189	H2 Stator Clg	2N43R315				

Minimize Operator Wait Time for Equipment Response

- Certain rounds tasks require operators to wait and watch equipment to confirm functionality.
- Example: Constellation (Nine Mile Point) operators must confirm intake screen pump action each shift. Pump typically actuates once every 20 minutes, and operators may wait idle for response.
- Non-invasive monitoring and trending of pump head pressure allows operators to be freed up from non-productive waiting.



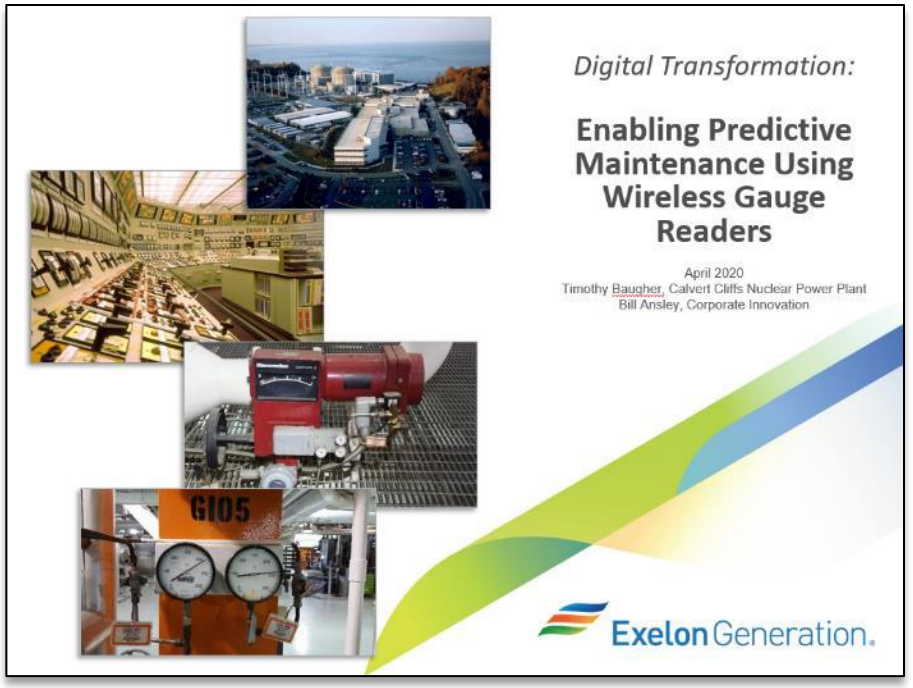
Silas Hoffstaetter – Constellation Nine Mile Point

Condition Based Maintenance + ALARA

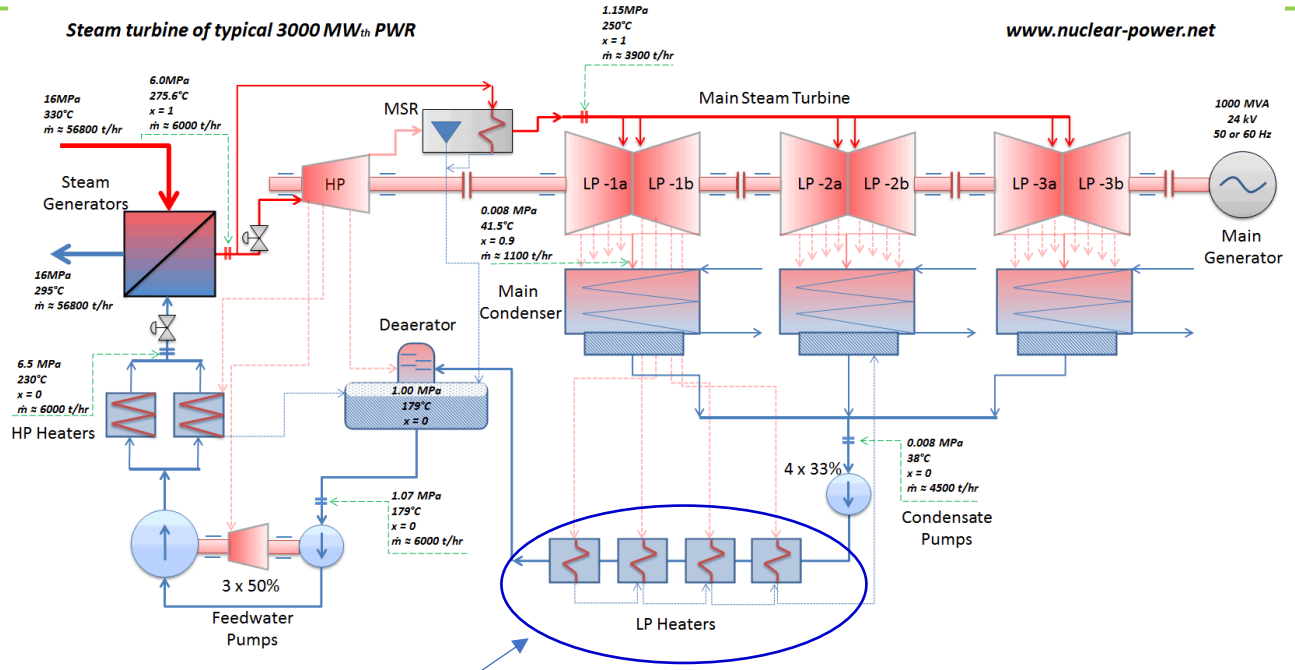
- Automated monitoring of filter delta-pressure for condensate polisher filters – minimize time and dosage exposure (BWR)
- Clinton observed problems with their condensate polisher – suspect that filters are clogging up.
- Short term fix to replace filters more often, but expensive and time intensive.
- Need to monitor filter delta pressure more often to detect when a change is needed – condition based maintenance.
- Only way to do this is sending operators to read pressure gauges. This is a BWR. Dose rates in CP area about 25 mrem/hr.
- WGR used to remotely monitor and trend filter pressures.

Fault Detection – Exelon/Constellation Calvert Cliffs

- Monitor performance and detect failures of Air Operated Valves used to control and maintain feedwater heater tank levels.
- AOV's fail when there is an air leak, drift from calibration, stuck actuator, worn out cam.
- Prior failures caused high-level dump of heater tank and unit shutdown, with costly overtime work to repair.
- Since installing WGR's, Calvert Cliffs detected two emerging failures and repaired them before there was any operational disruption.



Background: Air Operated Valves in Feedwater Heating Loop



- Feedwater Control Valves control tank water level for feedwater heaters (8 cascading stages).
- Existing valves are Air Operated – no motor, no voltage, no networking. Mechanical gauges display air pressure, but there is no remote monitoring or control.
- Cannot perform predictive analytics, automated fault detection, implement condition-based monitoring – no Predix, no Prism.
- Labor consuming (manual rounds).

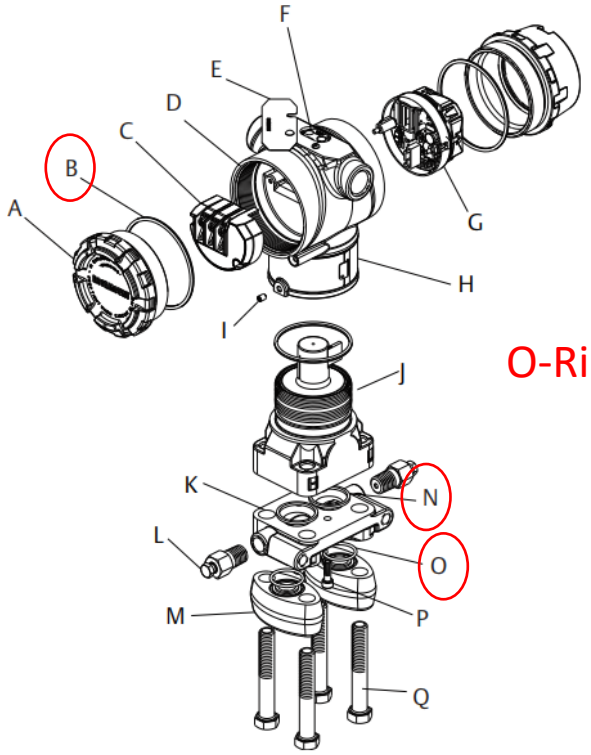
Local area temperature monitoring for Environmental Qualification life extensions

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

Long Term Trending: Turbine Valve Actuator Temperatures

Need:

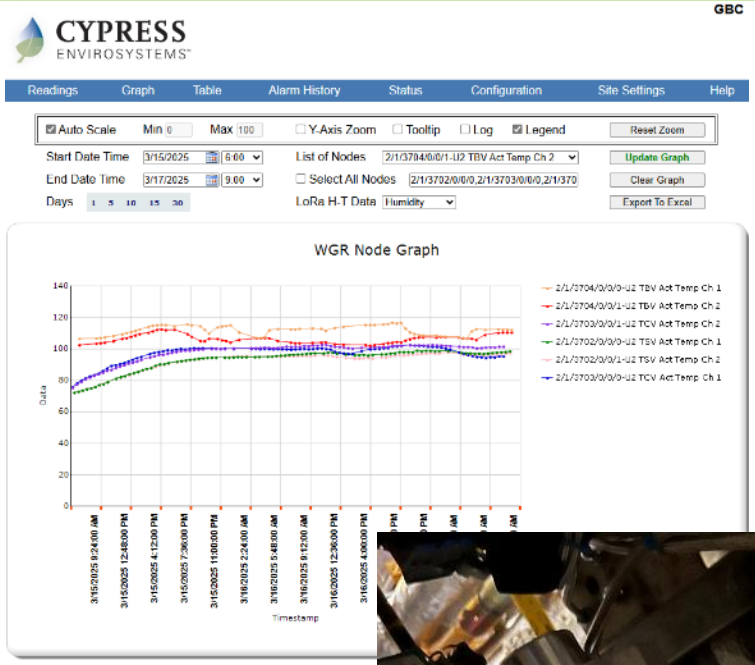
- Long term temperature trending to monitor for EHC fluid degradation due to temperature

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



Dry Well Temp / Humidity Monitoring

Need:

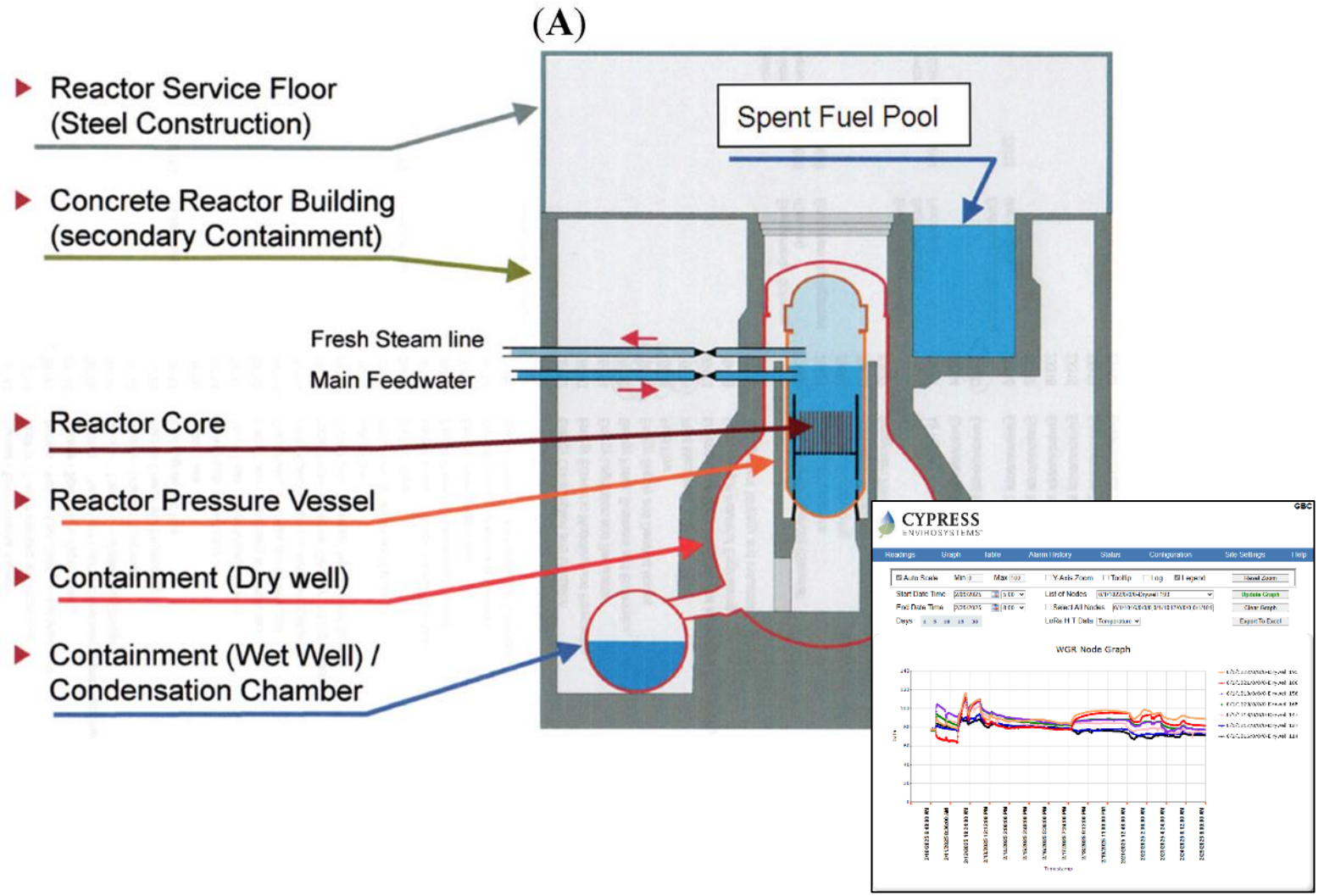
- During outage: Monitor temperature and humidity for worker safety (heat stress).
- Minimize time and dosage exposure for RP Tech to gather data each shift.

Solution:

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

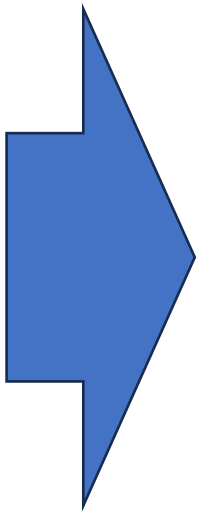
Benefit:

- 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



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.

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.

Valve Cycle Isolation Monitoring

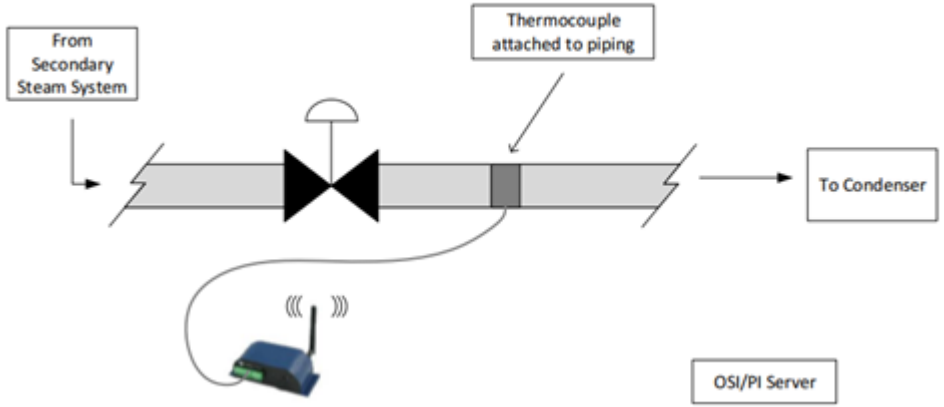
Need:

- 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

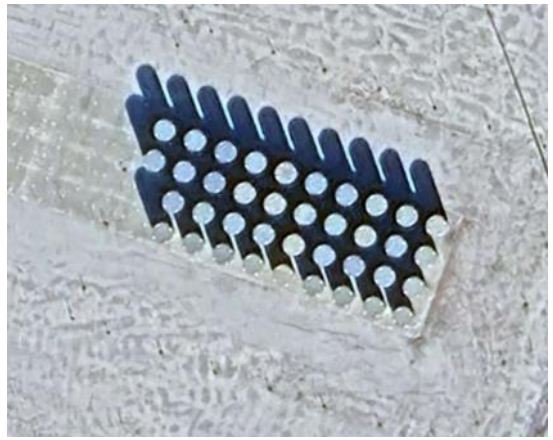
Detect Leaking Valves



Duke Brunswick: Environmental Compliance

- 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)

Drone Integration: Dry Cask Inspection



Skydio Drone
- May be piloted
- Or autonomous

Skydio Dock
- “Garage” protection
- Recharging
- Data download

Condensate vacuum pumps and valves monitoring

- Monitor condensate vacuum pumps and valves pressures, temperatures, valve position
- Undetected faults can cause >2 MW thermal performance impact
- Trending of data enables early fault detection – data sent to GE Smart Signal
- Improves operator efficiency – reduces need for manual readings.
- Reduces maintenance cost – condition based maintenance

Use of WGRs to confirm valve transfer function

Read Temperature, Pressure

Read Valve Actuator Position

CYPRESS ENVIROSYSTEMS

Void Detection in Pipe Flows
(Gas Accumulation Monitoring Program – GAMP)

- Ultrasonic technology to detect gas voids
- Wireless method expected to be approved by NRC imminently
- Non-invasive, clamp-on, wireless
- Avoids scaffolds, man-hours to manually perform void test.

Conventional Testing

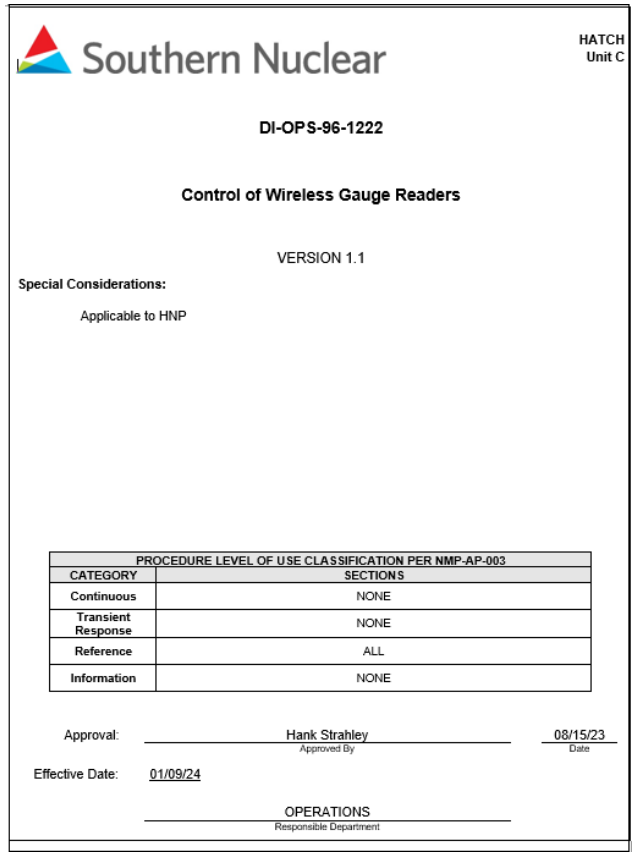
Steps	Efficiency (Time)	Cost ($)	Safety (Rad Exposure, climbing, crawling)***
Permitting/Planning	4 hr (3 containment & 1 aux)	-	-
Scheduling of two technicians	2 hr	-	-
Total examination time	6 hr (1 containment & 5 aux)	-	6 hr * 2 ppl = 12 hrs
Reporting time	2 hr (1 containment & 1 aux)		-
Scaffold tear down / build / inspection			-
Times per year	8 (2 trains/quarterly)	2	8 (2 trains/quarterly)
Total * 2 technicians	224 hours		96 hours

Wireless Sensor

Steps	Efficiency (Time)	Cost ($)	Safety (Rad Exposure, climbing, crawling)
Permitting/Planning	0 hr	-	-
Scheduling of two technicians	0 hr	-	-
Total examination time	0 hr	-	0 hr
Reporting time	1 hr		-
Scaffold tear down / build / inspection		-	-
Times per year	8 (2 trains/quarterly)	-	8 (2 trains/quarterly)
Total (1 data analyst)	8 hr	0	0 hrs

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

Transfomer Fault Detection

- Connect legacy transformer trace gas monitoring systems to PI Historian.
- Allow old ModBUS IP protocol to communicate and conform to latest cyber security requirements.
- Enable automated fault detection.

GE
Digital Energy

Intellix* MO150 specification sheet

Description

The Intellix MO150 is an intelligent, dynamic transformer monitoring system designed to provide comprehensive monitoring and interactive condition diagnostics for oil-insulated transformers used by electrical utilities and large industries.

Functionality

The Intellix MO150 system is designed to collect, process, analyze and interpret critical operations on data obtained from various sensors. It incorporates onboard intelligence, which utilizes the monitored transformer's characteristics along with real-time measurements to automatically compute on-line state-of-the-art mathematical transformer models based on IEEE® or IEC® standards. The on-line models of the system include:

- MVA model which computes apparent power on primary, secondary or tertiary winding
- Winding hot-spot temperature model which computes the hot-spot temperature of each winding where load current is measured
- Moisture in the thin conductor insulation and in the barrier insulation which computes the moisture content of each
- Insulation aging which computes aging acceleration factor from IEEE or IEC guidelines
- Top changer thermal model which computes temperature difference between the LTC tank and main transformer oil tank
- Top changer position tracking model as the top position transitions are recorded and tracked
- Cooling control for management and operation of the transformer cooling system
- Cooling efficiency which monitors actual efficiency of the cooling system

Electronic Controller

Microprocessor based
- W32/1600
- Clock
- Memory storage
- More than 3700 historical alarms and events
- More than 6900 historical service logs (once per day)
- More than 100 days of short term logging (15 min interval)

Components
- Basic embedded software
- Backlit graphic LCD display: 128 x 64 pixels, seven lines of 20 text columns
- Membrane keypad with eight functions: up, down, left, right, escape and three interactive keys
- Four LED indicators: power, "System OK," Alarm One and Alarm Two
- Internal temperature controlled

Communications
- Local serial RS-232 link; connector type DB-9M; dielectric withstand: 1500 V RMS
- RS-485 port
- Remote communication via LAN and modem

Inputs and Outputs

Analog inputs

Quantity: eight inputs, dielectric withstand: 1500 V RMS configurable to the following two options:
- RTD input; model PT-100; range: 0-270 Ω; accuracy: ± 0.15 Ω
- 4-20 mA isolated input (active/passive); wetting: 24 Vdc; maximum load: 40 mA; maximum input impedance: 220 Ω; accuracy: ± 0.01 mA

AC Analog Inputs

Quantity: Five inputs, dielectric withstand: 2000 V RMS; input impedance: 150 Ω
- Three inputs for transformer winding currents H, X and Y (clamp-on CTs 50 mA)
- Two inputs for fan group current

Cypress network:
Open System to Integrate with 3rd LoRaWAN sensors

Integration of 3rd Party LoRaWAN devices

MultiTech Reveal™ Wireless Proximity Sensors

MultiTech Reveal™ LoRaWAN Wireless Proximity Sensors detect contact between two wires, proximity detection with a magnet, range with an ultrasonic signal, while the Reveal UltraSonic Level Sensors provide high accuracy proximity detection and ranging in air.

MultiTech Reveal™ Wireless Push Button Sensors

The MultiTech Reveal™ LoRaWAN Wireless Push Button Sensor transmits on a button press event. They can be used as a panic button wearable device, personal emergency response system (PERS), remote control or other remote push button applications. When the button is pressed, an alert is sent to the wireless network.

MultiTech Reveal™ Wireless Movement Sensors

MultiTech Reveal™ LoRaWAN Wireless Movement Sensors use an ultra sensitive internal accelerometer to detect movement of a critical asset. When movement is detected that exceeds a certain threshold, an alert is sent over the wireless network. Reveal Tilt Sensors detect transitions between horizontal and vertical orientation, as well as reporting the angle of the tilt.

MultiTech Reveal™ Wireless Leak Detection Sensors

MultiTech Reveal™ LoRaWAN Wireless Leak Detection Sensors use a water probe to detect the presence of water or other liquids. When the presence of water or another liquid is detected, an alert is sent over the wireless network to prevent a potentially catastrophic event.

- Integrate devices with Cypress Gateway and GBC
- Same wireless network infrastructure
- Same cyber security approval
- Same OSI PI connectivity

CYPRESS ENVIROSYSTEMS™

Integration of 3rd Party Sensors

3rd party LoRaWAN sensor

Enclosure in Field

Blue Box

CAT 5
UDP

Green Box

Plant Wi-Fi or Ethernet (L2 Network)

Connection via RESTful API, OPC UA, or OPC DA

OSI PI Historian

3rd Party App

Web Application Clients HTTPS using browser

Laptop

Smartphones/ Tablets

Integration of 3rd Party IP Cameras

3rd party
IP camera

Ethernet

Green Box

Plant Wi-Fi or Ethernet (L2 Network)

Connection via RESTful API, OPC UA, or OPC DA

OSI PI Historian

3rd Party App

Web Application Clients HTTPS using browser

Laptop

Smartphones/
Tablets