Void Testing in Nuclear Plants

Wireless GAMP Solution
October 28, 2025

Justin Keim, Wolf Creek Nuclear Station

Eddyfi Technologies — **Steve Strachan**

CYPRESS ENVIROSYSTEMS™ — **Harry Sim**

Today's Topic – Wireless Void Testing for Nuclear Plants

- Operational Experience from Wolf Creek Nuclear Station:
  Justin Keim, Innovation Manager

- New Technology Partnership for GAMP solution:
  - Eddyfi Technologies: Steven Strachan, GAMP sensor manufacturer
  - Cypress Envirosystems: Harry Sim, WGR and wireless sensors and networks

WGR Users Group

- Share Operational Experience Among Users
  - Use cases, justification, ROI
  - Best practices
- Feedback to Cypress Envirosystems – priorities/needs for R&D roadmap
- Meeting participants limited to professionals working in nuclear plants, current WGR users and prospective users
- Discussion is NOT recorded

2025 Chairman
WGR Users Group
- Hank Strahley
- Operations Support Mgr.
- Plant Hatch
- Southern Company

CEO Cypress Envirosystems
- Harry Sim

WGR Users - 2025

- 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

Agenda

- What is GAMP (Gas Accumulation Monitoring Program)?
- How is GAMP traditionally performed?
- What is new GAMP sensor:
  Wolf Creek Operating Experience.
- Wireless sensors for GAMP: Update on latest state of installation at WC.
- How do they work with the existing Cypress wireless network?
- Summary: Quantification of Benefits and Costs

What is GAMP?

- Gas Accumulation Monitoring Progam
  - AKA: “High-Point Vent”, “Void Testing”, “Gas Intrusion Program”
- Who is Doing it: BWR & PWRs as mandated by NRC (Generic Letter) to maintain licensing basis
- Why is it Important: Due to presence of gas (voids) in piping which, when present can damage pumps, create water hammer, etc.
- Regulatory Implications: At minimum quarterly (90 days) to check predetermined locations for presence of voids in piping systems
- What’s the big deal: Safety, efficiency, & cost savings

Who & What is Involved in GAMP?

Personnel

- Site NDE teams
- Site Operations teams
- Site Maintenance teams
- Site Engineering teams

- Equipment / Requirements
- Ultrasonic flaw detector(s)
- Transducers, wedges, cables, couplant
- Scaffolds
- Ladders
- Radiation PPE
- Permits & scheduling

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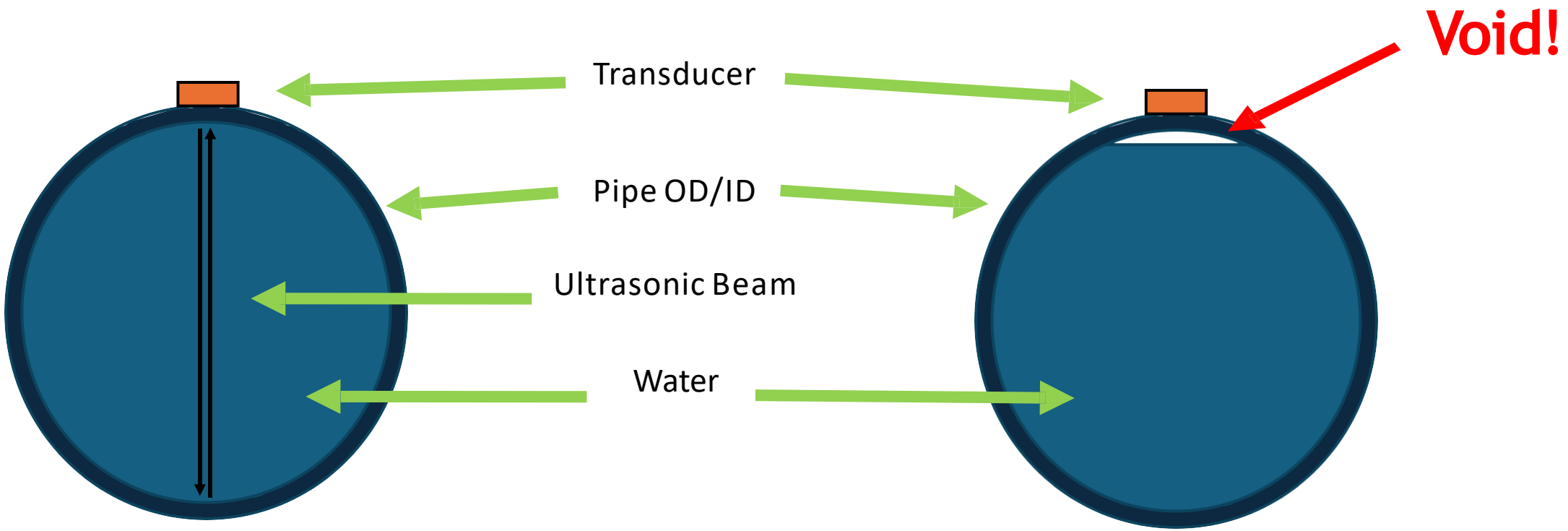
How it works … presence of

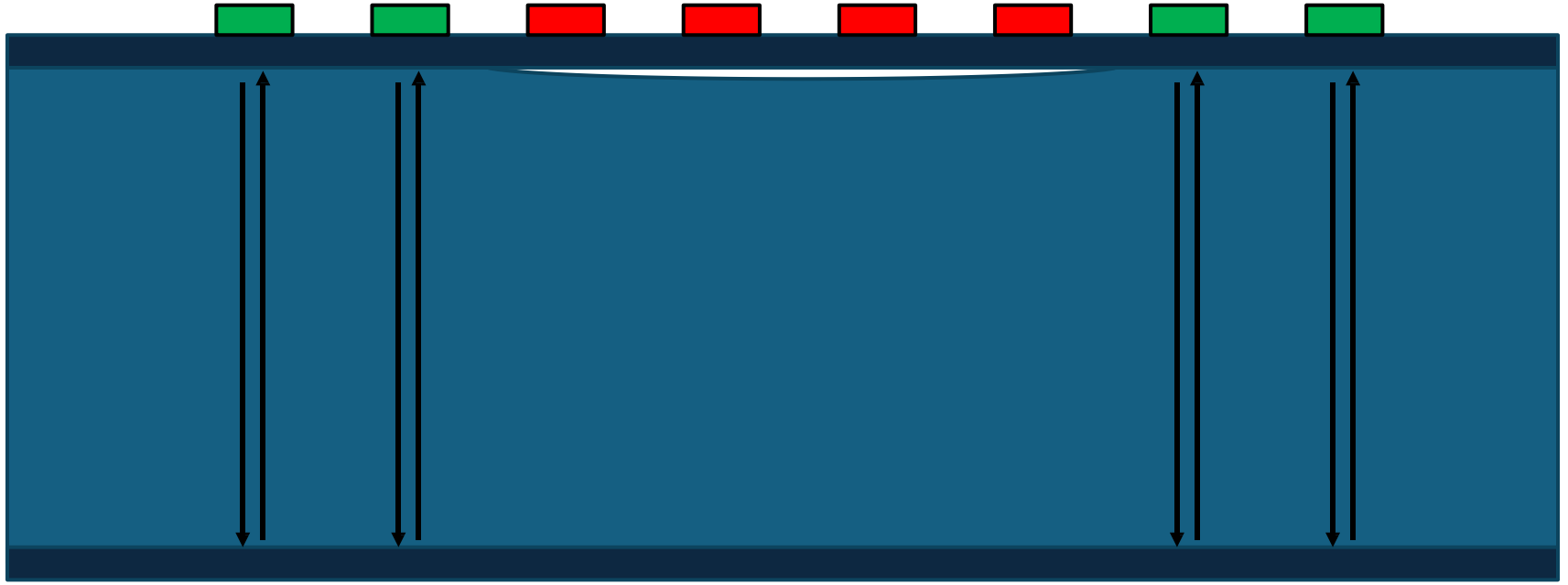


- Transducer from the top position identifies presence of void:

… if no void is present (left above), no action.

… if a void is present (right above), it must then be measured to determine size & corrective action

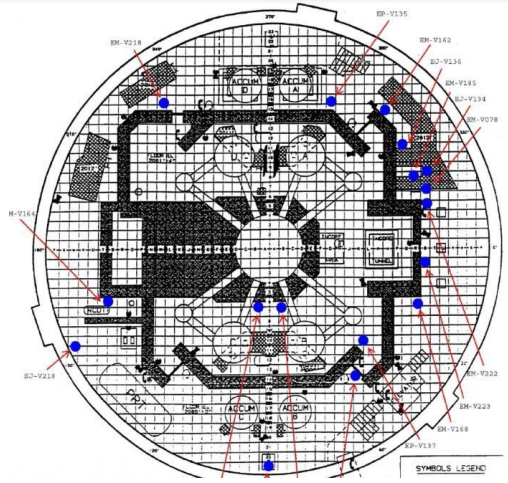
How it works … measuring



- Using manual scanning, a void is measured to determine size (arc & length) from either top or bottom position
- Depicted above is multiple transducer positions mounted to determine start & end point (and arc – not represented above) of void = size of void

How GAMP is ***Typically*** Performed …

- 2-man crew (minimum)
- 170 locations across 3 buildings
- 27 long term/permanent scaffolds to reach 144 locations in Aux building (many require dismantle & rebuild every other year)
- 1, 24’ ladder required to reach 26 locations in containment (must carry ladder, NDE equipment, & gear down 4 flights (~50’) of stairs outfitted in radiation suit/PPE
- Total ~200 climbs per year



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Costs for how GAMP is ***Typically*** Performed?

Steps	Efficiency (Time)	Cost ($)	Safety (RadExposure, 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

*Wolf Creek estimates 'typical' GAMP … for 44 of the 170 most critical points
**Estimates above represent 18 locations in AUX & 26 in containment (44 total GAMP locations)
***Scaffolding in the way blocking ability to perform other ancillary work/access to other components

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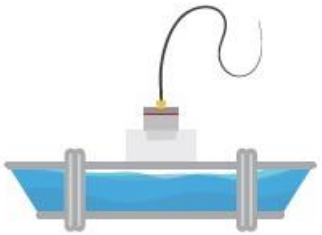
GAMP2.0: From *Typical* to **Installed**

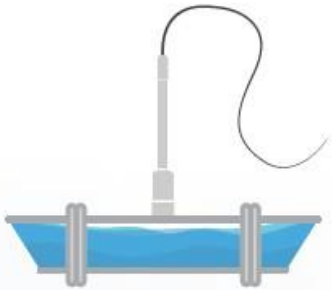


UT Sensor and Wedge

A standard UT Sensor paired with a wedge that has a long cable extending to an accessible location where an operator can plug in a flaw detector and take readings when desired. The 0-degree wedge, or delay, can be countoured allowing for installation on a wide range of pipe diameters. This method will work for applications up to 130°F (54°C) and can be optimized for virtually all pipe diameters.

Above: Low temperature (<130F) screw in style transducer w/ curved plex wedge epoxied to piping w/ long cable to collection area

- 18 installed in AUX – component cooling piping
- 26 installed in containment
- Above: Collection area for quick plug in to flaw detector for data collection



Ultra-High-Temp Sensor

This ultra-high-temp sensor is attached using a mechanical clamping system which allows it to be easily removed and reinstalled in new locations. The cable can be extended long distances to an accessible location where an operator can take readings with a flaw detector. This method will work for applications up to 932°F (500°C) and pipe diameters of 2-36 in. (50.8-914 mm).

Above: High temperature (up to 950F) transducer w/ metal foil clamped to piping w/ long cable to collection area

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Costs GAMP2.0–**Installed**

Steps	Efficiency (Time)	Cost ($)	**Safety (RadExposure, climbing, crawling)
Permitting/Planning	1 hr	-	-
Scheduling of twotechnicians	1 hr	-	-
Total examination time	1 hr	-	1 hr (2 ppl) = 2 hrs
Reporting time	2 hr	-	-
Scaffold tear down / build / inspection	-	-	-
Times peryear	8 (2 trains/quarterly)	0	8 (2 trains/quarterly)
Total (1.5 technicians)	60 hr		16 hrs

* Wolf Creek estimates as of 2025 (44 of 170 locations)
**No climbs, no stairs = for 44 critical locations

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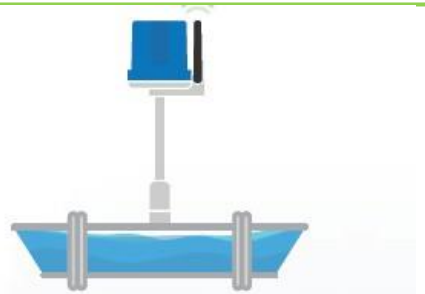
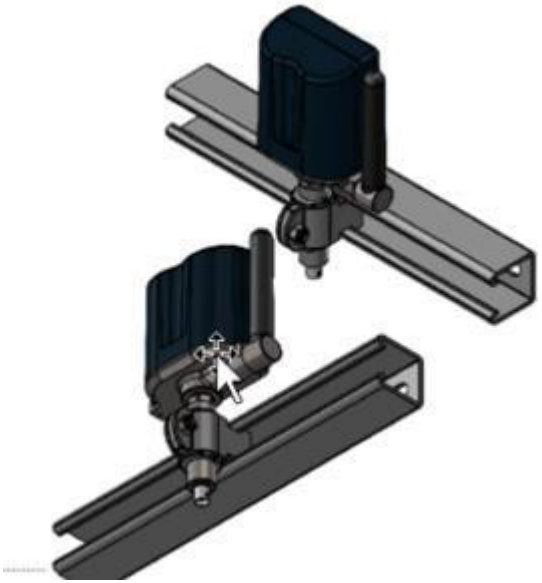
GAMP4.0: From **Installed** to ***Wireless***



microPIMS IS UHT

This Ultra-High-Temp wireless sensor is attached using a mechanical clamping system and uses metal foil as a couplant. microPIMS wirelessly takes and transmits data via 900MHz LoRaWAN wireless network. Data can also be incorporated into an existing LoRaWAN private network and backend software. This method will work for applications up to 932°F (500°C) and pipe diameters of 2-8 in. (50.8-203 mm).

Above: Fully wireless high temperature (up to 950F) transducer attached w/ metal foil &clamp



Above: Wireless transmitter mounted to hand rail connected via BNC to long cable to high temperature (up to 950F) transducer attached w/ metal foil &clamp

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Costs GAMP4.0 - ***Wireless***

Steps	Efficiency (Time)	Cost ($)	Safety (RadExposure, climbing, crawling)
Permitting/Planning	0 hr	-	-
Scheduling of twotechnicians	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

*Wolf Creek estimates as of 2025
**Permanently installed scaffolds, personal safety risk
***Not just for 50 critical locations but for all 170

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Wolf Creek Installation OE – wireless GAMP

- Critical digital asset documentation
  - Non-CDA
  - NEI 08-09 rev. 6 prevents "solely" relying on wireless
  - Alternate methods

Stakeholders & Key Steps

Stakeholder	Role	Status
EPRI	Common Design Chane Package Cybersecurity Consultation	Completed ~2019
NEI	Cybersecurity coordination via NRC	Ongoing
WC Cyber WC Design/Eng	Cybersecurity screening Seismic eval/documentation	Completed – April '25 Completed - Oct '25
SNI	High voltage pulser – up to 36" dia piping	Completed – April '25
DOE	Cybersecurity impact analysis ONLY required for CDA's	Ongoing – est. Dec '25

Tech Specs Cybersecurity Solution: 2 redundant & alternate methods to confirm

- Plant parameters/conditions (void factors)
- Sensors to confirm presence (or lack thereof)

Compatible with Existing Cypress Wireless Networks

- 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)
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- Vistra (Comanche Peak, Davis Besse, Beaver Valley)
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- France EDF (pilot deployment)

* Pending Installation

- **Leverage existing approved Cypress wireless network**
- **Already Cyber reviewed and approved – minimize effort**
- **Interface with PI Historian**
- **Fastest time to deployment**

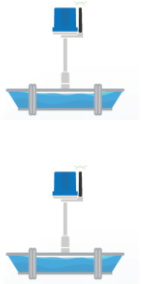
Wireless GAMP – Fully Compatible with Cypress

Connection via RESTful API, OPC UA, or OPC DA

OSI PI Historian

3rd Party App

Wireless GAMP Sensors



Blue Box

LoRaWAN Wireless

Green Box Controller*

Web Application Clients HTTPS using browser

Laptop

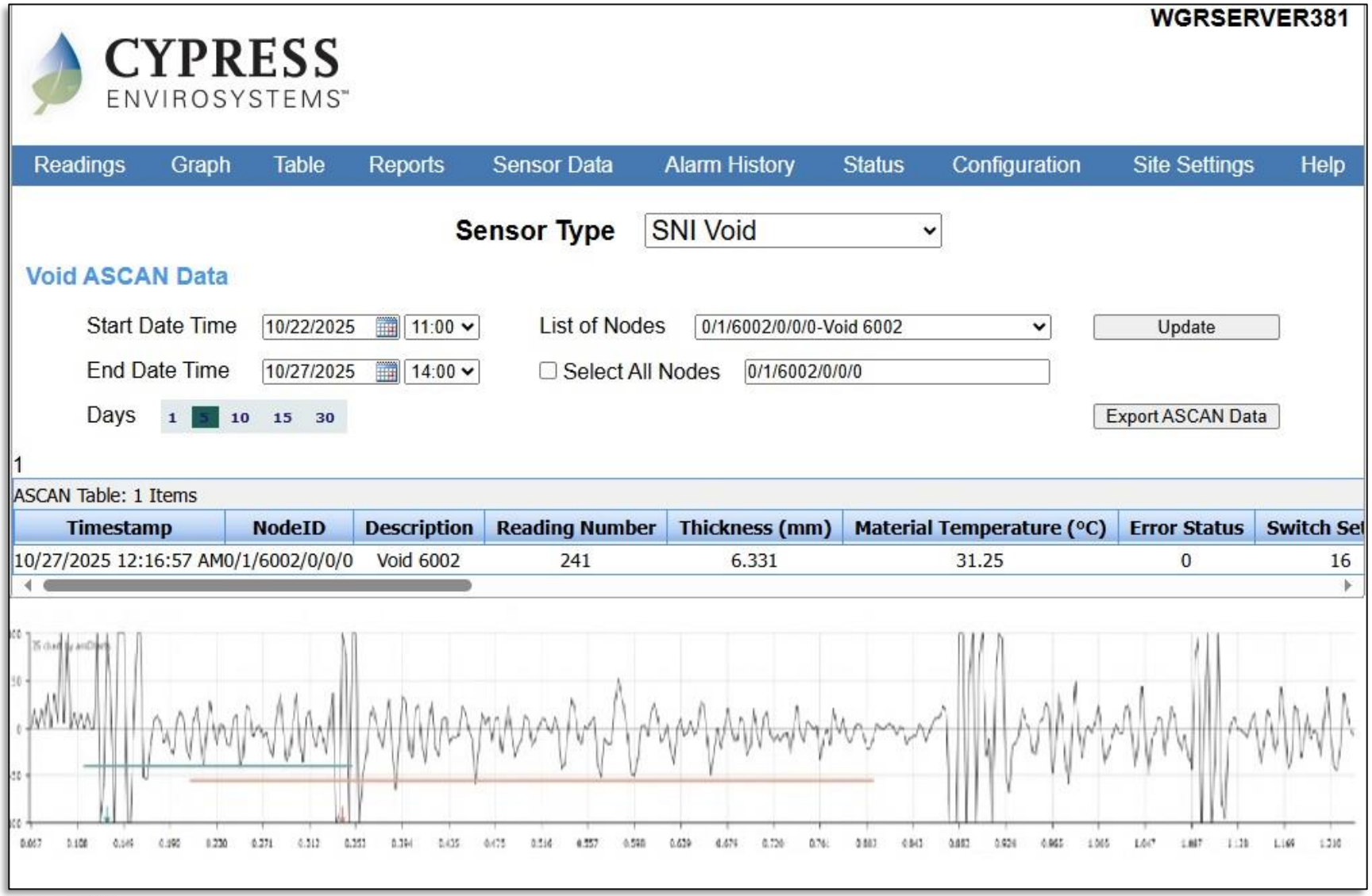
Smartphones/ Tablets

Wireless Gauge Readers

Blue Box

Level 2 Business Network (ethernet)

GAMP A-Scan HMI – Integrated on Cypress GBC



Data Visibility on Tablets or Plant Historian

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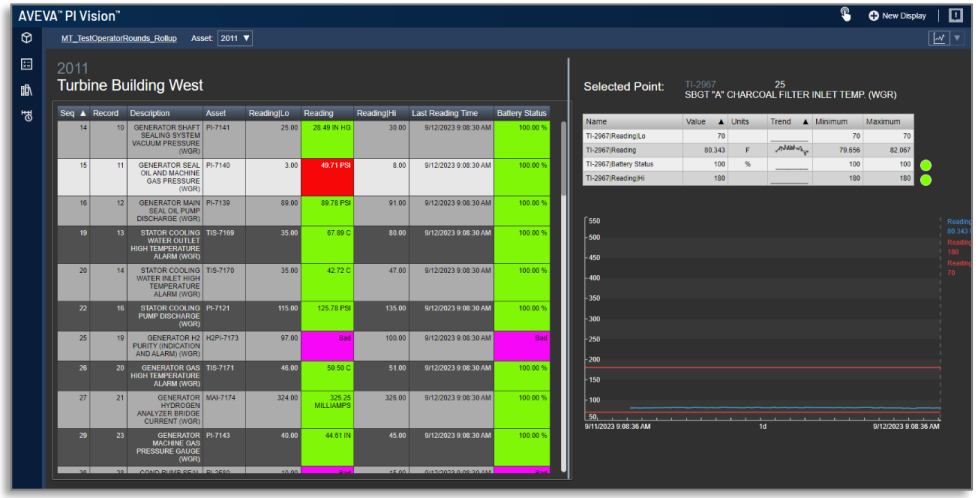
GBC

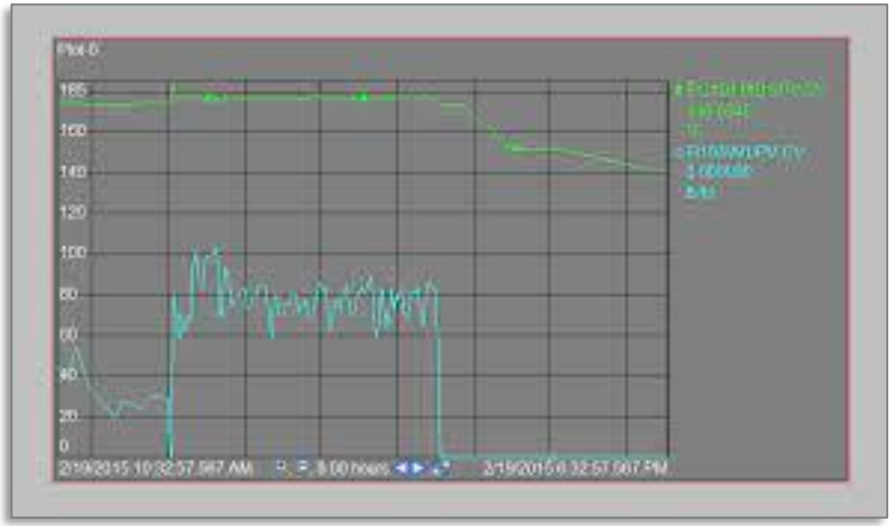
Readings | Graph | Table | Alarm History | Status | Configuration | Site Settings | Help

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	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	2/1/301/0/0/0	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(





Part of Family of 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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Conclusion

- GAMP is a required program in every plant due to NRC Regulation
- Using installed/automated sensors can detect gas void presence at a fraction of the efficiency, cost, & safety

GAMP Process	Efficiency (Time)	Safety (Rad Exposure)
Typical	224 hrs	96 hrs
Installed (2.0)	60 hrs	16 hrs
Wireless (4.0)	8 hrs	0 hrs

- What is the status of your GAMP program - is it time for a refresh?

GAMP Sensor Cost and Lead Time

Device	Unit Price	Comment
Wired UHT Sensor with 100’ cable	$2,750	Base sensor with wired output
Wireless Head (Transmitter)	$2,750	Optional wireless transmitter
Combined (both items above)	$5,500	Complete wireless GAMP solution

Lead time: 4-6 weeks after receipt of order.
Expedited delivery possible for end of year 2025 if needed.

Q&A

For More Information:

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