Industrial Product Training

May 2009

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Purpose

- Additional product training to support sales efforts. High level installation overviews will be provided.

- We will not discuss detailed installation steps in this meeting. This will be scheduled as an in-person activity.

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Agenda

- Wireless Infrastructure
- BBS
- WGR/WMR
- WTR
- WSTM
- WFM

Agenda

- Wireless Infrastructure
- BBS
- WGR/WMR
- WTR
- WSTM
- WFM

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Common customer concerns about wireless

Three main concerns

1. Emission
   - Will the Cypress products interfere with my existing equipment or wireless network?
2. Immunity
   - Will our equipment interfere with Cypress products?
3. Security
   - How secure is the wireless system?

(EMC covers emission and immunity)

Background on Cypress wireless

- Products operate in the 2.4GHz spectrum
  - Approved by the FCC, Certified to operate in Europe

- Wireless design evolved from the wireless keyboards and mice
  - Modified the technology for robust industrial applications
  - Cypress Semi has deployed millions of units

- Thousands of industrial transmitters in the field in a variety of industrial facilities
  - Semiconductor manufacturing
  - Biopharma
  - Power plants
  - Food processing
  - Hospitals
  - Wastewater facilities
  - Commercial buildings

- Device testing performed at various customer sites – No known issues to date
  - Worked with equipment engineers and IT departments
  - No impact to manufacturing equipment
  - No impact to other wireless networks

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Emission and Immunity

Emission

- Peak power transmission of 100mW
  - mobile phones transmit 1-2W
  - portable handset radios used in industrial plants transmit 1-5W
  - Cypress devices transmit 10x less power than mobile phones
- Cypress devices transmit on a very low duty cycle
  - Minimizes the chance of interference
  - Cypress protocol allows transmission for less than 1ms per sample period
  - Example: sample rate of 5 minutes translates to a duty ratio of 1:300,000

Immunity

- Cypress devices have been installed in many different facilities
  - Power plants
  - Semiconductor processing fabs
  - Areas with high energy emitting RF devices
- No issues found to date

Security

- Cypress uses a proprietary wireless protocol
  - Results in low overhead (so we can transmit in under 1ms)
  - less of a target for security breaks
  - Standard protocols are more typically broken because they are more common

- Blue Box Servers sit behind the company firewall
  - BBS is as secure as any other computer that the company is using

- Cypress software puts wireless data in local database if it recognizes the protocol

- Even if someone found the Cypress protocol, they could not gain any information from the computer network
  - No way to pull any information through Cypress wireless protocol
  - Not possible to embed an executable program/virus through Cypress wireless protocol

- Blue Box Servers may need antivirus protection
  - We can install McAfee out of the factory – possible corporate conflict
  - Customer can install their corporate anti-virus instead

What does it take to setup the wireless network?

- Wireless performance
- Wireless site survey
- Wireless channels

Wireless Performance

- Cypress wireless has been installed in many different sites including industrial plants, concrete bunkers, clean rooms and commercial high rises

- Typical wireless ranges for a single "hop" are:

Line of sight	300 ft (91m) open halls 150 ft (46m) in open office floor 100 ft (30m) in corridors
Sheet Rock / Dry wood	100 ft (30m), through five walls
Brick Walls	60 ft (18m), through three walls
Ceilings	25 ft (7.5m), through single ceiling

- WRE's allow for multiple "hops" which extend the communications range of the system

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Factors Reducing Wireless Range

- Wireless range is particularly affected when metal obstacles are in the line of transmission.

- A solid sheet of metal presents the greatest obstacle, while rebar reinforced concrete is less.

- Try to note the following objects and avoid in the line of transmission:

  - Elevator shafts and stairwells
  - Hollow lightweight walls filled with insulating metal foil
  - Metal reinforced concrete walls, pillars and columns
  - Plumbing and electrical risers

Bigger the metal obstacles in the transmission path shorter the wireless coverage

Wireless range of our products

- WGR has shortest range (internal antenna)
- WTR, WSTM, WFM, WRE and BBS have similar ranges (external antenna)

- WGR best case LOS tested range: 800' (244m)
- WRE best case LOS tested range: 1600' (488m)
- BBS best case LOS tested range: 1200' (366m)

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What does it take to setup the wireless network?

- Wireless performance
- Wireless site survey
- Wireless channels

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Wireless Survey Tool

- The wireless survey tool is used to capture signal strength information on a laptop

- 2 components to the wireless survey tool
  - Diagnostic receiver (HW)
  - CYHid application (SW)

- Start with a WGR at the furthest location from the receiver and set to survey mode
  - Setting the WGR to survey mode is covered later

- Using the CYHid application, find the spot where RSSI drops below 10 – that is a good spot for a repeater

- Upon completion of the install, use the wireless survey tool at each repeater location to verify that the RSSI (WGR Signal Strength) is greater than 10

 Note: The application and receiver only records signal strength from the last "hop"
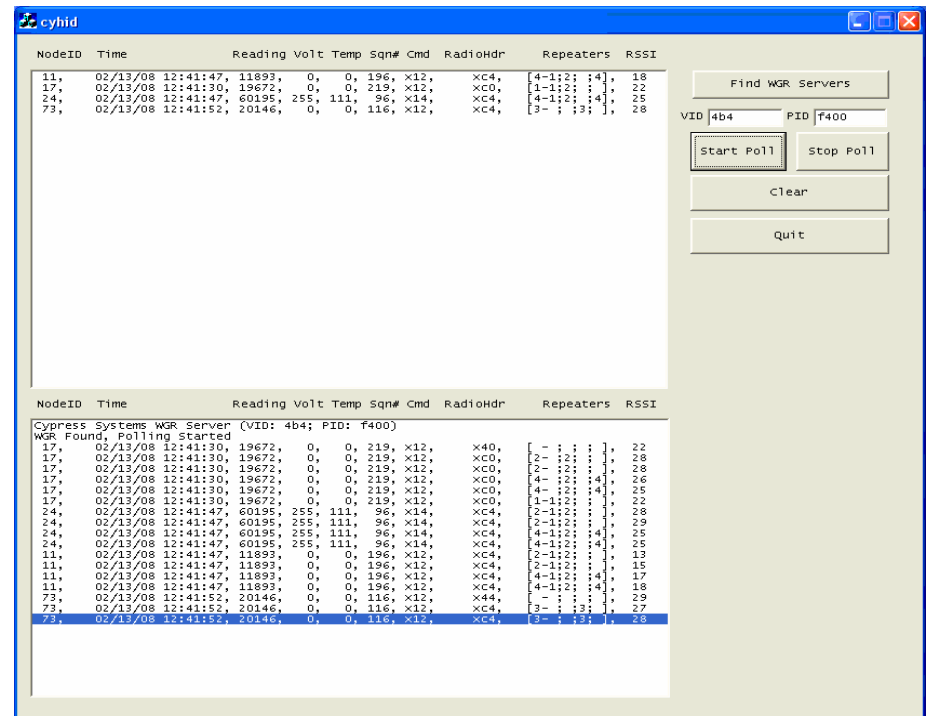
Setting up the Wireless Survey Tool

1. Connect the Diagnostic Receiver to your laptop via USB.
2. Launch the CYHid application
3. Click on "Start Poll" to start receiving

- The top window will contain the last reading for each unique NodeID
- The bottom window will show all readings as they are received

4. To stop, click on "Stop Poll"
5. To exit the application, click on "Close"

Top window

Bottom window
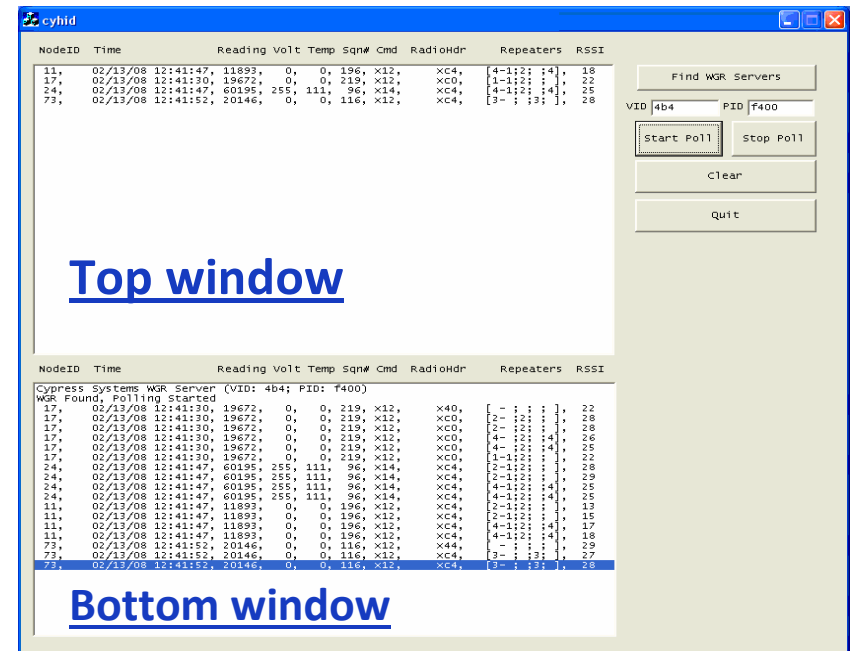
# Installing the Wireless Network Infrastructure

- Environment and building layout may change the number of repeaters required

- The wireless network infrastructure consists of Wireless Range Extenders (WRE's) and the Blue Box Server (BBS)

- Site survey is needed to identify WGR locations and estimate the WRE and BBS locations

- After site survey is complete, temporarily install WRE's and BBS

- Once wireless performance is verified, permanently install WRE's and BBS

What does it take to setup the wireless network?

- Wireless performance
- Wireless site survey
- Wireless channels

Wireless Receiver Channels

Frequency
Dip Switches
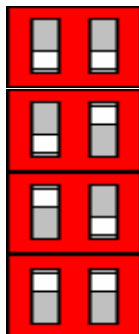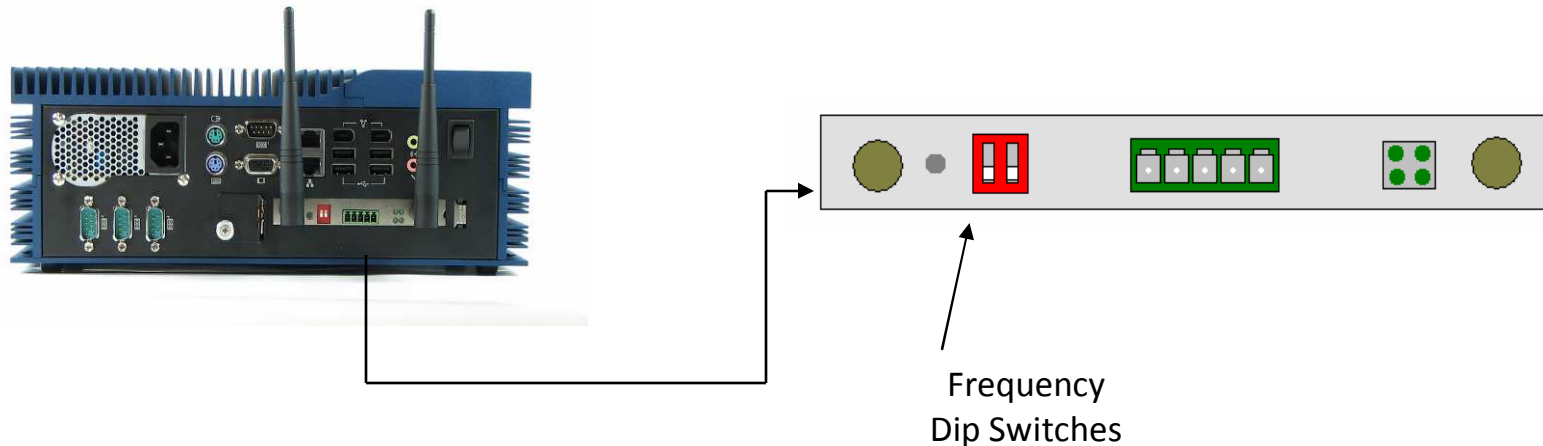
-Channel Set A (2,74) or (74,2)
-Channel Set B (6,78) or (78,6)
-Channel Set C (24,50) or (50,24)
-Channel Set D (30,54) or (54,30)

4 common channel sets – BBS and WRE's must match products

Note: WBM default on different channel set (Channel E)

Wireless Range Extender (WRE) Overview

- WRE's are used to extend the wireless range of a WGR

- WRE's require 5 VDC, which is provided by a 120/240 VAC adapter

- Multiple WRE's in a system require different delays for each WRE (either 1, 2, 3, or 4 ms)

- Up to 4 WRE's can be used to get a single WGR reading to the BBS. More than 4 WRE's can be used in a WGR System, depending on layout.

Short term:
- VAR's order 1 PN and reprogram appropriate channel/delay using PSoC Programmer and applicable hex file.

Long term:
- VAR's order 1 PN and configure channel/delay with HH

Verifying WRE Channel Set and Delay

- WRE's are pre-labeled with their channel set letter followed by the delay
  - The label is located on the bottom of the WRE

- A - 1 means channel set A with a delay of 1 ms

- Make sure the channel set of the WRE's matches the channel set of the BBS and all WGR's or WTR's.

Installing WRE's

- WRE's should be installed with the fastest delays (1ms) farthest away from the receiver, and slowest delays (4ms) closest to the receiver

- WRE's should be installed at eye level or above

- WRE's should be securely attached so it can't be moved
  - Preferably use screws or cable ties, otherwise VHB tape may be used

- Cords should be cable tied if possible

- Make sure antennas are screwed in all the way and vertical
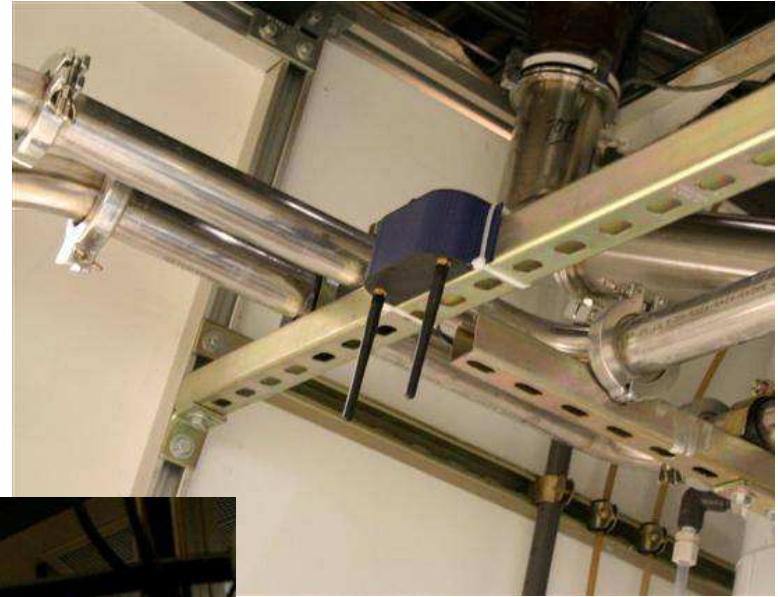
WRE Field Installations
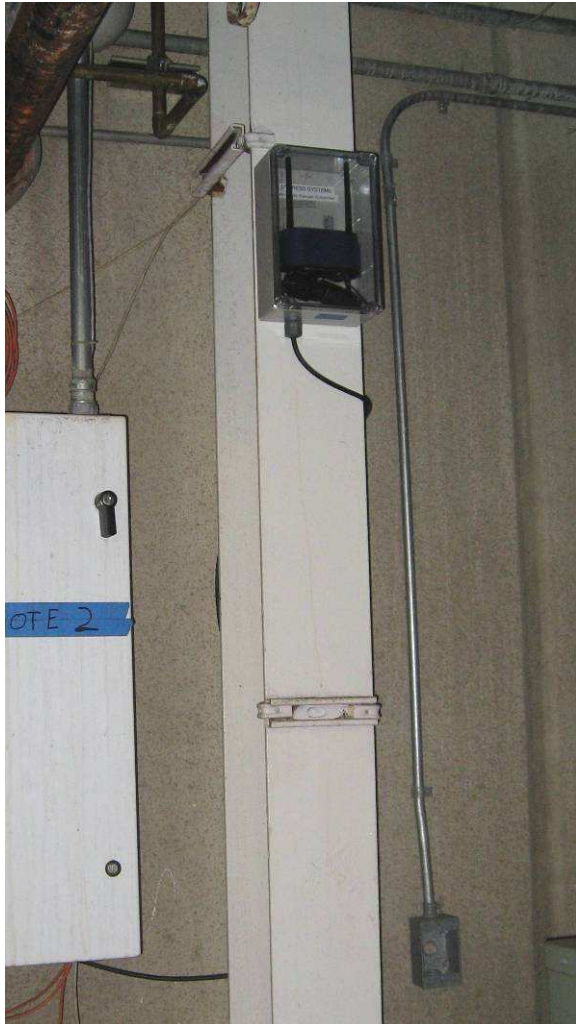
Note: Outdoor enclosures

Additional WRE Field Installations

Where to Place Receiver and Repeaters

Do

- Try to place the Blue Box Server in a central location on the site with power and LAN drop

- Mount WRE's at eye-level or higher to avoid obstructions

- Use wireless survey tool to determine where the signal is the strongest

Don't

- Avoid solid metal obstacles in the line of transmission

- Don't place WRE's or BBS inside metal cabinets

WRE common questions

- ## How does the WRE work?
  - Always listening for packet data (why it needs continual power)
    - All field devices sleep, but transmitted data is asynchronous
  - Once it receives packet, it sets a flag (WRE ID) and re-broadcasts
    - If the repeater ID is already set, it won't re-broadcast

- ## Why can't I have more than 4 WRE's in a path?
  - Field devices transmit, then need to wait for an ACK from BBS (or will re-transmit). This is "listening time" and uses power.
  - Adding WRE's increase listening time per transmission
  - Currently optimized for battery life
    - Devices listen for ~8ms (4 WRE's)
  - Will look at option on setting this in the field
    - Requires significant firmware change to wireless protocol

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Some high level product questions

- Certifications
  - FCC
- ATEX
  - Product for hazardous locations
  - Planning on Class 1, Zone 2 certification for ATEX
  - Availability in Q4
- Wi-Fi
  - Currently developed units for OEM
  - Will have Cypress version available in Q3

Blue Box Server (BBS) Overview

- Blue Box Server receives WGR readings and stores data in SQL database

- One receiver can handle 128 WGR's

- Multiple servers be installed at a single site.

Blue Box Interfaces

- Currently, the BBS supports the following standard protocols
  - OPC
    - Requires a license to be enabled
  - BACnet
    - Requires a license to be enabled
- The BBS will support the following in the future
  - Modbus
  - SCADA interface
- The BBS also supports SMS and email alarms

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BBS questions

- Why do we need different BBS for each product?
  - Originally, thought WSTM, WFM and WBM would require unique servers anyways due to number of field devices per server
  - Currently, using individual database tables for each product
    - Webpage server using SQL queries from specific page
  - To "fix", need to re-architect database tables and add code to web server

- When will we get a BBS that talks to all the products?
  - Engineering will focus on this (and BBS web page updates) in May– release by end of May (target)

- What is the real number of devices that can talk to the BBS?
  - 128 WGR/WTR per BBS is a soft limit.
  - Actual number depends on update rates and wireless range

- What happens with sites who have multiple BBS?
  - We set all field devices to different channels (to match BBS)
  - Currently, customer needs to see each BBS individually
  - Plans to have centralized server for all BBS at customer site (release end of Q3)

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Blue Box Server

- Features
  - Industrial computer
    - WinXP Pro
    - SQL database
  - Web server (Web Console App)
  - OPC server (optional)
  - BACnet server (optional)

- Simple Setup
  - Plug power cord
  - Connect to LAN
  - Provide static IP

Note: Install in temperature controlled environment

Connecting to the Web Console Application

- Option 1 (Connected to LAN)
  - From any PC web browser, enter the machine name or IP address
    - *Note: PC must be on the same LAN as the BBS*

- Option 2 (For standalone station)
  - Connect monitor, keyboard and mouse. Then start Internet Explorer.

High Level Setup Steps for the BBS

1. Set the receiver channel

2. Connect to the BBS for configuration

3. Add installed nodes to database

4. Configure alarms (if needed)

5. Verify wireless signal strength

6. Mount BBS (if needed)

Install Blue Box Server

Basic initial setup steps

- Determine location for mounting
  - Must be installed indoors, in a temperature controlled environment
  - Can use optional wall-mount bracket
- Set the IP address to the static IP specified by customer IT department
  - Use USB mouse, keyboard, and monitor to edit
  - OR, connect a Laptop with VNC
  - Edit the Network Adapter settings to assign the IP address
- Connect to Ethernet port on customer LAN

Adding Installed Nodes through WGR Console

- Click the "NODE CONFIG" button on the WGR Console. When prompted enter:
  - Username: admin
  - Password: wgradmin

- To add new node, enter NodeID in text box and click "Add"

- Enter node info into new dialog window, and click OK
  - See help file for explanation of Node Configuration parameters

Configuring SMS Alarms through WGR Console

- In web browser, go to WGR Console then click "SMS ALARMS" button

- Add SMS/Email Alarm recipients

- Customize Site Name
  - Custom site name will appear to the left of "WGR Console" label

- Same username and password as the Node Config page

*Note: If the SMS Alarm checkbox is checked for a node, everyone in the alarm list will be notified via SMS text and/or email when the node goes into alarm state

Verify Wireless Strength through Web Console

- Access admin page by typing http://WGRServerNNN/admin.aspx into web browser address bar. When prompted, enter
  - Username: master
  - Password: wgrmaster

- Use Diagnostic History and Diagnostic Latest Data to see WGR data reception paths
  - This will show which WRE's were used to get data to the BBS

- Verify all signal strengths (RSSI) are greater or equal to 10
  - If lower than 10, adjust WRE locations

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WGR Theory of Operation

- System powers up from deep sleep
- Low power camera takes low-res image of gauge face
  - High light sensitivity, reduced processing load
- Image captured in two halves
  - Uses dual independent ultra-bright LEDs to cancel glare
- Local image processing of select pixel areas to convert pointer orientation into an angle
- Further image processing to determine tip/tail
  - If image algorithm detects faults, error code sent with last good reading
- Displays updated result on LCD
- Wirelessly transmit result to BBS
  - Periodically also transmits health status
- Deep sleep until next sample interval

WGR LCD Display Details

LCD Display and Push Buttons
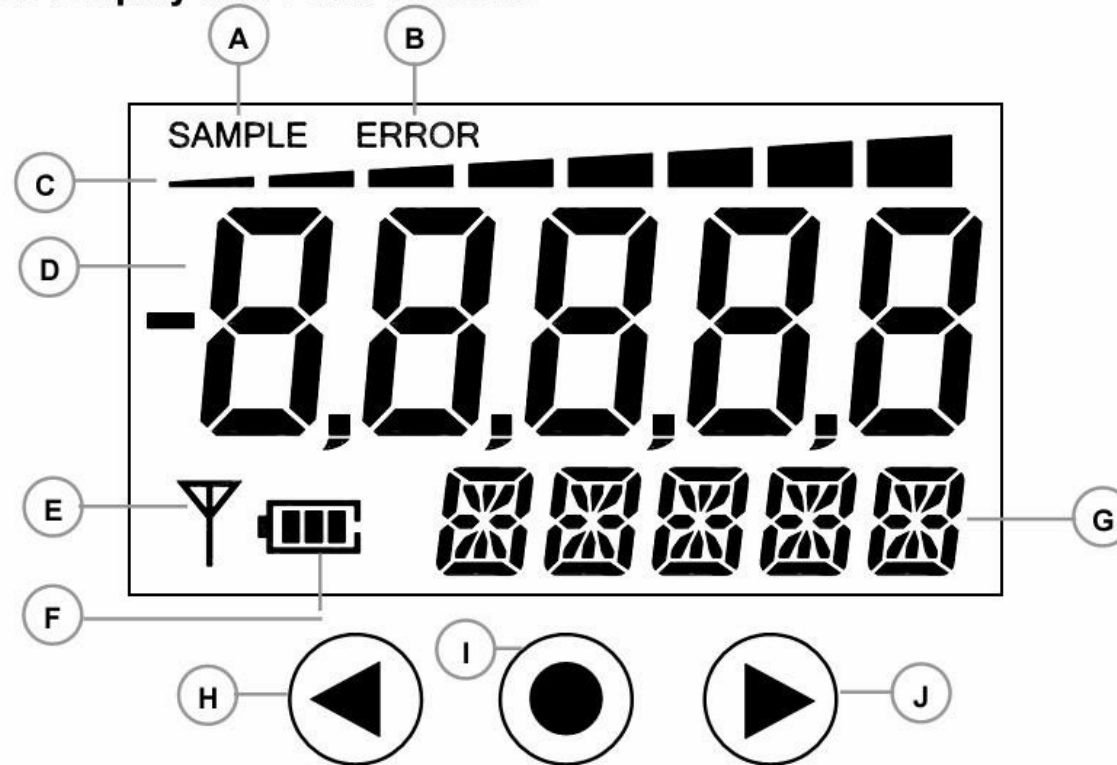
A.	SAMPLE Icon	Displayed when a new reading is being captured and converted
B.	ERROR Icon:	Displayed when an error condition is detected
C.	Bar Graph	Indicates percent of full-scale reading
D.	Numeric Display	Displays the converted reading value
E.	Antenna Icon	Displayed when wireless communication is successful
F.	Battery Level	Displays percentage of battery life remaining
G.	Alpha-numeric Display	Displays the reading units or diagnostic messages
H.	Left Button	Menu navigation and decrease values
I.	Center Button	Requests immediate updated reading and menu navigation
J.	Right Button	Menu navigation and increase values

WGR menu structure
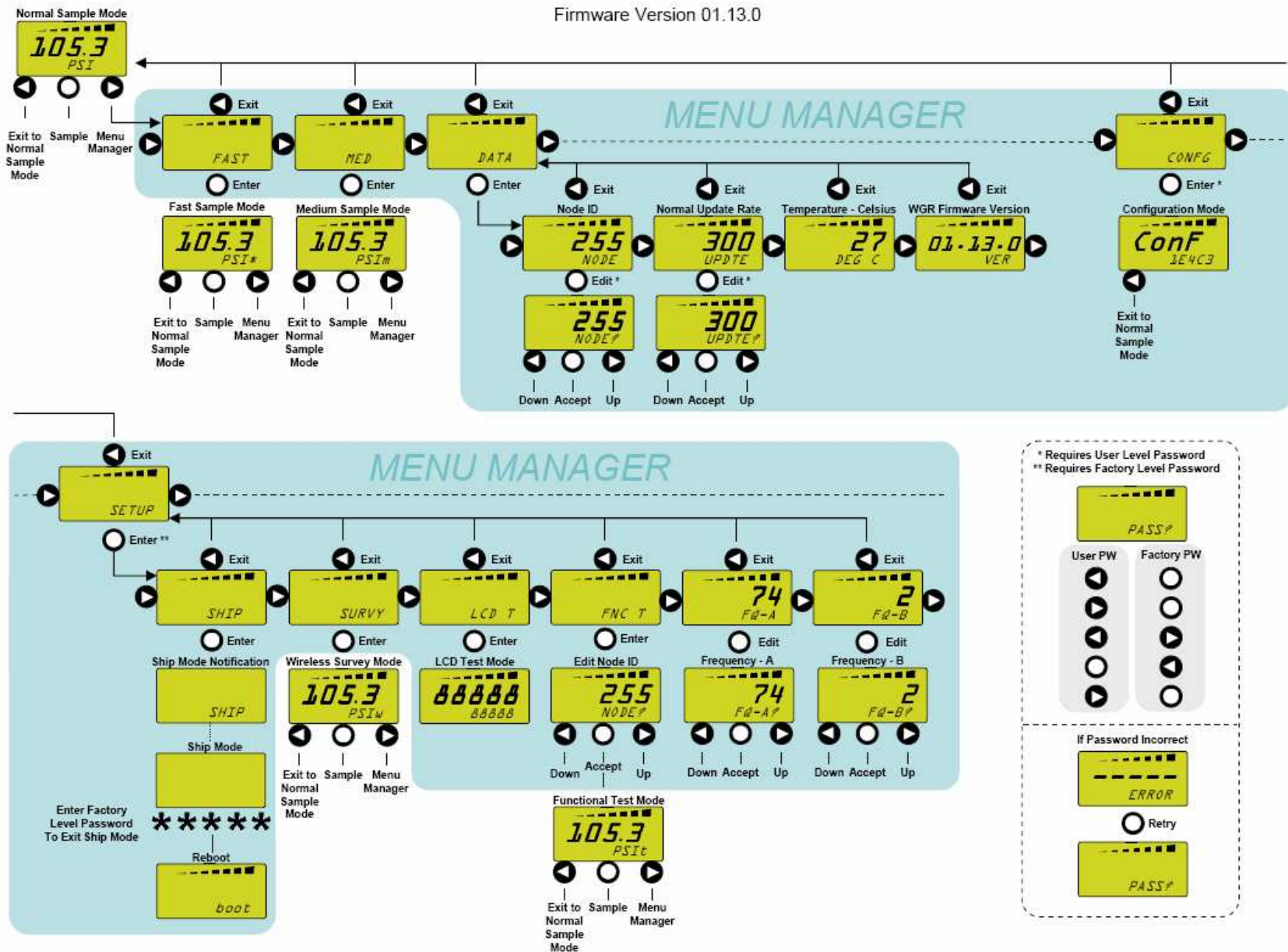
Wireless Gauge Reader – Exploded View
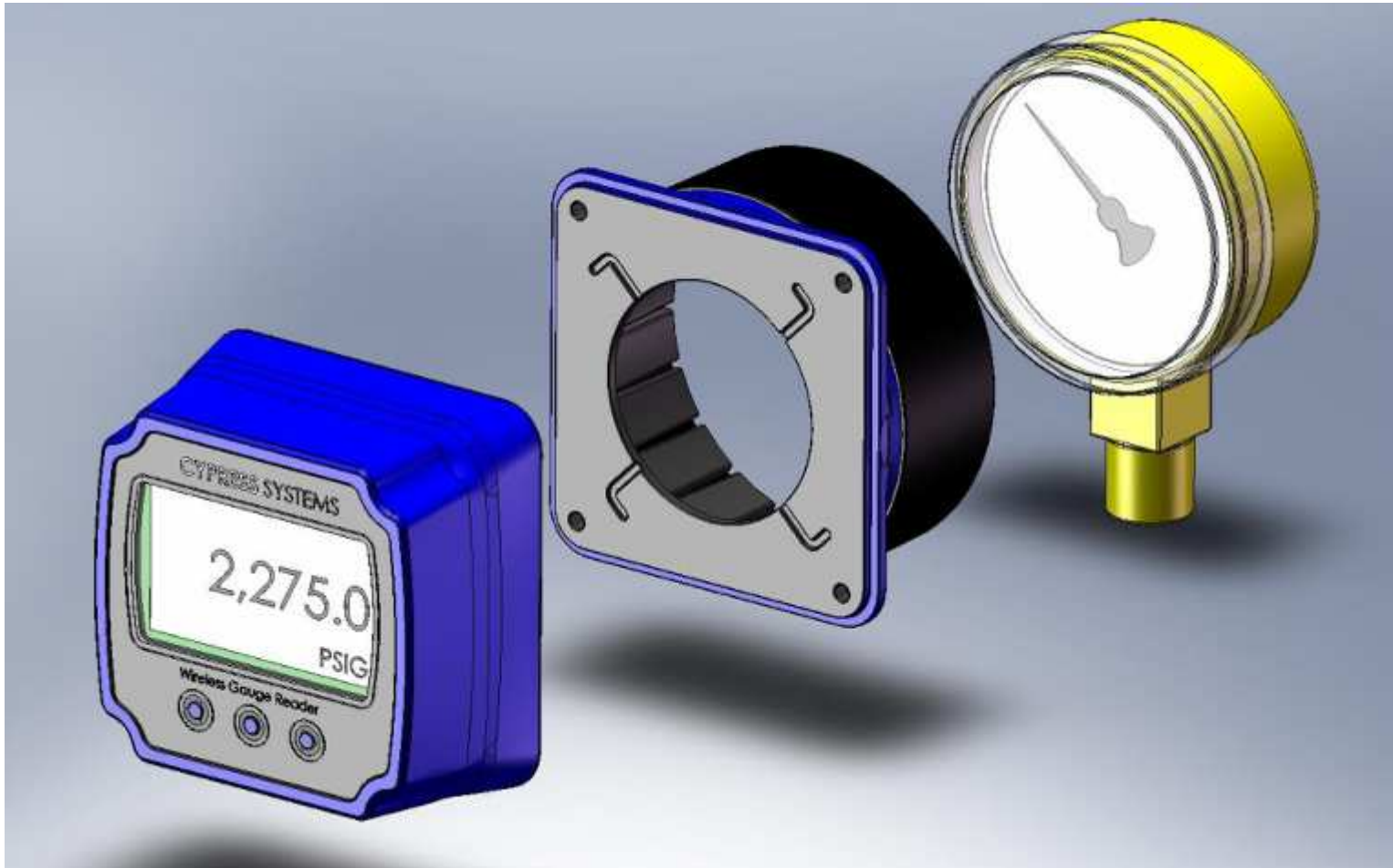
Common Gauge Types

Free-standing
(dry, liquid filled)

Process Gauge

Magnehelic

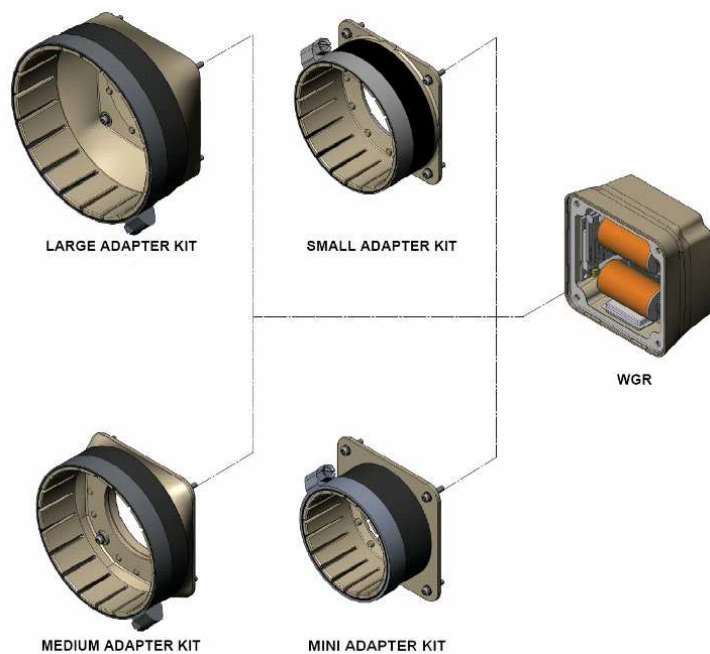
Panel Mounted

Photohelic

Standard Mounting Adapters

LARGE ADAPTER KIT

SMALL ADAPTER KIT

MEDIUM ADAPTER KIT

MINI ADAPTER KIT

WGR

Near focus

EXTRA GRANDE ADAPTER KIT

GRANDE ADAPTER KIT

EXTRA LARGE ADAPTER KIT

WGR
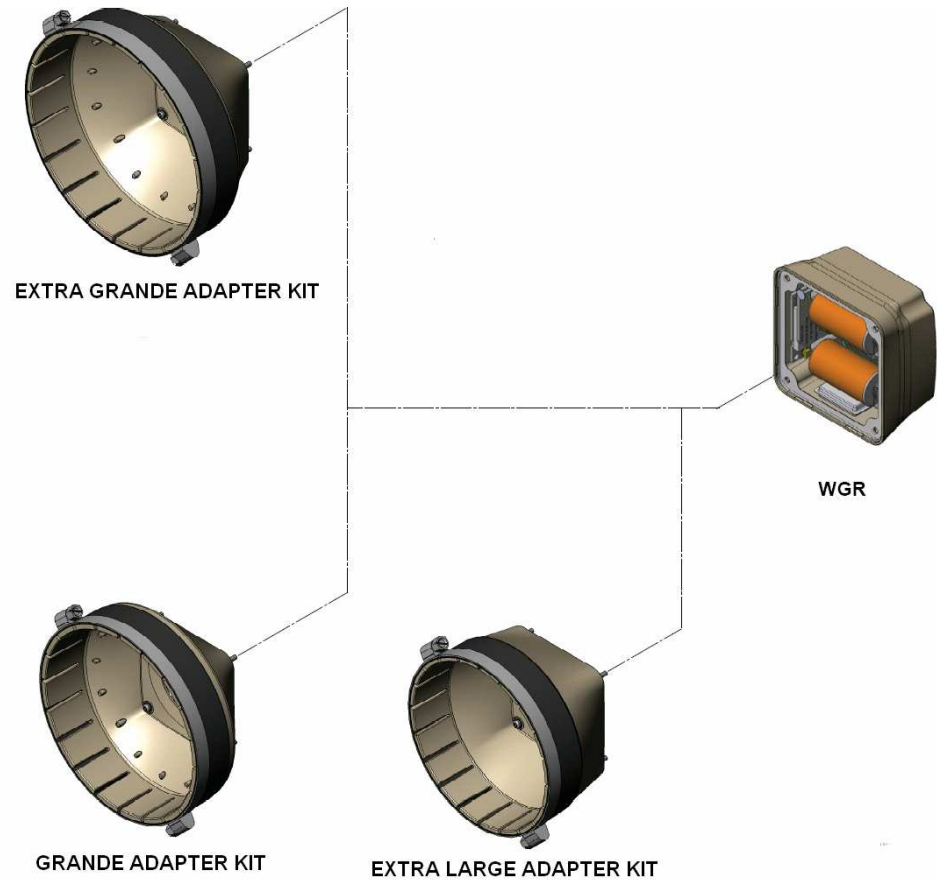
Far focus

Mounting adapter sizes

Adapter size	Dimensions		
	ID @ Gauge Interface	Max OD of Gauge	Min OD of Gauge
Mini	1.955"	1.995"	1.600"
	[49.66mm]	[50.67mm]	[40.64mm]
Small	2.350"	2.390"	1.995"
	[59.69mm]	[60.71mm]	[50.67mm]
Medium	2.782"	2.822"	2.390"
	[70.66mm]	[71.68mm]	[60.71mm]
Large	3.245"	3.285"	2.820"
	[82.42mm]	[83.44mm]	[71.63mm]
Extra Large	3.675"	3.715"	3.285"
	[93.35mm]	[94.36mm]	[83.44mm]
Grande	4.083"	4.123"	3.715"
	[103.71mm]	[104.72mm]	[94.36mm]
Extra Grande	4.600"	4.680"	4.181"
	[116.84mm]	[118.87mm]	[106.20mm]

- Also have special adapters for:
  - 4.5" Process, Magnehelic, and Photohelic gauges

Adapter assembly

Panel Mount adapters

Dual Lock Material; One Side on Panel, Other Side on Adapter Ring

WGR Adapter

Panel Mounted Gauge

Dual Lock Panel Mount
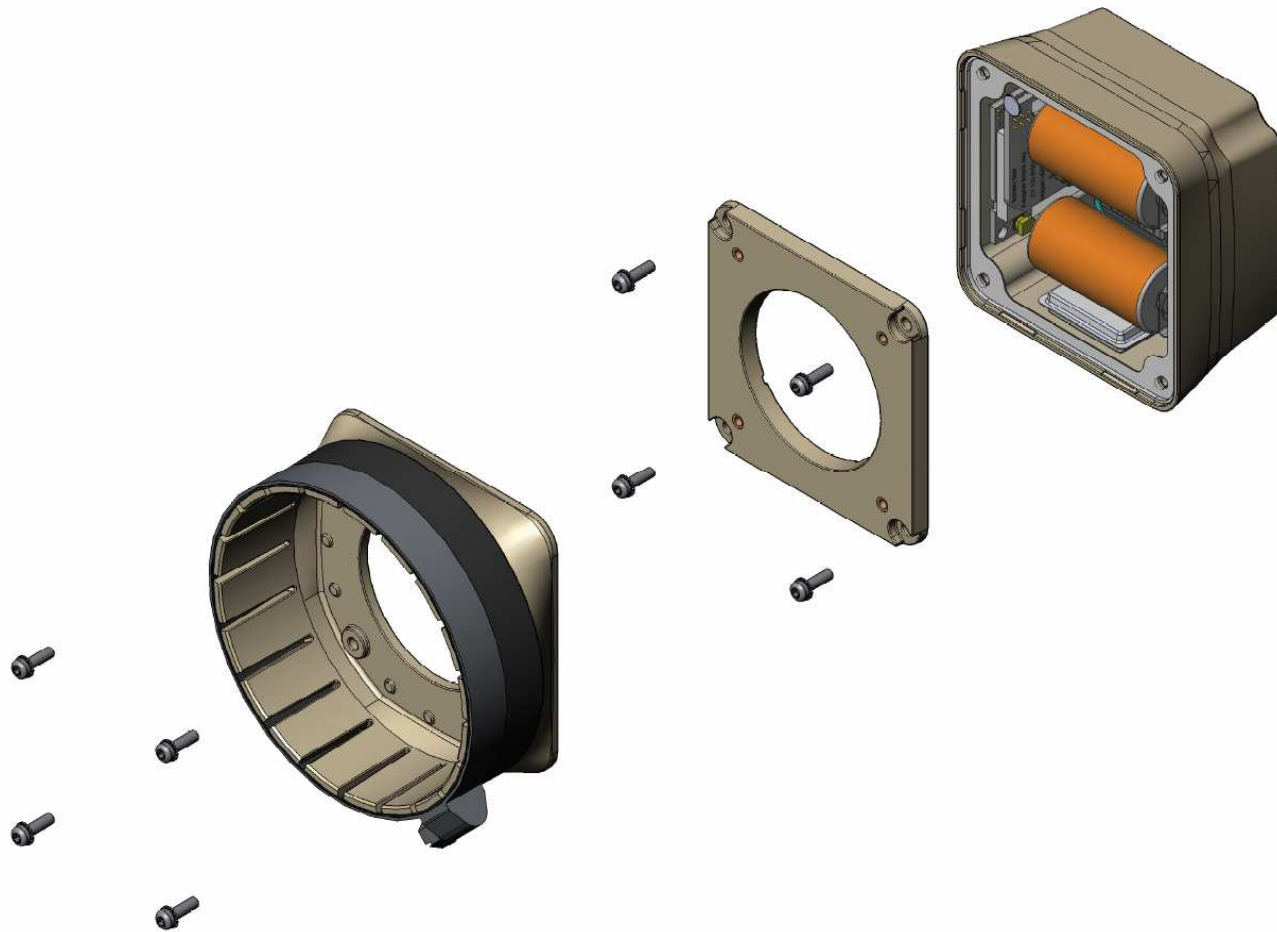
Special adapters – Magnehelic/Photohelic
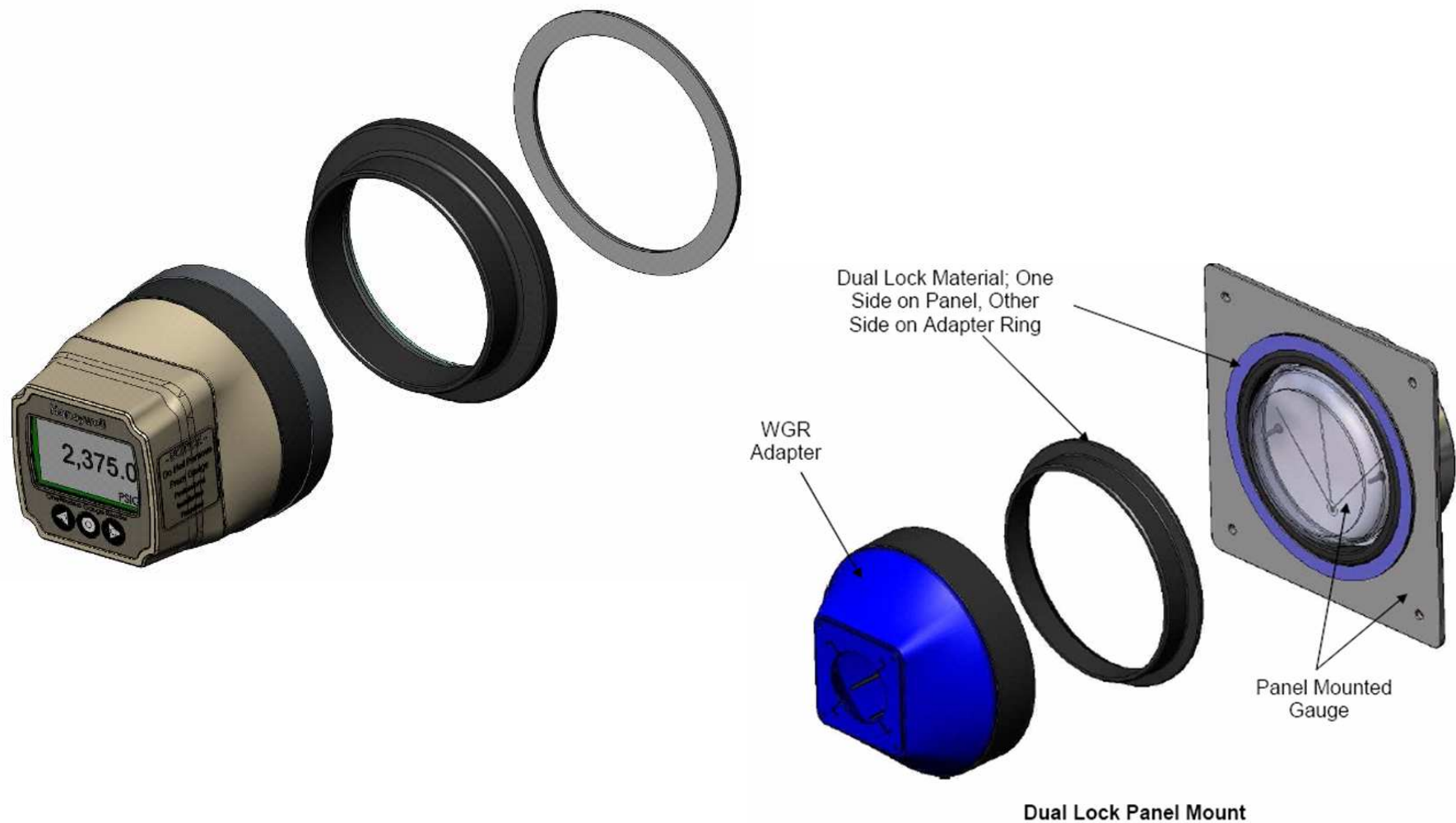
Special adapter – Process Gauge

Recommended Installation Procedure

- Site survey
  1. If possible, have paper copy of floor plan
  2. View the gauge and mark location on floor plan
  3. Take picture of each gauge (close-up and surrounding area)
  4. Note any possible issues (dirty gauge, tight mechanical area, etc.)
  5. Look for power outlets and BBS location
     - Is there a network port near the BBS?

- Install prep
  1. Summarize all gauges and determine required adapters
  2. Determine initial wireless plan based on marked-up floor plan
     - Identify possible locations for repeaters (WRE's)
     - Determine if more than 1 BBS is needed
  3. Prepare install kit (HW, tools, etc.)

- Installation
  1. Test wireless plan w/ WGR's (survey mode) and Diagnostic Survey Tool
  2. Install and calibrate WGRs
  3. Train customer on how to look at data

Mechanical Installation Overview

- Verify mechanical gauge functionality
- Verify proper WGR mounting adapter
- Monitor gauge pointer.
    - Record the current gauge reading.
    - Monitor typical movement
    - Determine if excessive pointer vibration/flutter
- Record gauge Information: Units, Min/Max Value
- Prepare the gauge
    - Clean the front window with alcohol
    - Clean the outside diameter
    - If there is excessive background writing, and the front window is removable, install white tape to cover background writing
- Install 1-3 shim bands, if needed
- Mount the WGR and align as desired
- Tighten the clamp

Handheld (HH) Basics

1. **Touch Screen:** Main display. Use stylus to navigate on screen.

2. **Navigation Arrows:** Up, down, left, and right navigation keys. Used to navigate to different text entry fields in application. Also, Left Arrow used to type negative symbol "-" into text entry field.

3. **[Enter/On] Key:** Used to power on HH and accept changes/entries.

4. **[FN] Key:** Has 2 functions
   - Off state: Press [FN] then [Enter/On]
   - Forced power down and full reboot: Hold [FN] + [Enter/On] for 5 sec

5. **[BKSP] Key:** Backspace key.

6. **Green LED:** Shows power and charge status

7. **Docking Station:** Docking station to charge HH and extra battery pack. Also used to connect HH to a PC via USB.

4 Menu Tabs of HH Control Application

Gauge Parameters
- Used to set gauge specific parameters

Status
- Summary tab
- Used to verify proper configuration

Name ID
- Default page
- Used to select device for configuration

Gauge Image
- Displays gauge image and

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Confidential

Considerations when Evaluating Customer Site

- WGR compatibility
  - Single pointer
  - Relatively clean gauge
  - Minimal background writing on gauge face
  - Liquid filled sufficiently
  - Range of gauge diameter for adapter fitting
  - Clearance for WGR in front of gauge

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WTR Overview

- Used to remotely monitor voltage and current loop outputs from wired sensors and transducers
- Two input channels
- Power options: Wall powered, internal battery powered, or powered by external power supply (5-24 VDC)
- The WTR's can be programmed to take readings at any given interval (in seconds).
  - Fastest supported sample rate is 1 second. However, need to adjust database for high update.
- To acquire and transmit a new reading, press the button next to the external DC input jack.

Note: If mounted outdoors, will need outdoor enclosure (like WRE)

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WTR Front Panel
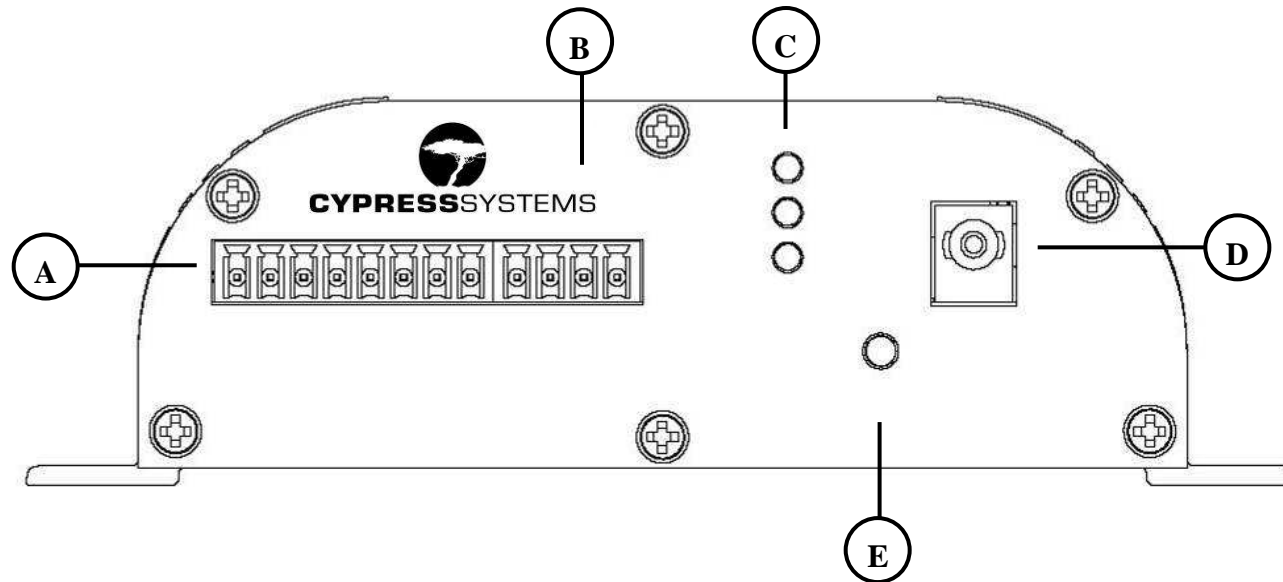
A. Sensor input terminal strip

B. External power terminal strip

C. LED Indicators

D. 5V-24V barrel jack input, 5.0mm x 2.1mm

E. Function Button: used to initiate a sample, set fast and medium update mode and for binding to the configuration tool.

WTR Back Panel
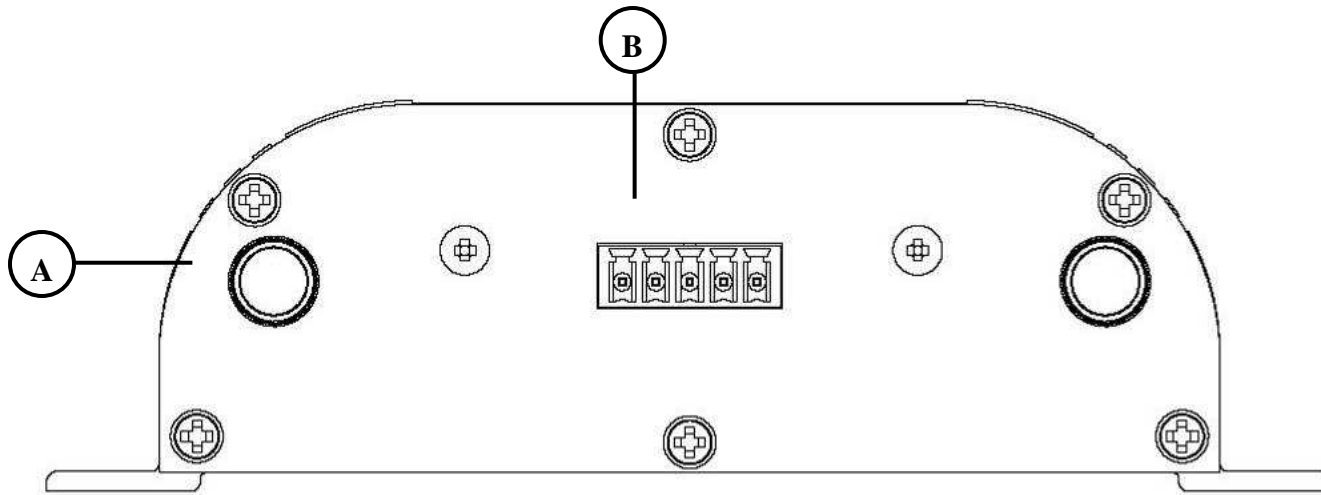
A. Radio 1 antenna connector

B. Programming or Serial port (RS232/485)

Power on sequence

- When the WTR starts up, its normal boot sequence is as follows:

1. Turn on all LEDs for 2.5sec
2. Turn off Red LED
3. Turn off Orange LED
4. Turn off Green LED

- If the above sequence does not take place, something is wrong with the WTR (most likely the battery is not fully charged).

WTR Function Button and LED Lights

- The function button can be used to
  - take a sample
  - put the unit into fast update mode
  - put the unit into medium update mode
  - put the unit into configuration mode

Function Button

Hold Time	Indication	Function
< 2 sec	Green LED flash	Single sample on both RF channels
2 sec+	Yellow LED	Fast update mode (sample every 5sec for 5min)
4 sec+	Red LED	Medium update mode (sample every 30sec for 8hr)
> 5 Sec	Green, Yellow and Red LED flash once, Green continuously flashing	WTR is in configuration mode. Use the Hand Held to configure Node ID, Channel set,

WTR Supported Connections

- Transducers with the following analog outputs
  - 0-5V
  - 0-10V
  - 4-20mA

- Some digital signals, but additional WTR firmware customization may be needed
  - RS232
  - RS485

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WSTM Overview

- Modified WTR with two thermocouple type K sensors

- The WSTM is battery powered (batteries typically last 3-5 years based on a sample rate of 15 min)

- Easy to install – just clamp on thermocouple sensors to the inlet and condensate out of the steam trap

Principle of Operation of Steam Systems

- Types of steam:
  - Plant Steam – Generation from a boiler; general use steam for heating systems, heat exchangers, vessel jacket heating, etc.
  - Clean Steam / Pure Steam – Made using a generator; typically have requirements for cleanliness and used for sterilization or sanitization
- Steam traps are placed strategically in steam systems to collect and remove condensate in the system.
- Purpose of removing condensate from steam system
  - Maintain quantity and quality of steam
  - Improve efficiency of steam generation
- Placement of steam traps - typically in low points of distribution system and at use points
  - Distribution piping is slightly sloped to move condensate in a specific direction toward a low point, where a steam trap can remove the condensate

Description of Steam Traps

- ## Steam trap function
    - A steam trap is a valve that is operated by a trigger.
    - The trigger opens an orifice in the trap to release condensate.
    - The trigger resets when the condensate has been removed and the orifice is closed.

- ## Various types of steam traps
    - Float (and Thermostatic)
    - Thermostatic
    - Inverted Bucket

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Analysis of Steam Trap Function

- Failure modes of steam traps
  - Blocked: the orifice is blocked and no steam or condensate is removed through the trap
  - Blown: the orifice is always open and steam is released through the trap
  - Partially blocked/blown: the trigger is starting to show signs of failure
- Three methods to analyze steam trap function
  - Visual inspection: observation to see if steam is constantly flowing from the trap, or not at all
  - Temperature measurement: measure the temperature differential across the trap and measure the outlet temperature to determine if the trap is functioning
  - Ultrasonic measurement: measure the frequency of the trap to indicate functionality (each trap will operate at a specific frequency)
- Steam trap failure is usually determined by using two of the three methods

Principle of Operation of the WSTM

- Thermocouples are placed at the inlet and outlet of the steam trap to measure temperature
  - Type K thermocouples are used with a range of 32F to 2012F (0C to 1100C)
  - Per Steam Tables, ~ 150 C → 70 PSIA
- Expectations:
  - Inlet temperature is approximately equivalent to the saturated steam temperature for the operating pressure of the steam system
  - Outlet temperature is just below the boiling point of water
  - There is a differential temperature between the inlet and outlet temperatures to show that there is steam on one side of the trap and condensate on the other side
    - Note: Expected temp differential is function of steam pressure and condensate piping

Installation/Operation Details

- WSTM is a WTR that uses thermocouples (TC's) as inputs
- WSTM uses its own server (different from WGR and WTR)
- Temperature limits on the TC's: 1000° C
- Installation: non-invasive. TC's clamp onto inlet and outlet pipe of steam trap
- Each WSTM has three nodes – inlet temperature, outlet temperature, differential temperature
- Readings page displays each Steam Trap's data as a single line of data: Inlet_Temp/ Outlet_Temp/ Delta_Temp
- Alarm set points may vary by steam trap
  - Dependent on steam pressure
  - May be dependent on steam trap type

WSTM Data Analysis – The Algorithm

Scenario	Inlet Temperature	Outlet Temperature	Differential Temp > 20°C
Functioning Trap	At saturated steam temperature	Just below boiling point of water	Yes
Partially blown trap	At saturated steam temperature	Hovering at the boiling point of water	Yes
Blown trap	Above saturated steam temperature	Above boiling point of water	Yes
Blocked Trap	Below boiling point of water	Below boiling point of water	No
Off Trap or Bypassed Trap	Ambient temperature	Ambient temperature	No

Note: Expected temperature differential a function of steam pressure and condensate piping

Sample Trend
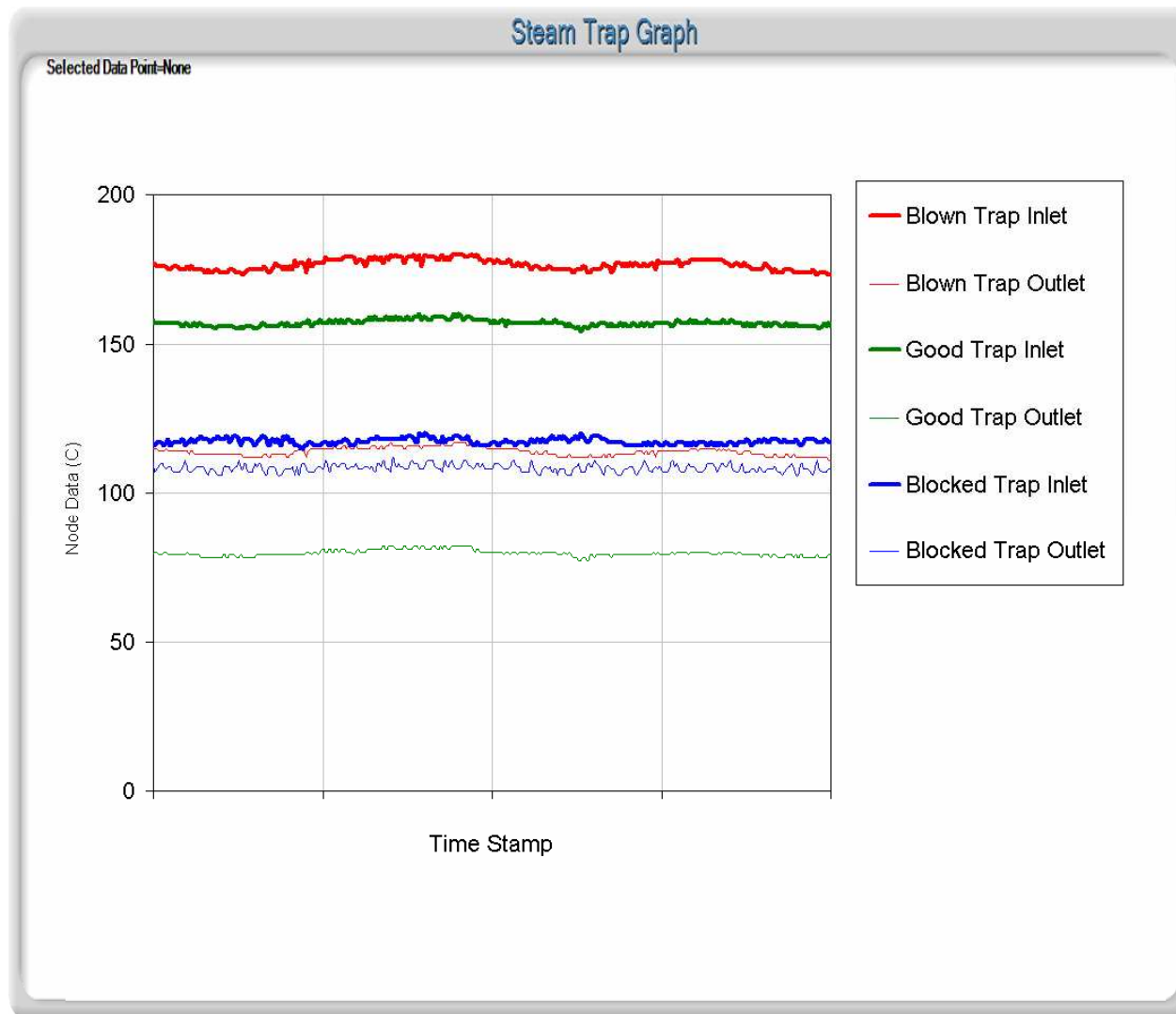
Value of WSTM

- Predictive maintenance
  - Reduce manual inspection needs
  - Can identify potential failures before they occur
  - Can plan maintenance activities

- Energy savings
  - Typically only perform steam trap maintenance on an annual basis; losses go undetected until next maintenance
  - Can minimize steam loss by catching them as they occur

Potential Questions

- Reliability of temperature measurement over ultrasonic measurement?
  - Somewhat of a religion – not easy to debate
  - Both methods have issues
    - Temperature method can be unreliable if:
      - Condensate system has a lot of back pressure (not vented)
      - Inlet steam pressure is low (less of a delta T to detect)
    - Ultrasonic method can be unreliable because:
      - Sonic device needs to be used correctly
      - Need to know what the sound profile is telling you. Automating the process is not easy. Plus, comparing real-world sound to a reference signature is not guaranteed either.
  - Ultrasonic devices are much more expensive
  - Ultimately, many people still use thermal guns to test steam traps → give good indication of problems

Note: Some traps may not have proper bypass and may not be easy to repair/replace except during shutdown. This impacts savings.

Considerations when Evaluating Customer Site

- Need to know approximate pipe sizes on inlet and outlet of steam traps
  - Helps installers size thermocouples
- Helpful to know:
  - Steam operating pressure – helps in analysis of data
  - Steam trap orifice sizes – helps to calculate losses and savings
  - Whether or not condensate goes to drain or goes to a condensate tank – may be some backpressure in the system, which might impact temperature
- If there is insulation around the trap, installers will need to pull it back – WSTM thermocouples must be installed directly on the pipe
- Smallest pipe diameter to get a TC around - ½"
- Installation time per steam trap:
  - Dependent on accessibility of trap
  - Dependent on insulation around trap
  - Dependent on knowing size of pipe around steam trap
  - Can take from 20 minutes to 1 hour

Agenda

- Wireless Infrastructure
- BBS
- WGR/WMR
- WTR
- WSTM
- WFM

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Principle of Freezer Operation

- Freezers have compressors and a refrigerant loop that controls the chamber temperature of the freezer
  - Ultra-low freezers will have two compressors.
  - 'Regular' freezers will have one compressor.
- The only "working" components are the compressors
- Freezers typically monitored for temperature
- Temperature deviations are indications of failures that have occurred, not potential failures
- Failure modes of freezers
  - Compressor failure
  - Power failure – no power to freezer
  - Refrigerant loop failure – refrigerant leak or failure
  - Chamber seal failure – door or gasket failure

The WFM

- The WFM is a four-channel WTR
  - Channel 1: Low stage compressor amperage monitor
  - Channel 2: High stage compressor amperage monitor
    - This channel will not be used if the freezer only has one compressor
  - Channel 3: Temperature monitor
  - Channel 4: Door switch monitor (open or close)
- All four channels record at the same time
  - This helps to correlate any deviations
- The door switch triggers an increased sampling rate
  - When the door switch is triggered, the sampling rate is increased to 30 seconds for a 2 minute duration.
  - This was programmed to catch the peak amperage draw of the compressor when it starts.

How WFM Works to Prevent Failure

- The WFM monitors parameters that would indicate a potential failure

- Compressor Amperage Monitor
  - Indication of the failure modes
    - Compressor failure – compressors working too hard, or not working at all
    - Power failure – no amperage readings or constant amperage readings
    - Refrigerant loop failure – compressors working too hard, drawing too much amperage

- Door Status Monitor
  - Indication of the chamber seal failure mode

- Temperature Monitor
  - Indication that failure has occurred

- Monitoring all points together correlates the data to indicate imminent failure, cause of failure, or operator error

Value Add for the Customer

- ## Risk Mitigation
  - Minimizing the risk of product loss within freezers by monitoring multiple parameters
- ## Predictive Maintenance
  - Indication of problems prior to equipment failure
  - Minimizing preventative maintenance activities
- ## Equipment Useful Life Extension
  - Resolving small problems before they result in equipment failure and replacement
- ## Flexibility of Monitoring
  - Some freezers are moved around. Hard wiring limits monitoring capabilities.

WFM Installation

- Ammeters installed for each compressor
  - Ammeters connected in-line with existing wiring in freezer
  - Short downtime required for personnel safety during installation (approx. 5 minutes)
- Thermocouple installed inside chamber to monitor temperature
  - Location of thermocouple consistent with existing chamber control thermocouple
  - Installation method will depend on customer
    - May be installed through door, if freezer cannot be defrosted
    - May have existing port for TC to be wired through
- Door switch connected to existing door switch
  - Most freezers have door alarms
  - Polarity of switch tested during installation
  - Output is 1 or 0 (0 is closed)

WFM Installation

- The WFM antenna is connected to rear of freezer
- WTR portion of WFM can be placed inside the mechanical space of the freezer
- Access Requirements for Installation
  - Installers have to open up the mechanical space of the refrigerator.
  - Installers need to access the chamber in order to install the thermocouple.
- Installation Time – Up to 1 hour
  - Wiring of compressors may take time to interpret.
  - Accessibility of the mechanical space of freezers may be difficult.

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WFM Installation

- The downtime required for installation is minimal.
    - Most work can be done without downtime.
    - A 5-minute downtime on a freezer that is maintaining temperature will have little/no impact.
        - -70C freezers can hold temperature for >1hr if functioning properly.
        - Most freezers have battery backup to monitor temperature, even in a power failure.
        - The installation team can monitor temperature while the amperage points are installed.
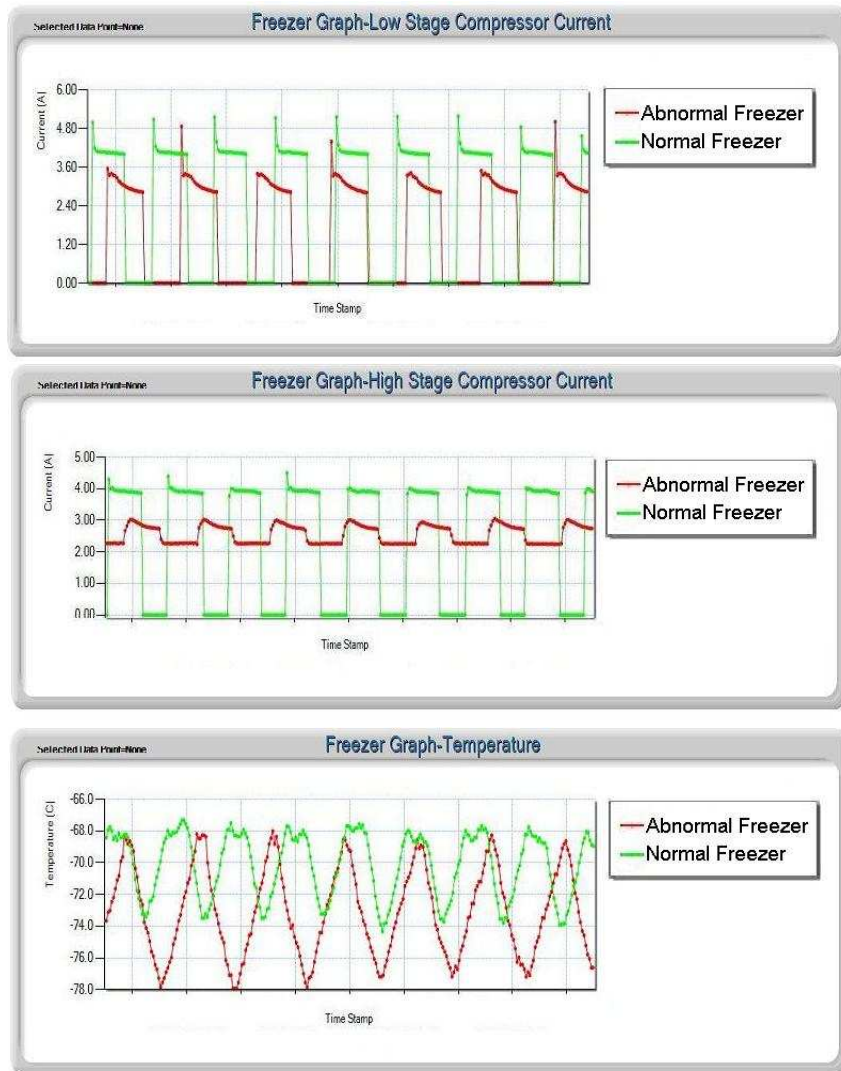
Things to Know about the WFM

- The server for the WFM cannot be combined with the WGR/WTR or WSTM.
  - The readings pane for the WFM shows all parameters on a single line.
  - The graph pane for the WFM shows all parameters for a single freezer.
- Power Options
  - The WFM is battery powered.
  - The WFM can be plugged in, or powered by the freezer power.
- Dual Chamber WFM
  - Freezers may have more than one chamber. Or, freezers may have more than one door, but a single chamber.
  - Dual chamber freezers may require multiple WFMs to effectively monitor the freezer.

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Things to Know about the WFM

- Door Switch
  - Because the door switch monitor ties into the built-in door switch, the monitoring methodology is dependent on the existing switch.
    - This may be a factor if the freezer is an older unit with multiple doors, but the door switch is only triggered by one of the two doors.
    - This may be a factor if the existing door switch is not functioning.

Pictures and Trends

Appendix