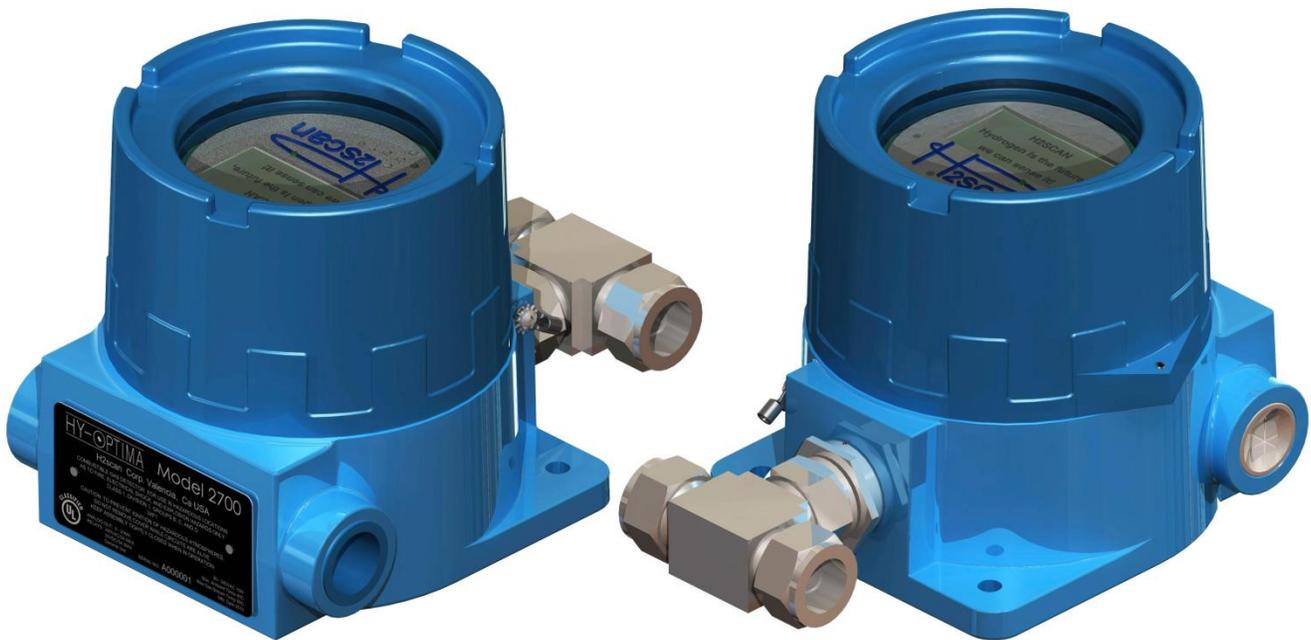


HY-OPTIMA™

HYDROGEN SPECIFIC MEASUREMENT SOLUTIONS

HY-OPTIMA™ 2700 Series

Explosion Proof In-line Hydrogen Process Analyzer



OPERATING MANUAL



Hydrogen is the future, we can sense it!™

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MISSION STATEMENT

Our Mission

Deliver unsurpassed value and optimize green initiatives with our one of a kind continuous hydrogen-specific sensing technology worldwide.

Our Value Propositions

Enable end-user customers to efficiently and effectively optimize:

- Electric utility power transformer fleet and other oil-filled assets (Grid)
- Petroleum refinery and other industrial process control
- Facility and equipment safety to minimize downtime

...at a much lower total costs of ownership than the competition.

Our Strategic Objectives

H2scan's technology accepted as the new gold standard in hydrogen sensors.

H2scan's business recognized for innovation and ingenuity, high quality products and systems, application - specific solutions, and exceptional customer service and satisfaction.

H2scan's success results from teamwork, strategic partnerships and market leadership leading to sales growth and improved profitability.

Manual release date: 2022-10-06

Manual updated to reflect 2700 firmware revisions 3.88 (Sensor Board), 1.74 (Display Board)

Chapter 1: Model Specifications and Certifications

1.1	Description.....	6
1.2	Models	6
1.2.1	Model 2710	6
1.2.2	Model 2720	6
1.2.3	Model 2730	7
1.2.4	Model 2740	7
1.3	Specifications.....	8
1.3.1	Performance Specifications.....	8
1.3.2	Operating Specifications	8
1.4	Analyzer Certifications	9
1.5	Remote Control Certifications	9
1.6	Dimensions	10

Chapter 2: Installation

2.1	Opening the Analyzer	11
2.2	Wiring	12
2.2.1	AC Power Wiring	14
2.2.2	Relay Wiring	14
2.2.3	Pressure Sensor Wiring (Optional).....	14
2.2.4	4-20mA Interface Wiring.....	15
2.2.5	Serial Interface Wiring	15
2.3	Relays.....	15
2.4	Analyzer Mounting	16
2.5	Startup	17
2.5.1	Models 2710, 2730, 2740	17
2.5.2	Model 2720	17
2.6	Shutdown.....	17

Chapter 3: Operation and Configuration

3.1	Optimum Analyzer Performance.....	18
3.1.1	Effect of Pressure	18
3.1.2	Calibration Gas Bottle Accuracy.....	18
3.2	Pressure Sensor (Optional)	18
3.2.1	Pressure Sensor Installation	19
3.2.2	Pressure Sensor Configuration	19
3.2.3	Pressure Sensor Installation Troubleshooting.....	21
3.3	Cleaning	21
3.4	Analog Output.....	21
3.5	Serial Communication.....	22
3.5.1	Serial Commands Summary	22
3.5.2	A Command (Relays)	23
3.5.3	CI Command (Calibrate Analog Output).....	24
3.5.4	D Commands (Display Product Information)	24
3.5.5	G Command (Go, Stream Data).....	24
3.5.6	H Command (Modify H2 Reporting Range).....	25
3.5.7	I Command (Modify Analog Output).....	25
3.5.8	PS Command (Configure Pressure Sensor)	26

- 3.5.9 SV Command (User Selectable Averaging)26
- 3.5.10 T Command (Data Log).....27
- 3.5.11 X Command (Clear Field Cal)28
- 3.5.12 F Command (Perform Field Cal)28
- 3.6 Display Menus 28
 - 3.6.1 Intrinsically Safe Infrared Remote Control28
 - 3.6.2 Intrinsically Safe Requirements28
 - 3.6.3 Navigating the Display Menus30

Chapter 4: Field Calibration

- 4.1 Calibration Interval 31
- 4.2 Calibration Gases 31
 - 4.2.1 Background Gases31
- 4.3 Calibration Procedure 32
 - 4.3.1 Procedure Using the Remote Control.....32
 - 4.3.2 Procedure Using the Serial Interface.....35
 - 4.3.3 Clear Field Calibration (Restore Factory Calibration)35

Chapter 5: Supplemental Information and Troubleshooting

- 5.1 Storage 36
 - 5.1.1 Storage Oxidation & Offsets36
 - 5.1.2 Expected Oxidation Time and Recovery Time36
 - 5.1.3 Conditioning to Remove an Oxidation Offset36
 - 5.1.4 Avoiding a Storage Oxidation Offset37
- 5.2 Sensor Behavior 37
 - 5.2.1 H2 Measurement.....37
 - 5.2.1.1 Inert Backgrounds 37
 - 5.2.2 H2 Detection.....37
 - 5.2.3 Diurnal Effect.....37
- 5.3 General Troubleshooting 38
- 5.4 Command Terminal Messages 39
- 5.5 Serial Communication Troubleshooting 39
 - 5.5.1 Connections40
 - 5.5.2 COM Port Number.....40
 - 5.5.3 USB Adaptor Device Driver:40
 - 5.5.4 Rebooting40
 - 5.5.5 Terminal Program.....41
 - 5.5.6 Analyzer Command Line41
- 5.6 Analog Output Troubleshooting 41
 - 5.6.1 Verify the hydrogen values41
 - 5.6.2 Verify the H2 range41
 - 5.6.3 Verify the Analog Output42
 - 5.6.4 Verify the SCADA analog input42
 - 5.6.5 Calibrate the Analog Output42

Appendix A: Foxterm Setup 43

IMPORTANT NOTICES



Read and understand this operating manual before installing or using the unit.
Only use cables from H2scan with this unit.
If this equipment is used in a manner not specified by H2scan, the protection provided by this equipment may be impaired.



Hydrogen is flammable at 4% in air. Take indications seriously and be prepared to take action. In the event of detection of 4% or higher of a hydrogen gas concentration there is a high probability of a hazard to safety. Inform local emergency response personnel immediately.



Do not apply power to the analyzer if the sensing element is exposed to air, with the exception of Model 2720 Analyzers. This could severely affect accuracy and stability.

LIMITATION OF LIABILITY - SELLER SHALL UNDER NO CIRCUMSTANCES BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL, PUNITIVE, OR OTHER DAMAGES, INCLUDING, BUT NOT LIMITED TO, LOSS OF BUSINESS OR PROFIT, PROMOTIONAL OR MANUFACTURING EXPENSES, INJURY TO REPUTATION, OR LOSS OF CUSTOMER, BASED ON ANY ALLEGED NEGLIGENCE, BREACH OF WARRANTY, STRICT LIABILITY, BREACH OF CONTRACT, OR ANY OTHER LEGAL THEORY ARISING OUT OF THE USE, MISUSE, PURCHASE, SALE OR POSSESSION OF ITS GOODS OR ITS PERFORMANCE OF THIS CONTRACT TO THE EXTENT THAT SUCH LIABILITY EXTENDS SELLER'S OBLIGATIONS BEYOND THE PRICE PAID BY BUYER TO SELLER FOR THE ITEM ON WHICH SUCH CLAIM IS BASED. SELLER ADVISES BUYER TO PERFORM ACCEPTABLE TESTS ON ALL HARDWARE PRIOR TO DEPLOYMENT AND TO PERFORM MAINTENANCE AS DESCRIBED IN THE SELLER'S INSTRUCTION GUIDE. UNDER NO CIRCUMSTANCES SHALL THE EQUIPMENT PROVIDED HEREUNDER BE USED IN A MANNER WHERE IT IS THE SOLE PROTECTIVE SYSTEM FOR FACILITIES, EQUIPMENT AND PERSONNEL SAFETY; THE EQUIPMENT IS INTENDED FOR USE IN CONJUNCTION WITH OTHER APPROPRIATE PROTECTIVE SYSTEMS.

LIMITED WARRANTY

H2scan Limited Warranty: Each hydrogen instrument ("Product") will conform, as to all substantial operational features, to the Product specifications set forth in this Manual and will be free of defects which substantially affect such Product's performance for twelve (12) months from the ship date for such Product.

Must Provide Notice of Defect: If you believe a Product that you believe is defective, you must notify H2scan in writing, within ten (10) days of receipt of such Product, of your claim regarding any such defect.

Return Product to H2scan for Repair, Replacement or Credit: If the Product is found defective by H2scan, H2scan's sole obligation under this warranty is to either (i) repair the Product, (ii) replace the Product, or (iii) issue a credit for the purchase price for such Product, the particular remedy to be determined by H2scan on a case-by-case basis.

Voided Warranty: H2scan's 12 Month Limited Warranty is void for any of the following:

The unit is opened and the manufacturing seal is broken

Unauthorized repair work performed at the customer's location or carried out by anyone other than H2scan's factory trained technicians

Equipment or parts that have been tampered with, misused, neglected, mishandled, improperly adjusted, or modified in any way without the written consent of H2scan.

Equipment or parts that have been damaged due to shipping, misuse, accidents, mishandling, neglect, or problems with electrical power sources.

Repair work performed during the warranty period does not prolong the warranty period past the original period.

System operation in incorrect or inappropriate environments.

Usage that is not in accordance with system guidelines or an operator's failure to follow manual instructions.

LIMITATION OF WARRANTY: THE ABOVE IS A LIMITED WARRANTY AS IT IS THE ONLY WARRANTY MADE BY H2SCAN. H2SCAN MAKES NO OTHER WARRANTY EXPRESS OR IMPLIED AND EXPRESSLY EXCLUDES ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. YOUR SOLE REMEDY HEREUNDER IS REPAIR OR REPLACEMENT OF THE PRODUCT OR A CREDIT FOR THE PURCHASE PRICE FOR SUCH PRODUCT, THE PARTICULAR REMEDY TO BE DETERMINED BY H2SCAN ON A CASE-BY-CASE BASIS. H2SCAN SHALL HAVE NO LIABILITY WITH RESPECT TO ITS OBLIGATIONS UNDER THIS AGREEMENT FOR CONSEQUENTIAL, EXEMPLARY, OR INCIDENTAL DAMAGES EVEN IF IT HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE STATED EXPRESS WARRANTY IS IN LIEU OF ALL LIABILITIES OR OBLIGATIONS OF H2SCAN FOR DAMAGES ARISING OUT OF OR IN CONNECTION WITH THE DELIVERY, USE OR PERFORMANCE OF THE PRODUCTS.

Chapter 1: Model Specifications and Certifications

1.1 Description

The HY-OPTIMA™ 2700 Series, Explosion Proof In-line Hydrogen Process Analyzer is designed to detect and/or measure hydrogen using a solid-state, non-consumable sensor that is configured to operate in process gas streams. The H2scan thin film technology provides a direct hydrogen measurement that is not cross sensitive to other gases. The hydrogen specific solid-state sensing element is designed for ease of use, interface flexibility and true process control. The analyzer contains all the circuitry necessary to operate the sensor and present calibrated hydrogen readings to an analog current output and an RS232 or RS422 digital output. The analyzer is ideal for hydrogen production and petrochemical applications where real-time measurements can enhance process plant efficiencies, diagnostics, and maintenance management.

1.2 Models

The HY-OPTIMA™ 2700 Series product family includes sensor types that are designed for specific hydrogen ranges, corrosive gas tolerances and operation when no hydrogen is present. See the guide below for more details.

MODEL	Hydrogen Range		Hydrogen MUST be present	CO Limit	H2S Limit	Calibration Background Gas	Max Pressure
	Min	Max					
2710	0.1%	10%	Yes	<100 ppm	<20 ppm	N2	2 atm
2730	0.5%	100%	Yes	<100 ppm	<1000 ppm	N2	2 atm
2740	0.5%	100%	Yes	20%	3%	N2	2 atm
2720	0.4%	5%	No ¹	0	0	O2, N2	2 atm

Notes:

1. 2720 models operated in background streams in which H2 is not typically present and may be operated in an Air, O2, or N2 background.

1.2.1 Model 2710

The HY-OPTIMA™ 2710 Process Hydrogen Analyzer has been specifically manufactured to operate in low hydrogen conditions with increased accuracy.

- Hydrogen Range:
 - 0.1% to 10% hydrogen by volume at 1.0 atm
- CO and H2S tolerance:
 - CO tolerance: 100 ppm
 - H2S tolerance: 20 ppm

1.2.2 Model 2720

The HY-OPTIMA™ 2720 Process Hydrogen Analyzer has been specifically manufactured to operate in an air or inert background.

- Operation in background streams in which H₂ is not typically present
- Calibration Background Gas: Air or Inert
- Hydrogen Sensitivity Range:
 - 0.4% to 5% hydrogen by volume at 1.0 atm
 - 10% to 125% hydrogen lower flammability limit

Note:

Please disregard all warnings and statements to avoid operation in air or oxygen background; these warnings and statements do not apply to the HY-OPTIMA™ 2720 Explosion Proof In-Line Process Hydrogen Analyzers which have been manufactured for implementation in background gas streams with air.

HY-OPTIMA™ 2720 Explosion Proof In-Line Process Hydrogen Analyzers operating in air do not require the conditioning procedure.

H2scan recommends the hydrogen gas concentrations for both the Field Verification and Field Calibration gases to be 1% and 2% hydrogen in a balance of air.

1.2.3 Model 2730

The HY-OPTIMA™ 2730 Process Hydrogen Analyzer has been specifically manufactured to operate in full range (0.5% to 100%) hydrogen conditions with the following enhanced tolerances to CO and H₂S in process gas streams:

- CO tolerance: 100 ppm
- H₂S tolerance: 1000 ppm

1.2.4 Model 2740

The HY-OPTIMA™ 2740 Process Hydrogen Analyzer has been specifically manufactured to operate in full range hydrogen conditions with the following enhanced tolerances to CO and H₂S in process gas streams:

- CO tolerance: 20% by volume
- H₂S tolerance: 3% by volume

1.3 Specifications

1.3.1 Performance Specifications

MODEL	Hydrogen Range		Hydrogen MUST be present	CO Limit	H2S Limit	T90 Response Time (sec)	Accuracy		Drift/Week		Repeatability		Linearity	
	Min	Max					Min to 10% H2	10 to Max% H2	Min to 10% H2	10 to Max% H2	Min to 10% H2	10 to Max% H2	Min to 10% H2	10 to Max% H2
2710	0.1%	10%	Yes	<100 ppm	<20 ppm	< 90	0.15%	N/A	0.15%	N/A	0.15%	N/A	0.15%	N/A
2730	0.5%	100%	Yes	<100 ppm	<1000 ppm	< 60	0.3%	1.0%	0.2%	0.4%	0.2%	0.4%	0.2%	0.4%
2740	0.5%	100%	Yes	20%	3%	< 90	0.3%	1.0%	0.2%	0.4%	0.2%	0.4%	0.2%	0.4%
2720	0.4%	5%	No ¹	0	0	< 60	0.3%	N/A	0.3%	N/A	0.3%	N/A	0.3%	N/A

Note: Sensor performance specifications are absolute and assume a dry process stream, an ambient temperature of 25°C, pressure compensation, and are in addition to any errors in the calibration gases used. The accuracy is specified for the serial port and digital display output only.

1. 2720 models operated in background streams in which H2 is not typically present and may be operated in an Air, O2, or N2 background.

1.3.2 Operating Specifications

Sample Gas Flow Rate	0.1 to 10 slpm (1.0 slpm is recommended)
Temperature	Gas Stream: -20°C to +60°C Sensor Ambient Temperature: -20°C to +55°C Storage: -30°C to +80°C Intrinsically Safe Infrared Remote Control Ambient Temperature: -20°C to +55°C
Input Power	90VAC to 240VAC, 15W, 50Hz to 60Hz
Analog Output	Isolated and self-powered 4 – 20mA, Maximum load impedance: 650Ω
Conduit Size	¾ inch NPT
Relay Contacts	Three programmable SPDT relays with both normally open (N.O.) and normally closed (N.C.) contacts. 5A, 240VAC max General Use
Serial Communication	RS232 or RS422 19200 bps, No parity, 8 bit data, 1 stop bit, No flow control (preferred) or Xon/Xoff
Weight	2.7kg (5.9lbs)

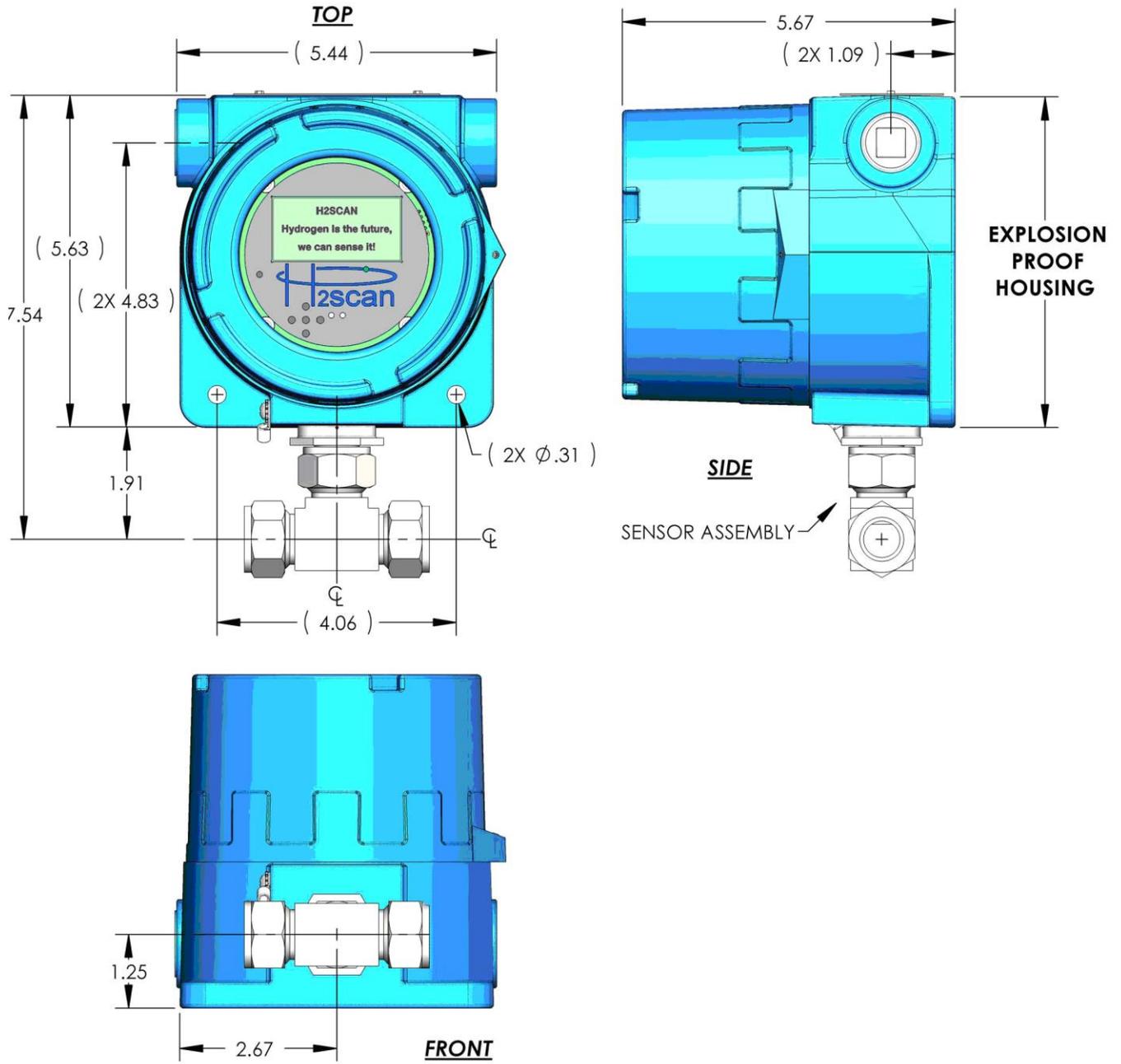
1.4 Analyzer Certifications

UL: Class I, Division 1, Groups B, C, and D 		
↑ Hazard Class	↑ Area Classification	↑ Gas Group
Hazard Class:	Groups:	Substance:
Class I Flammable Gases	Group B	Hydrogen
	Group C	Ethylene
	Group D	Propane
Division:	Protection Methods:	Applicable Certification Documents:
Division I	Explosion-proof Enclosures	UL 1203 (U.S.) CSA-30 (Canada)
UL 1203 - STANDARD FOR EXPLOSION-PROOF AND DUST-IGNITION-PROOF ELECTRICAL EQUIPMENT FOR USE IN HAZARDOUS (CLASSIFIED) LOCATIONS UL 508 - STANDARD FOR INDUSTRIAL CONTROL EQUIPMENT CSA-C22.2 NO. 30-M1986 – EXPLOSION-PROOF ENCLOSURES FOR USE IN CLASS I HAZARDOUS LOCATIONS		

1.5 Remote Control Certifications

UL: Class I, Division 1, Groups A, B, C, and D 		
↑ Hazard Class	↑ Area Classification	↑ Gas Group
Hazard Class:	Group:	Substance:
Class I Flammable Gases	Group A	Acetylene
	Group B	Hydrogen
	Group C	Ethylene
	Group D	Propane
Division:	Protection Methods:	Applicable Certification Documents:
Division I	Intrinsically Safe Equipment	UL 913 (U.S.) CSA-157 (Canada)
UL 913 - STANDARD FOR INTRINSICALLY SAFE APPARATUS AND ASSOCIATED APPARATUS FOR USE IN CLASS I, II, III, DIVISION 1, HAZARDOUS (CLASSIFIED) LOCATIONS CSA C22.2 NO. 157-92 – INTRINSICALLY SAFE AND NON-INCENDIVE EQUIPMENT FOR USE IN HAZARDOUS LOCATIONS		

1.6 Dimensions



(Units in inches)

Chapter 2: Installation

Safety Information

- All cable entry devices, conduit sealing devices, and blanking elements shall be certified in type of explosion protection flameproof enclosure “d”, suitable for the conditions of use and correctly installed. Conduit sealing fittings must be installed within 18” of the analyzer.
- Unused apertures shall be closed with suitable blanking elements.
- Field wiring shall be suitable for at least 80°C.
- For ambient temperatures below -10°C use field wiring suitable for minimum ambient temperature.

WARNING: H2scan’s HY-OPTIMA™ 2700 Series Explosion Proof In-line Hydrogen Process Analyzers are calibrated in a hydrogen/nitrogen (H2/N2) background and should NEVER be operated in an air or oxygen background unless using the 2720 model.

The analyzer can be exposed to oxygen for short periods of time without adverse effects if the analyzer is turned off. If the analyzer is operated in oxygen or stored in air for longer than a week, the hydrogen readings may be high due to oxygen adsorption on the sensor. Hydrogen exposure will then cause the readings to drift lower as adsorbed oxygen is slowly removed and the analyzer recovers to normal steady behavior.

If this drift behavior is observed, the sensor should be conditioned by operating in a hydrogen concentration exceeding 5% until the readings are stable. The required hydrogen conditioning may vary from several hours to several days depending on the level of oxygen exposure. Higher hydrogen concentrations used during conditioning may accelerate the process. Once stable, the analyzer should be checked for accuracy and calibrated if needed.

2.1 Opening the Analyzer

WARNING: If the analyzer is installed in a classified location then it is the responsibility of the user and installer to make connections to related equipment in a manner consistent with the location classification.

To access the Interface Board and Display Board simply unscrew the cover of the explosion proof housing. The Display Board connects with the Interface Board (shown in Figure 3) via a cable that allows the Display Board to be moved aside for wiring the analyzer. No tools are required. Ensure all precautions regarding electrostatic discharge (ESD) are taken.

To remove the Display Board, simply pull it straight up from the posts gripping the PCB. Plug it into another post to hold it in a convenient spot out of the way as shown in Figure 1. **DO NOT unplug the cable.**

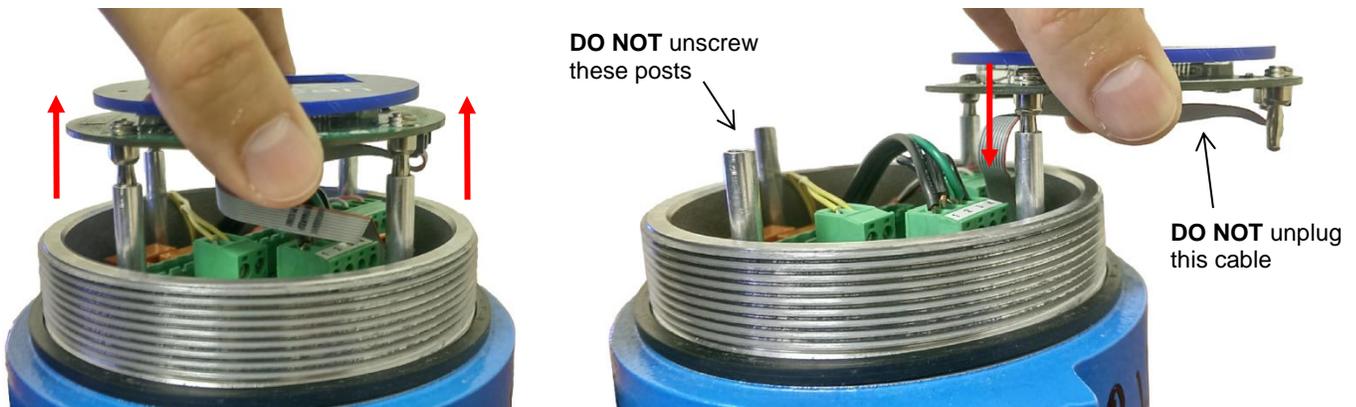


Figure 1: Removing the Display Board

If the cable is accidentally unplugged, plug it into the connector marked “INTF” (See Figure 2). Plugging it into any other connector will damage the Display Board and the Sensor Board.

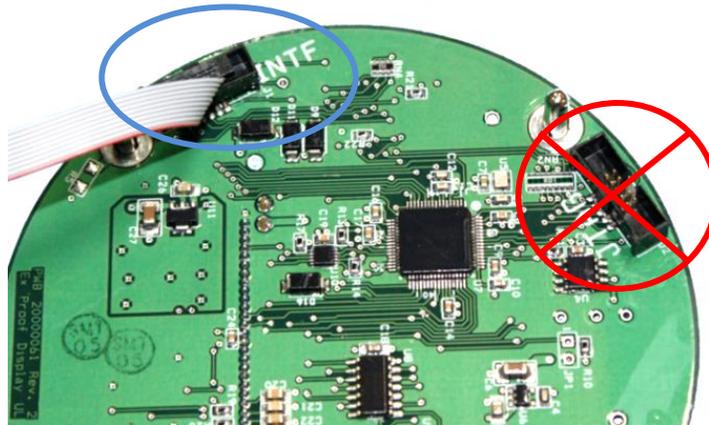


Figure 2: Display Connections

After wiring is complete (see Section 2.2 Wiring), reinsert the Display Board into the posts.

Further disassembling the analyzer voids the warranty and could cause serious damage. The board directly beneath the Display Board is the Interface Board. **DO NOT disconnect the Interface Board.**

2.2 Wiring

All wiring is done on the Interface Board (Figure 3). The connectors are two piece designs in which the wires are screwed into a receptacle in standard terminal block style. This is plugged into the board.

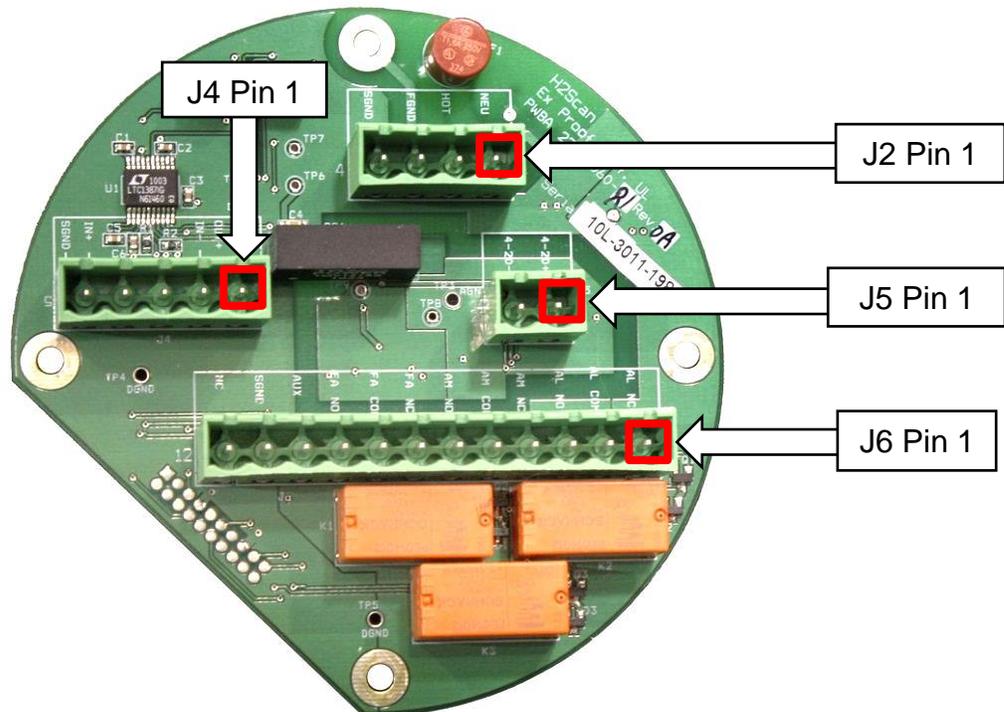
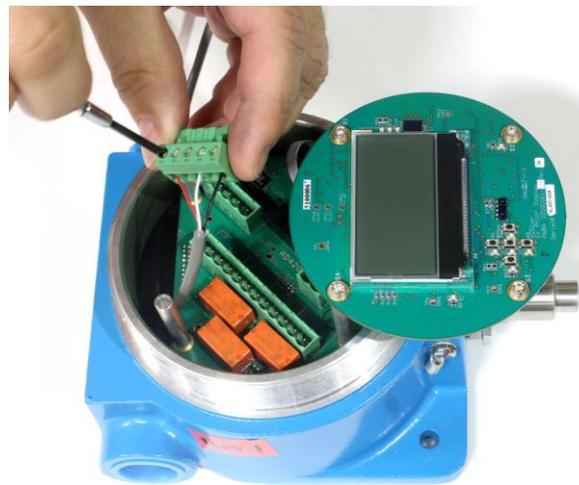


Figure 3: Interface Board Showing Connectors



1. Insert wires through the conduit connections.



2. Strip the insulation off the wires and make the connections to the connector block.



3. Plug the connector into the receptacle.



4. Pull any excess wire out of the enclosure.

2.2.1 AC Power Wiring

Power Board: J2 4-Pin Terminal Block for the Power Cable		
Pin Number	Function	Description
1	NEUTRAL	Alternating current return
2	LINE	Hot AC power
3	CHASSIS GROUND	Safety connection to ground
4	SIGNAL GROUND	Common ground for sensitive circuitry isolated from chassis ground. If a signal ground is not available, short this pin with the chassis ground.

Some facilities have separate grounds for signal and AC power. If this is the case run the signal ground and chassis ground wires to the appropriate locations. If there is one ground, jumper the chassis ground and signal ground pins together in J2.

2.2.2 Relay Wiring

WARNING: Do not exceed the maximum ratings of the relay contact specifications (5A, 240VAC MAX)

Interface Board: J6 12-Pin Terminal Block for Output Cable		
Pin Number	Function	Description
1	ALERT NC	SPDT Relay 1 for the Alert level of hydrogen
2	ALERT COM	
3	ALERT NO	
4	ALARM NC	SPDT Relay 2 for the Alarm level of hydrogen
5	ALARM COM	
6	ALARM NO	
7	FAULT NC	SPDT Relay 3 for fault conditions
8	FAULT COM	
9	FAULT NO	

2.2.3 Pressure Sensor Wiring (Optional)

Interface Board: J6 12-Pin Terminal Block for Output Cable		
Pin Number	Marking	Description
10	AUX IN	Signal: 1 to 5V pressure sensor input
11	S GND	Ground: Return for pins 10 and 12
12	NC	Hot: +12VDC

The analyzer is designed for use with a pressure sensor that outputs a 1 – 5 volt analog signal and can be powered by 12 volts.

See Section 3.2 - Pressure Sensor (Optional) for more detailed installation instructions.

2.2.4 4-20mA Interface Wiring

Interface Board: J5 2-Pin Terminal Block for Output Cable		
Pin Number	Function	Description
1	4-20mA+	4-20mA analog output
2	4-20mA -	

Hydrogen Level	Power-On Self Diagnostic	Error
4 mA to 20 mA	2 mA	3 mA
0 mA to 20 mA	0 mA	20 mA

The analog output range can be changed in the field. Please refer to Section 3.4 Analog Output.

2.2.5 Serial Interface Wiring

Interface Board: J4 5-Pin Terminal Block for Serial Interface Cable		
Pin Number	Function	Description
1	TxD- (Device Transmit, Negative)	RS422 – Data out – RS232 – Data Out
2	TxD+ (Device Transmit, Positive)	RS422 – Data out + RS232 – NC
3	RxD- (Device Receive, Negative)	RS422 – Data In – RS232 – Data In
4	RxD+ (Device Receive, Positive)	RS422 – Data In + RS232 - NC
5	SGND	Signal Ground

2.3 Relays

Relay	Usage
1. Alert	A warning that the hydrogen value has exceeded the set point.
2. Alarm	An alarm that the hydrogen value has exceeded the set point.
3. Fault	One of the following faults has occurred: <ul style="list-style-type: none"> • PCB temperature is too high • H2 resistor value is out of range • Data not valid • Heater Off Error • Power Failure (if enabled)

The Alert and Alarm relays can be programmed to respond to user-defined hydrogen levels that suit the installation. The Alarm relay should be programmed to react to a higher hydrogen level than the Alert relay. The Fault relay has a Power Fail Indicator feature that may be enabled or disabled.

Selection	Usage
Enabled	Under normal conditions the fault relay is energized with NO connected to COM.
Disabled	Under normal conditions the fault relay is de-energized with NC connected to COM.

2.4 Analyzer Mounting

Mounting is achieved with two ¼ inch diameter screws through mounting holes in the base of the explosion proof housing. ¾ inch solid conduit threaded into the enclosure will also serve as further structural support. Conduit unions are recommended on both sides of the analyzer to prevent damage to its threads in case a high torque is applied to the conduit. Additionally it is recommended the housing be mounted vertically to prevent condensation from affecting the sensor with display on top and the sensor tube pointing downwards as shown in Figure 4. See the Safety Information at the beginning of this chapter for information regarding additional safety requirements.



Figure 4: Analyzer Mounting Orientation

Adaptors such as the 4PC12 by Parker can be used to adapt the ¾" ports on the T-Fitting to a ¼" tube.

2.5 Startup

2.5.1 Models 2710, 2730, 2740

If the analyzer is being turned on from an off position, power on the analyzer before flowing gas across the sensor. The sequence of steps which are to be followed is:

1. Power on the analyzer and wait for the 5 minute warmup routine to complete.
2. Apply the low span calibration gas to the analyzer and wait for the reading to stabilize (typically 2 hours on first startup). See Section 4.2 Calibration Gases for choosing the low and high span gas concentrations. Do not apply greater than 10% H₂/N₂ to the Model 2710.
3. Perform a Field Calibration (see Chapter 4: Field Calibration).

The analyzer can be exposed to oxygen for short periods of time without adverse effects if it is turned off. If it is stored in air for longer than a week, the analyzer may read higher than the true hydrogen concentration due to oxygen absorption on the sensor. Steady hydrogen exposure will slowly remove this absorbed oxygen and cause the analyzer reading to continually drift downward until it reaches the true hydrogen concentration.

If this drift behavior is observed refer to Section 5.1.3 Conditioning to Remove an Oxidation Offset for instructions and more information.

2.5.2 Model 2720

If the analyzer is being turned on from an off position, power on the analyzer before flowing gas across the sensor. The sequence of steps which are to be followed is:

1. Power on the analyzer and wait for the 5 minute warmup routine to complete.
2. Apply air for 30 minutes.
3. Perform a Field Calibration (see Chapter 4: Field Calibration).

The analyzer is designed to be exposed to an air or inert background gas where hydrogen is normally absent. For optimal performance keep any hydrogen exposure to the sensor to less than one hour. If the hydrogen exposure exceeds this time, the sensor may need to be reconditioned by leaving it powered on in air for at least 24 hours.

2.6 Shutdown

1. Purge the system using gas with a hydrogen concentration of less than 5% H₂ or with 100% N₂ for 5 minutes.
2. Turn off all gas flow to the analyzer.
3. Power off the analyzer.

Chapter 3: Operation and Configuration

3.1 Optimum Analyzer Performance

To maximize the performance of the analyzer:

- Verify that all electrical connections are made as recommended. Switching the polarity can cause damage to the analyzer.
- Verify the process gas stream is properly regulated with a stable pressure and flow between 0.1 and 10 slpm (1.0 slpm is recommended).
- After installation complete the conditioning steps described in the Section 2.5 Startup and perform a Field Calibration (Chapter 4: Field Calibration). Use two calibration gases for the Field Calibration for optimal results.

An optional pressure sensor can be installed to further increase the analyzer's accuracy. Refer to Section 3.2 Pressure Sensor for more information.

3.1.1 Effect of Pressure

The analyzer is hydrogen specific and sensitive to only the hydrogen partial pressure in the gas stream. Since changes in total gas pressure will affect the hydrogen partial pressure, they will also affect the analyzer readings. At 1.0 atm, a 50% H₂/N₂ mixture will be reported as 50% by the analyzer. At 1.1 atm the reading will increase to 55% and 2.0 atm will result in a reading of 100%. The analyzer is capable of measuring multiple atmospheres of hydrogen, and readings above 100% H₂ are interpreted as hydrogen pressures above 1.0 atm. For example, a reading of 150% H₂ means 1.5 times the hydrogen pressure of a 100% H₂ concentration at 1.0 atm. The analyzers are factory calibrated at 1.0 atm. Performing the Field Calibration at the operating pressure will correct the hydrogen reading for static pressures. For example, if the local atmospheric pressure is 0.97 atm, doing a Field Calibration will correct for this assuming the pressure remains static. Installing a pressure sensor allows the analyzer to compensate for this effect as well as dynamic changes in pressure.

3.1.2 Calibration Gas Bottle Accuracy

The inaccuracy of the gas bottle concentration will directly affect the measured accuracy by the analyzer. During factory calibration, the analyzers are calibrated with high accuracy gases (as high as +/- 0.02% accurate). It is strongly recommended that the user perform calibration with similar high accuracy gases to maintain the accuracy specified in the manual.

3.2 Pressure Sensor (Optional)

The analyzer may use an optional external pressure sensor to compensate for pressure changes in the process gas stream. A pressure sensor configured for absolute pressure is preferable to a pressure sensor configured for gauge pressure as it will prevent local barometric fluctuations from influencing the measurements.

Note: In general, if a pressure transducer was calibrated as a pair with the hydrogen analyzer at the factory, it should remain with the hydrogen analyzer for the lifetime of the hydrogen analyzer. If the factory paired pressure transducer is replaced or removed, a factory recalibration of the hydrogen analyzer is required.

The analyzer is designed for use with a pressure sensor with a 1 – 5V analog output signal and capability of being powered by 12V DC.

Note: Pressure sensors with a 0 – 5V analog output signal may still be used but only the pressure readings in the 1 – 5V range will be valid. During configuration the low pressure value must be set to the psi value of the pressure sensor corresponding to 1V. For example, when using a 0 – 5V pressure sensor with a 0 – 30 psia range, the low pressure value must be set to 6 psia. The system would thus have to operate in the 6 – 30 psia range.

3.2.1 Pressure Sensor Installation

Note: If using SB firmware older than 3.00, ensure a computer is available with a serial port and terminal software set up as this will be necessary to configure the analyzer. See Appendix A: Foxterm Setup for instructions.

The pressure sensor can be placed before or after the analyzer in the process gas stream. There should be no components or changes in orifice diameter between the pressure sensor and analyzer as this would cause a pressure differential. For example, devices such as flow meters, moisture filters, and pressure gauges must not be placed between the pressure sensor and the analyzer in the process gas stream.

Connect the signal, ground, and power of the pressure sensor to pins 10, 11, and 12 of the J6 12-Pos terminal block on the interface board as shown in Figure 5.

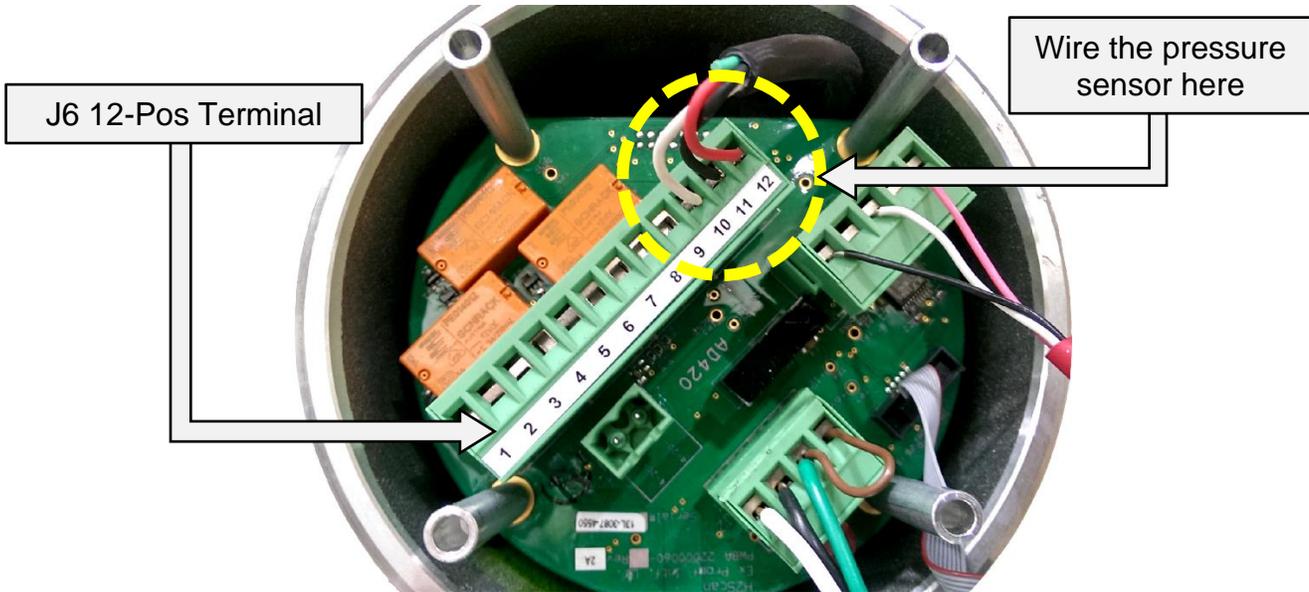


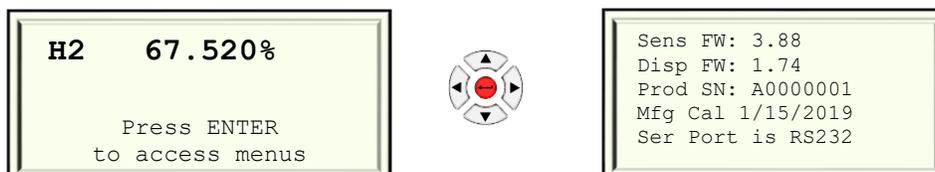
Figure 5: Pressure Sensor Wiring

Interface Board: J6 12-Pos Terminal Block for Output Cable		
Pin Number	Marking	Description
10	AUX IN	Signal: 1 to 5V pressure sensor input
11	S GND	Ground: Return for pins 10 and 12
12	NC	Hot: +12VDC

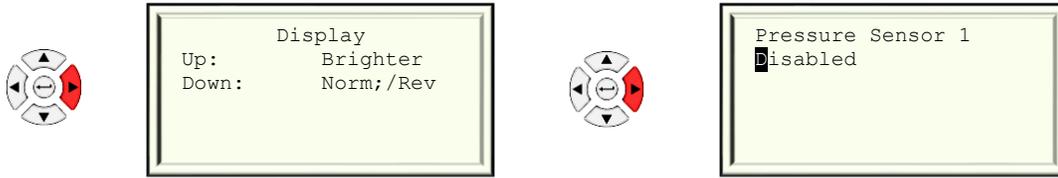
3.2.2 Pressure Sensor Configuration

If the sensor board has a firmware version greater than 3.00 the pressure sensor can be configured using the display following the procedure below. Otherwise, the pressure sensor must be configured using the serial interface using the **PS** command. See Section 3.5 Serial Communication for instructions on establishing serial communications, and Section 3.5.8 PS Command (Configure Pressure Sensor) on how to configure the pressure sensor using the serial connection.

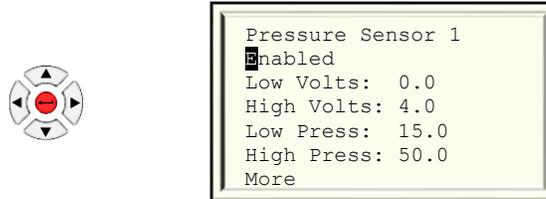
1. The main screen is shown below. Access the menus by aiming the remote control just below the display and pressing the middle button. This will display the Information Menu as follows:



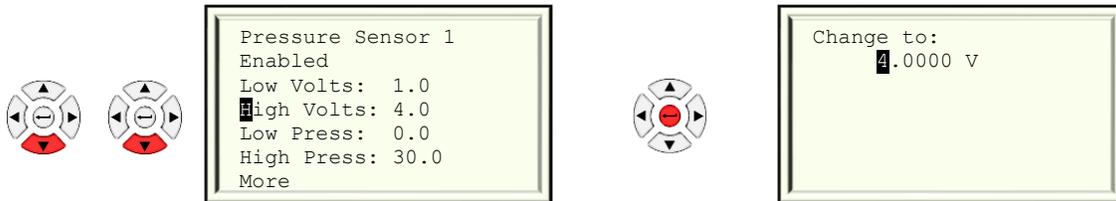
- From the Information Menu, scroll to the Pressure Menu by pressing the right button on the remote twice as follows:



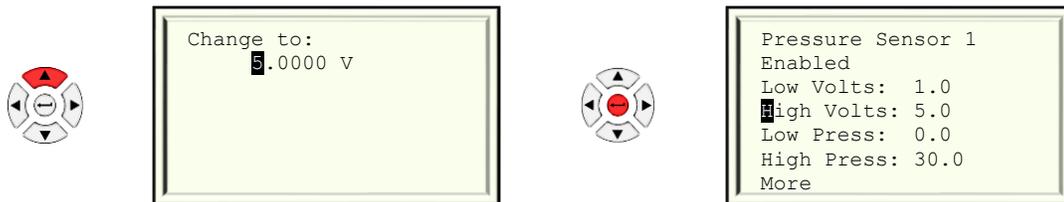
- To enable the pressure, press the middle button on the remote. This will open the configuration settings.



- To adjust the configuration to match the pressure sensor, use the up and down arrows on the remote to select a setting, and press the middle button on the remote to edit the value. An example is as follows:



Use the left and right arrows on the remote to select the digit, the up and down arrows to change the value, and the middle button to save the final value.



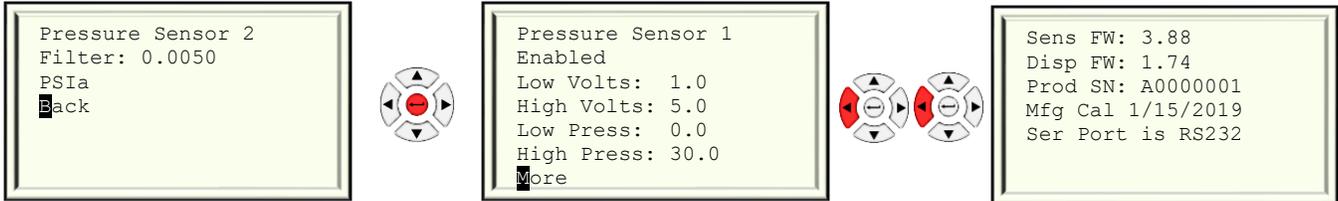
Continue until the low and high volts as well as the low and high pressure correspond to those of the pressure sensor. Note that the high voltage must be lower than 5.0 V.

- Select the "More" setting to bring up the next page.

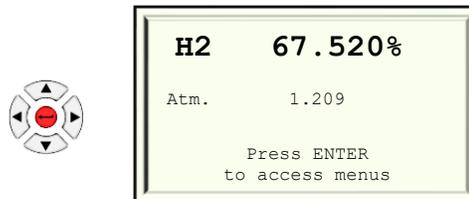


- The filter constant is used to match the response time of the pressure sensor to the response time of the hydrogen sensor. If the two are not synchronized then sudden changes in pressure will result in the analyzer reporting a brief drop or jump in hydrogen. By default the filter constant is set to 0.005. To speed up the response time of the pressure sensor, increase this value (maximum 1.0000), and to slow down the response time of the pressure sensor, decrease this value (minimum 0.0001).

- If using a pressure sensor with an absolute reading, set the PSI value to “PSIa.” If using a pressure sensor with a gauge reading, set the PSI value to “PSIg.” The gauge setting will require a reference atmospheric pressure. This value can be measured, researched, or calculated based on altitude.
- Now that all the settings have been set, return to the Pressure Sensor 1 Menu by selecting “Back.” From there return to the Information Menu by pressing the left arrow on the remote control twice.



- Exit the Information Menu by pressing the middle button on the remote control. The main screen will now have the pressure reading in atmospheres (atm), and the reported %H2 value is now pressure compensated.



If the reading is not present or does not seem accurate, see Section 3.2.3 Pressure Sensor Installation Troubleshooting.

3.2.3 Pressure Sensor Installation Troubleshooting

If the pressure is not shown (display) or the columns are showing no values (serial), verify the wiring and connections. Ensure the pressure sensor is being powered and the analog output signal of the pressure sensor is in the 1 – 5V range (adjustable up to 0 – 5V with SB firmware greater than 3.00). Verify the analog signal is connected to position 10 of the J-6 terminal block on the analyzer interface board.

If the incorrect pressure is being reported verify the pressure sensor was properly configured using the display menus (SB firmware greater than 3.00) or using the “ps” command over serial communication. Verify the pressure sensor has a 1 – 5V analog output (adjustable up to 0 – 5V with SB firmware greater than 3.00) and the range was correctly entered into the analyzer when configured. Also make sure the setting between absolute and gauge pressure was chosen correctly. If using a gauge pressure reading ensure the reference atmospheric pressure is correct.

3.3 Cleaning

If the analyzer is exposed to process streams containing debris, condensates or other material that may collect over the sensor tip then the analyzer should be removed from the stream periodically and the tip cleaned by a gentle wiping with a clean lint-free cloth or paper.

3.4 Analog Output

The analog output is derived from the final hydrogen value as shown on the serial display and is scaled to the hydrogen and current ranges desired. All of this is initially set to factory defaults as shown in the table below or per customer specifications at the time of order. They can also be changed with the “H” and “I” commands or the remote control. If the distance between the high and low H2 range is reduced then more current resolution is obtained in the valid H2 region. This may be desirable if the system will only be operating in a specific

concentration region, like 90-100% H2 concentration for example. Changing the values of H2 current is not recommended.

Variable	Label in Device	Default Value and Units
I_{H_2Lo}	LowH2Current	4 mA
I_{H_2Hi}	HighH2Current	20 mA
H_{2Lo}	LowH2Range	0% H2
H_{2Hi}	HighH2Range	100% H2

Use the following equation to calculate hydrogen from the analog output:

$$H_2\% = \frac{I_{meas} - I_{H_2Lo}}{I_{H_2Hi} - I_{H_2Lo}} \cdot (H_{2Hi} - H_{2Lo}) + H_{2Lo}$$

Where $H_2\%$ is the concentration of hydrogen measured as a percent, I_{H_2Hi} and I_{H_2Lo} are the high and low H2 currents measured in mA, and H_{2Hi} and H_{2Lo} are the upper and lower hydrogen concentration limits as a percent. These values can be displayed using the “D1” command.

3.5 Serial Communication

WARNING: If commands are sent over the serial port the display on the LCD will be unpredictable. To restore proper LCD operation, cycle the power.

The user can monitor and log the output and interface with the analyzer to perform calibration or adjust user settings via the serial communication connector. The serial communication is accomplished via the serial interface.

Serial Communications Software – Any serial port two-way communications software such as terminal emulators (H2scan uses Foxterm) and purpose-built software (using LabView, Visual Basic, C++, etc.) can be used to establish serial communication with the analyzer. See Appendix A: Foxterm Setup for instructions on setting up a serial connection.

3.5.1 Serial Commands Summary

Two communication modes are available:

Keystroke – This is the default mode which shows a continuous stream of output data until an ESC key is pressed. Then the H2scan prompt is displayed for the user to enter a command. After the command is finished the stream of output data continues.

Prompted – This mode is entered by executing =H2scan command at H2scan prompt. The analyzer continues with the H2scan prompt after completing each command. Enter the =0 command to end this mode and continue the stream of output data.

Keystroke Commands While Data Streams	
Keystroke	Description
ESC	Stops continuous display to enter a password or command. If in level zero, the continuous display will resume after executing one command.
Sp (spacebar)	Pressing the Space key while the serial output is active will display a label line showing the heading for each column of data.
a	Take average of reading (SB firmware 3.00 or greater required)
. (period)	Display current status.
' (single quote)	Append a user comment to the end of current line.
;	Add a user comment line to the serial stream.
C	Clear peak hydrogen value.

Prompted Commands @ H2Scan prompt	
Command	Description
=<password>	Enter the password to change security level. A null or invalid password returns to level 0. Level 0 password = "0" Level 1 password = "h2scan" Level 2 password = "sensor"
A	Modify the Alarm set points
Cl	Calibrate analog output
D <page>	Display Product Information. Enter page number 0-6 or A for all pages, default is page 0. 0 – Product information 1 – User configuration
F	Perform Field Calibration
G	Go, resume analyzer operation
H	Modify the hydrogen reporting range
I	Modify the DAC current output range
PS	Configure the pressure sensor
SV	User selectable averaging
T	Data log
X	Clear field calibration data (returns to last factory calibration data).

3.5.2 A Command (Relays)

The A command is used to modify the alert and alarm set points that control the relays. In this example R1 is changed to 1%, R2 is changed to 4%, and R3 Power Fail Indication is changed to Enabled. One method is prompted

```

H2scan: a

Current R1=2.00000%, R2=3.00000% Relay #3 Power Failure Indication disabled
Enter new R1 value: 1
Enter new R2 value: 4
R3 Power Failure Indication disabled. Change (Y/N)? y

Save these values (Y/N)? y
...Wait...SAVED - Done
  
```

The settings may also be entered directly on the command line.

The format is: A <R1 value><R2 value> <R3 enabled/disabled>

```
H2scan: A 1 4 e
```

```
Current      R1=2.00000%, R2=3.00000%, Relay #3 Power Failure Indication disabled
New          R1=1.00000%, R2=4.00000%, Relay #3 Power Failure Indication enabled
...Wait...SAVED - Done
```

3.5.3 CI Command (Calibrate Analog Output)

Calibrate the Isolated DAC output range using a precision current meter and requires the level 2 password to be entered first (“=sensor”). Connect the current meter to the 4-20mA output and enter “ci” at the H2scan prompt as follows:

```
H2scan: ci
Calibrate 4-20mA output
Set to 3.000000mA, Enter actual value: 3.019
Set to 19.000000mA, Enter actual value: 18.996
m=1.000000, b=0.000000
Test 4-20mA output
Set to 3.000000mA, Is this good (Y/N)? y
Set to 19.000000mA, Is this good (Y/N)? y
...wait...
```

3.5.4 D Commands (Display Product Information)

Display Product Information. Enter page number 0-6 or A for all pages, default (no value) is page 0.

0 – Product information

1 – User configuration

```
H2scan: d0
H2scan hydrogen sensor
Model Number: 2730
Serial Number: A000001
Sensor Board Firmware Rev: 2.19
Display Board Firmware Rev: 1.09
Table Version: 0.50
Hardware Version: 1.00
Latest Calibration
Factory: 00/00/0000
Field: 00/00/0000
```

```
H2scan: d1
User configuration is:
Hydrogen reporting range .50000-100.0000% H2
Isolated Output is enabled: 4.000 to 20.000 mAmps
Error output is 3.000 mAmps
Not-Ready output is 2.000 mAmps
Voltage Output is disabled
Relay #1 threshold is 1.00% Hydrogen
Relay #2 threshold is 4.00% Hydrogen
Relay #3 Power Failure Indication enabled
Pressure compensation is disabled
```

3.5.5 G Command (Go, Stream Data)

The G command is used to resume analyzer operation and specify the arrangement of the data in columns. These columns are:

Header	Description
TimeSec	The time in seconds since power on.
PcbTemp	The internal electronics temperature.
SnsrTemp	The sensor temperature.
ResAdc	The raw hydrogen sensor measurement in ADC counts.
AdjRes	The adjusted sensor measurement: these adjustments include compensation for variations in sensor temperature, sensor electronics, and other parameters.
ResZero	Sensor reference value (not zero as implied).
%H2	The final hydrogen measurement
%H2_Pk	The peak hydrogen measurement
%H2_Res	The hydrogen resistor measurement
HCurrent	The current used to heat the sensor element
PS_Volt	The voltage measurement from the optional pressure sensor
PS_psiX	The psi (A: absolute or G: gauge) measurement from the pressure sensor
PS_ATM	The pressure measurement in atmospheres from the optional pressure sensor
Messages	Some messages are displayed in this column
Average	Average indicates that several samples are being averaged

To change display format press ESC followed by G <fmt>; where <fmt> is a 4 digit hexadecimal number. Some common formats are listed below:

Command	Columns
G	Use default (generally B5B8)
G 80B0	TimeSec %H2
G B0C0	TimeSec PcbTemp SnsrTemp %H2 %H2_Pk
G B0B0	TimeSec PcbTemp SnsrTemp %H2
G B4C0	TimeSec PcbTemp SnsrTemp ResAdc AdjRes ResZero %H2_Res %H2 %H2_Pk
G F4F0	TimeSec PcbAdc TempAdc HCurrent ResAdc PcbTemp SnsrTemp ResAdc AdjRes ResZero %H2_Res %H2 %H2_Pk
G 0100	PS_Volt PS_psiX PS_ATM
G B5B8	TimeSec PcbTemp SnsrTemp HCurrent ResAdc AdjRes %H2_Res %H2 PS_Volt PS_psiX PS_ATM Messages
G FFFF	Display All Columns

3.5.6 H Command (Modify H2 Reporting Range)

Modify the hydrogen reporting range.

```

H2scan: h
Hydrogen reporting range 0.0000-5.0000% H2
Enter new H2 low range: 1
Enter new H2 high range: 25
New Hydrogen reporting range 1 - 25% H2
Save these values (Y/N)? y
SAVED - Done
  
```

3.5.7 I Command (Modify Analog Output)

Modify the Isolated DAC output range.

```

H2scan: i
DAC range is 4.0mA to 20.0mA, error output is 2.0mA, not ready output is 3.0mA
Enter new low H2 output current: 4
  
```

```
Enter new high H2 output current: 20
Enter new error output current: 3
Enter new not ready output current: 2
New DAC range is 4.0mA to 20.0mA, error output is 3.0mA, not ready output is 2.0mA
Save these values (Y/N)? y
SAVED - Done
```

3.5.8 PS Command (Configure Pressure Sensor)

This “ps” command allows configuring the analyzer for use with an external pressure sensor and requires the level 2 password to be entered first (“=sensor”). The settings shown below are for a pressure sensor with 0 – 30 psia pressure range.

The filter constant is used to slow the pressure sensor’s response to changes in pressure. This helps to reduce apparent spikes in the analyzer’s hydrogen reading which is a result of the fact that the pressure sensor will respond faster to changes in pressure than the sensor on the hydrogen analyzer. The default value is 0.05.

```
H2scan: ps
External pressure sensor is disabled
Anything to Change (Y/N)? y
Enable External pressure sensor (Y/N)? y
Low pressure (psi): 0
High pressure (psi): 30
Use Absolute (A) or gauge (G) pressure? a
using absolute pressure
Filter constant (0.0001 to 1): .05
...Wait...
```

If gauge pressure is used, the analyzer will prompt for the local atmospheric pressure in psi as shown below. This value can be measured, researched, or calculated based on altitude.

```
Local Atmospheric Pressure (psi): 14.12
```

Once the configuration is complete, verify the analyzer is reading the correct pressure values by entering the command “G 100” in the terminal.

To stream more data to the terminal press “Esc” to enter prompted mode and enter the command “G B5B8.” This will display the readings from the pressure sensor with the other readings in the stream.

If the columns are showing no values (i.e. dashes), verify the wiring and connections. Ensure the pressure sensor is being powered and the analog output signal of the pressure sensor is in the 1 – 5V range. Verify the analog signal is connected to position 10 of the J-6 terminal block on the analyzer interface board.

If the incorrect pressure is being reported verify the pressure sensor was properly configured using the “ps” command. Verify the pressure sensor has a 1 – 5V analog output and the range was correctly entered into the analyzer when configured. Also make sure the setting between absolute and gauge pressure was chosen correctly.

3.5.9 SV Command (User Selectable Averaging)

Note: Requires SB firmware 3.00 or greater.

Both the field calibration function and the “a” keystroke calculate an average on the sensor reading. By default the number of samples in the average is set to 30, but if there is a large amount of noise in the reading or a different average length is desired for some other reason, the value can be changed using this command.

```
H2scan: sv

Number of samples to average is 30. Change (Y/N)? y
Number of samples to average: 60

Number of samples to average is 60. Change (Y/N)? n
...wait...
```

3.5.10 T Command (Data Log)

Note: Requires SB firmware 3.00 or greater.

By default the analyzer stores a sensor reading every 3 minutes into memory. The memory can hold roughly one month of data and once full, overrides the oldest data. This allows access to the latest month of data. Additionally, any error events and power cycles are stored in the log. The parameters of the data log such as update interval and which values to store are configured at the factory.

```

H2scan: t
Trace Functions:
  c = clear log
  d = display log
  e = exit
Select function: d

=== Begin Log Data ===
Data Log Summary:
  Total= 9702 records, sample= 9702, event= 0
  Records captured: 117440 to 127152
  Time captured [w:d:h:m] 0:01:17:58
  Estimated download time [h:m:s] 00:13:18
End of Data Log Summary:
Main menu:
  a: Display ALL
  s: Sample
  e: Event
  q: exit
Selection a
  Final estimated download time [h:m:s] 00:13:18

continue (Y/N)? y
  
```

The events recorded in the data log are described below:

Event Code	Description
0x01	Power On
0x02	Power Fault
0x03	Relay 1 Set (%H2 raises above relay threshold)
0x04	Relay 1 Clear (%H2 returns below relay threshold)
0x05	Relay 2 Set (%H2 raises above relay threshold)
0x06	Relay 2 Clear (%H2 returns below relay threshold)
0x07	Relay 3 Set (Fault relay)
0x08	Relay 3 Clear (Fault relay)
0x09	Field calibration start
0x0A	Field calibration end
0x0D	PCB temperature too high
0x0E	Die temperature not at set point
0x0F	H2 resistor is out of range (possibly due to a bad configuration, calibration or damage to the sensor)
0x10	Data not valid (possibly due to a bad configuration, calibration, or damage to the sensor)
0x11	Die temperature fault (often due to rapid process temperature change or H2 concentration change)
0x13	Configuration error, check the settings (H2 range, analog output, etc.)
0x15	Field calibration failure (be sure the lower concentration gas was applied first, and the gases are at least 1% different)

3.5.11 X Command (Clear Field Cal)

Clear the field calibration data. See Section 4.3.3 Clear Field Calibration (Restore Factory Calibration). To begin streaming data again, enter “G B5B8” at the “H2scan:” prompt or any other desired “G” command.

Clear Field Calibration (Restore Factory Calibration).

3.5.12 F Command (Perform Field Cal)

Perform a field Calibration. See Chapter 4: Field Calibration for more details.

3.6 Display Menus

The display on the analyzer can be used to configure various settings such as the analog output, the hydrogen concentration at which the relays are activated, etc. Additionally, a field calibration can be performed using the display, as well as configuring the analyzer to use a pressure sensor (only with SB firmware 3.00 and greater), and adjusting the brightness and color inversion of the display (only with SB firmware 3.00 and greater).

3.6.1 Intrinsically Safe Infrared Remote Control

A 5-button Intrinsically Safe Infrared Remote Control is used to access the Display Menus, change settings and initiate calibration. If lost or damaged, spare remote controls can be purchased directly from H2scan.

3.6.2 Intrinsically Safe Requirements

- Only replace the battery in a safe (non-hazardous) location.
- Only the following batteries have been tested and approved for maintaining the intrinsic safety of the remote control:
 - Panasonic CR1632
 - Energizer CR1632
 - Renata CR1632
- Using any other battery may impair the safety of the remote.
- A lanyard or anything else attached to the remote while in hazardous locations must not have metallic parts.



The Keypad on the remote control is used to alter the display or initiate special functions from the Display Menus.

The following functions will be found in the Display Menus:

Information – Model information

Sensor Firmware Rev – Sensor Board firmware revision

Display Firmware Rev – Display Board firmware revision

Product Serial Number – This analyzer’s serial number

Manufacturer’s Calibration Date – Date of the last factory calibration

Serial Port – The serial port type; RS232 or RS422

Configure Relays – configure hydrogen levels where relays actuate

R1 Level – level of hydrogen detected where first relay will actuate; Alert Level (standard factory setting: 1% hydrogen by volume)

R2 Level – level of hydrogen detected where second relay will actuate; Alarm level (standard factory setting: 2% hydrogen by volume)

R3 – Select whether the Power Fail Indicator is enabled.

Set H2 Range – Define hydrogen sensitivity range (standard factory setting: 0% to 100% hydrogen by volume)

Low H2 Range – Lowest level of hydrogen (standard factory setting: 0% hydrogen by volume) to correspond with the low range IDAC setting

High H2 Range – Highest level of hydrogen (standard factory setting: 100% hydrogen by volume typical) to correspond with the high range IDAC setting

Configure 4-20mA – Define analog output range (standard factory setting: 4mA to 20mA)

Low Range – Low level analog output (standard factory setting: 4mA) to correspond with lowest level of hydrogen range

High Range – High level analog output (standard factory setting: 20mA) to correspond with highest level of hydrogen range

Error – Analog output (standard factory setting: 3mA) of error status

Not Ready – Analog output (standard factory setting: 2mA) of self-diagnostic test

Field Calibrate

Calibrate Sensor – Field Calibration procedure

Clear Field Cal - Restores the instrument to the last factory calibration

Exit – Exit Configuration Menu to standard display output setting

Pressing the ↵ (enter button) selects the function.

▲ or ▼

Scrolls up through a numerical range.

Moves the cursor up or down to make a menu selection

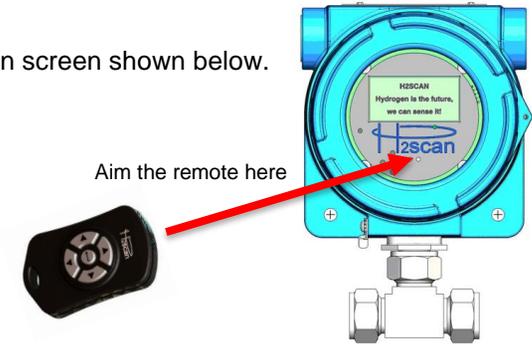
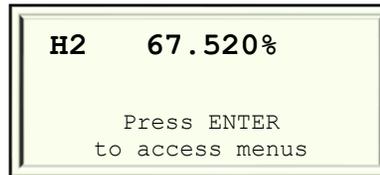
◀ and ▶ together

Returns to the Main Screen from any menu.

↵ Selects the value or function.

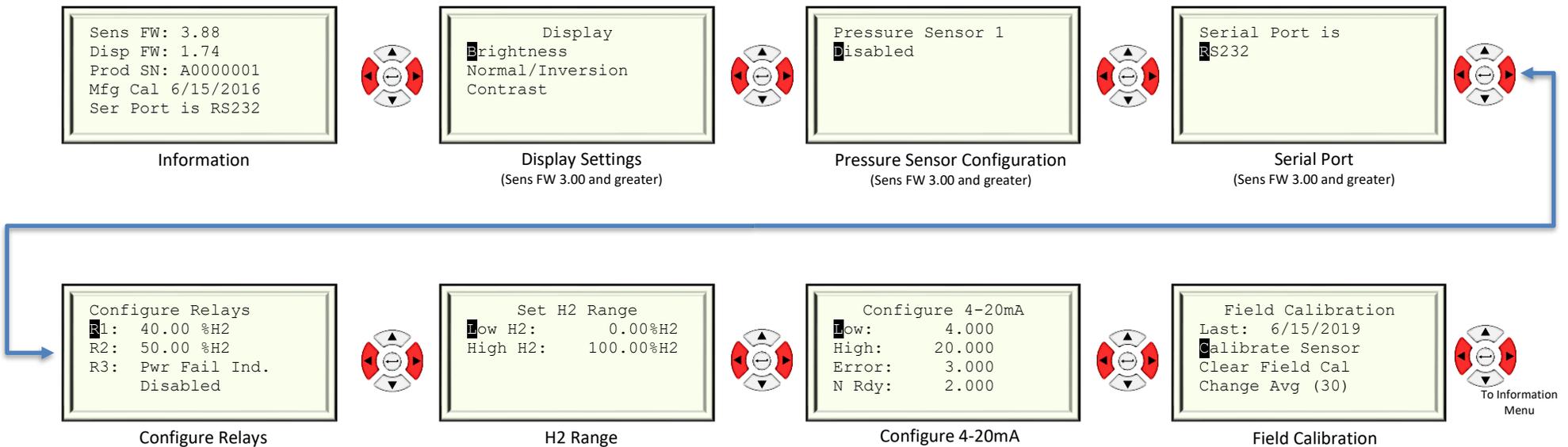
3.6.3 Navigating the Display Menu

The display menu can be accessed by pressing the middle button  on the remote control from the main screen shown below.



The screen will now display the Information Menu. Use the left and right buttons on the remote to scroll between menus. Use the up and down buttons as well as the middle button on the remote control to select and change settings within a menu.

To exit the display menu return to the Information Menu and press the middle button  on the remote.



Chapter 4: Field Calibration

4.1 Calibration Interval

Calibrations do not cause any wear on the sensor and can be performed as often as desired.

The recommended interval between calibrations depends on the desired tolerance. For example, if the drift specification for a given model is 0.3% per week (absolute) and the desired tolerance requires no more than 1% of drift (absolute), then the analyzer should be calibrated every three weeks. If there is not a specific desired tolerance, H2scan recommends the calibration be performed every three months. See Section 1.3.1 Performance Specifications to find the drift specification for a given model.

A weekly or biweekly verification of the analyzer is recommended when high accuracy is desired. This can be performed by exposing the sensor to a calibration gas for 15 minutes and comparing the reported value to the calibration gas specification. If the analyzer is outside the desired tolerance then perform a field calibration to restore accuracy.

4.2 Calibration Gases

WARNING: DO NOT use gases with a hydrogen concentration exceeding 10% at 1.0 atm for the 2710 or gases with a hydrogen concentration exceeding 5% at 1.0 atm for the 2720.

Two primary standard ($\pm 0.02\%$) gases are recommended. The option of using a single calibration gas is available if higher tolerances are acceptable and there are constraints preventing the use of two gases. However, the given accuracy specification of the analyzer does not include the error of the calibration gas certification and is only valid if two gases are used with an exposure time of at least 30 minutes per gas for all models except the 2720. The recommended exposure time for the 2720 is 20 minutes per gas. It is recommended that the 2720 be powered on in air for a minimum of three days before performing a calibration, keeping H₂ exposure minimized.

DO NOT use concentrations below 0.5% H₂ as the low span calibration gas. If the process stream hydrogen concentration range is known then to obtain the highest accuracy use a low span calibration gas just below the lowest expected reading, and a high span gas just above the highest expected reading. For example, if the process stream is expected to operate between 61% and 78% H₂, then calibration gases of 60% and 80% H₂ would be ideal.

The recommended flow rate is 1.0 ± 0.2 slpm.

Gases are applied to the analyzer through user's plumbing.

4.2.1 Background Gases

Calibrate the analyzer in the proper background gas. For an analyzer operated in hydrogen with an inert gas background (2710, 2730, 2740), the following background gases are safe:

- N₂
- Alkanes / Alkenes / Alkynes
- CO₂
- He, Ar, etc. (Noble)

For an analyzer operated in hydrogen with an air gas background (2720), carry out calibration in hydrogen in an air background.

Contact H2scan for inquiries regarding potential background gases not listed above.

Field calibration kits are available from H2scan.

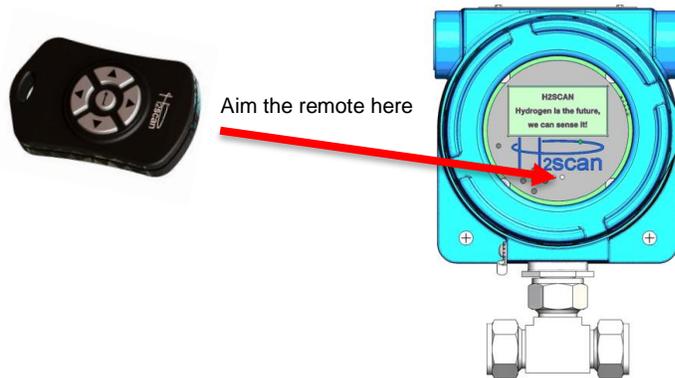
4.3 Calibration Procedure

Required materials:

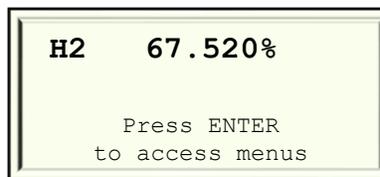
- Two primary standard ($\pm 0.02\%$) calibration gases
- Flowmeter set to 1 slpm (~2 scfh)
- 30 minutes of time per gas (roughly 75 minutes total when including setup and gas switching)
 - Only 20 minutes of time per gas is required for the 2720
- The plumbing and tools required to flow the gases to the sensor and switch between them when necessary
- One of the following:
 - (Standard) The intrinsically safe infrared remote if calibrating using the display on the analyzer
 - (Less Common) A computer with terminal emulating software and required connecting equipment (including any necessary adapters) if calibrating using the serial port on the analyzer

Note: Deviating from the above materials may result in lower accuracy. See Section 4.2 Calibration Gases for information.

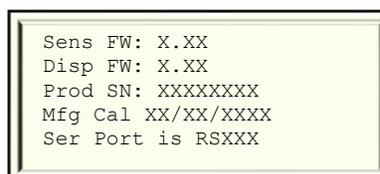
4.3.1 Procedure Using the Remote Control



1. If the analyzer is not powered on, follow the instructions in Section 2.5 Startup and return here when instructed to perform a field calibration. The analyzer display should appear as follows:



2. Using the remote control, aim at the analyzer as shown above and press the middle button.  The screen will update to show the Information Menu:



3. Press the left arrow button on the remote  to rotate to the Field Calibration menu:

```
Field Calibration
Last: 7/4/2019
Calibrate Sensor
Clear Field Cal
Change Avg (30)
```

4. Press the middle button on the remote  to select "Calibrate Sensor." The calibration settings can now be adjusted:

```
Use : 2 Gases
Gas 1 : 40.000 %H2
Time 1: 15 min
Gas 2 : 100.00 %H2
Time 2: 30 min
```

5. If the settings appear correct the calibration can be started now by pressing the right arrow button on the remote and skipping to step 7. To change a value use the up and down arrows on the remote  until the desired line is selected . . .

```
Use : 2 Gases
Gas 1 : 40.000 %H2
Time 1: 15 min
Gas 2 : 100.00 %H2
Time 2: 30 min
```

- . . . and press the middle button on the remote  to edit the value.

```
Change to:
15 min
```

- Use the up and down arrow buttons on the remote  to increase or decrease the selected digit.

```
Change to:
35 min
```

- Use the left and right arrow buttons on the remote to select the digit. 

```
Change to:
30 min
```

- When the desired value is displayed, press the middle button on the remote to save it. 

Note: Gas 1 must be the **low** span calibration gas when performing a two point field calibration.

- Enter the exact certification from the calibration bottles for highest accuracy. Verify all settings are set to the desired values and then press the right button on the remote to continue.

```
Use : 2 Gases
Gas 1 : 40.120 %H2
Time 1: 30 min
Gas 2 : 59.990 %H2
Time 2: 30 min
```



```
Apply 40.120%H2

Press ENTER
to continue
```

- Begin flowing the low span calibration gas to the sensor at 1 slpm (~2 scfh) and then press the middle button on the remote.



```
Apply 40.120%
Settle 20

Hold ENTER key to
cancel field cal.
```

```
Hydrogen = 37.892%
Wait 1695

Hold ENTER key to
cancel field cal.
```

After 20 seconds of settling time the analyzer will start the countdown timer for the first gas. The hydrogen value shown uses the previous calibration and may not match the applied gas concentration. This is OK. When the countdown timer reaches 0 the analyzer will take an average and then prompt the user for the next gas as shown below.

```
Hydrogen = 38.188%
Finding Average
Remaining 1
```

```
Apply 59.990%H2

Press ENTER
to continue
```

- Repeat step 7 with the high span calibration gas if performing a two point field calibration.

- Enter the month, day, and year using the up and down arrow buttons on the remote to increase or decrease the selected digit, the left and right arrow buttons on the remote to select the digit, and the middle button on the remote to save the value.



```
Enter Date:
 6 Month
```

```
Enter Date:
 15 Day
```

```
Enter Date:
2016 Year
```

- The calibration has completed. Press the middle button on the remote to finish.



```
Calibrate Sensor
DONE

Press ENTER
to continue
```

The analyzer may now be returned to the process gas stream.

4.3.2 Procedure Using the Serial Interface

To calibrate using the serial interface, follow the sequence below:

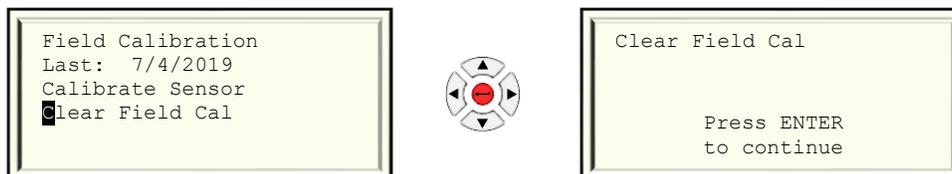
Press “Esc” to get the analyzer to the command prompt “H2scan:”

Field Calibration Steps	
Display	User response
H2scan:	Type “f” to run field calibration
Ready to Calibrate (Y/N)?	Type “y”
Gas 1	
Cal Gas: X.XXX%H2 (Y/N)?	Type “n” if incorrect
Enter gas:	Enter the hydrogen concentration % by volume
Cal Gas: X.XXX%H2 (Y/N)?	Type “y” if correct
Settle time: X min (Y/N)?	Type “n” if incorrect
Enter time:	Enter the duration in minutes for gas #1
Settle time: X min (Y/N)?	Type “y” if correct
Apply X.XXX%H2: Ready (Y/N)?	Apply gas and type “y” when flowing at 1 slpm (~2 scfh)
Streaming data...	
Taking Average... res=x.xxxxx	Calibration Gas #1 finished.
Gas 2 (Y/N)?	Type “y” if desired (highly recommended)
Cal Gas: X.XXX%H2 (Y/N)?	Type “y” if correct
Settle time: X min (Y/N)?	Type “y” if correct
Apply X.XXX%H2: Ready (Y/N)?	Apply gas and type “y” when flowing at 1 slpm (~2 scfh)
Streaming data...	
Taking Average... res=X.XXXX	Calibration Gas #2 finished

To begin streaming data again, enter “G B5B8” at the “H2scan:” prompt or any other desired “G” command.

4.3.3 Clear Field Calibration (Restore Factory Calibration)

In the Field Calibration menu on the display, highlight “Clear Field Cal” and press the middle button on the remote control. Press the middle button again to confirm or the left button to cancel.



If using the serial interface the **X** command restores the instrument to the last factory calibration.

Chapter 5: Supplemental Information and Troubleshooting

5.1 Storage

Note: Oxidation effects are not applicable to the model 2720 as it is designed to operate in air.

5.1.1 Storage Oxidation & Offsets

Analyzer readings will develop an offset when the sensor element is not exposed to hydrogen. This offset accumulates slowly while the sensor is in storage, and quickly while the sensor is powered on without being exposed to hydrogen. Try to minimize the time the sensor is powered on without being exposed to hydrogen.

This offset is due to oxidation of the sensing element; oxidation can be reversed (and sensor readings returned to normal) if the sensor is left powered on (conditioned) in an appropriate concentration of hydrogen gas.

5.1.2 Expected Oxidation Time and Recovery Time

The severity of sensor oxidation depends on the sensor's recent operation history.

Recent Operation History	Time Period	Oxidation	Conditioning Regime
Powered off or in storage	Less than 1 week	Mild	Apply conditioning gas until readings are stable. Typically less than 2 hours
Powered off or in storage	Less than 6 months	Mild to moderate (<1%)	Apply conditioning gas until readings are stable. Typically less than 24 hours
Powered off or in storage	More than 6 months	Significant (~1%)	Apply conditioning gas until readings are stable. Typically 24 - 48 hours
Powered on <i>without</i> hydrogen present	Less than 12 hours	Mild to moderate (<1%)	Apply conditioning gas until readings are stable. Typically less than 24 hours.
Powered on <i>without</i> hydrogen present	More than 12 hours	Significant (~1%)	Apply conditioning gas until readings are stable. Typically 24 - 48 hours

5.1.3 Conditioning to Remove an Oxidation Offset

Generally, condition the sensor with a gas mixture that has about the same hydrogen concentration as what you expect during normal operation.

Note: Do not ever apply gas with greater than 10% H₂ content to the Model 2710. This model is specially built for only low concentrations of hydrogen. Doing so will damage the sensor and void the warranty.

If you are not sure of the conditions the sensor will operate under, a hydrogen-nitrogen mix with a hydrogen concentration from 5% to 10% is a conservative (but effective) choice. Using gas with a slightly higher concentration of gas will remove the oxide layer (and the offset) slightly faster.

In all cases, **apply an appropriate conditioning gas until the hydrogen readings are stable**. Sensor readings may drift up or down during the conditioning process. In most cases, the readings stabilize after 48 hours.

Once stable, the analyzer should be checked for accuracy by performing a Field Verification; see Chapter 4: Field Calibration.

If the analyzer passes the Field Verification, the analyzer may be placed back into storage. If the analyzer fails the Field Verification, please perform a Field Calibration (Chapter 4: Field Calibration). If problems persist, contact H2scan for support.

5.1.4 Avoiding a Storage Oxidation Offset

Alternatively, some customers leave the backup analyzer in H₂ gas (powered on) continuously, to eliminate any recovery time the analyzer may require. H2scan recommends this approach whenever it is feasible.

For a fee, H2scan will keep a customer's backup analyzers continuously powered on in hydrogen gas at our calibration facility, and ship out the fully conditioned backup sensor when it is needed.

5.2 Sensor Behavior

H2scan provides two different types of calibrations for sensors employed in process analyzer models. This includes sensors calibrated for continual H₂ exposure (H₂ measurement applications), and sensors calibrated for uncommon H₂ exposure (H₂ detection applications).

5.2.1 H₂ Measurement

The sensors employed in Models 2710, 2730 and 2740 are designed for continual H₂ exposure, i.e. H₂ measurement applications. The standard range of measurement for these models is 0.5% to 100% by volume or 0.1% to 10% for the 2710.

Because these sensors are designed to see H₂, if they are left on for periods of time with no H₂ present, an offset will develop in the reported H₂. The more oxygen that is exposed to the sensor, the faster and stronger the offset will be. Oxygen offset varies by sensor.

5.2.1.1 Inert Backgrounds

Even small amounts of H₂ (2000ppm, for example) should ensure no offset takes place (as long as there is no oxygen present).

If oxygen were to cause an offset to the indication of the sensor, it can be reversed by purging the sensor with H₂ and performing a field calibration (See Section 5.3 - General Troubleshooting).

5.2.2 H₂ Detection

The sensor employed in Model 2720 is designed for brief H₂ exposure of less than a few hours at a time, i.e. leak detection applications.

If continual H₂ is exposed to this sensor, it will bond with the oxygen (on the sensor surface) and the indication of the sensor will be less than the H₂ actually present.

Exposures to H₂ for periods exceeding several hours may require overnight operation in H₂-free air followed by a field calibration to obtain accurate readings. H2scan does not recommend use of the Model 2720 unless there is generally no H₂ exposure to the sensor.

5.2.3 Diurnal Effect

Temperature changes throughout the day may induce small changes to the H₂ reading of the analyzer. As explained in Section 3.1.1 - Effect of Pressure, the sensor measures the number of hydrogen molecules present which means pressure changes (brought on by temperature fluctuations) can create fluctuations in the reported H₂ concentration. While the software in the analyzer corrects mostly for these effects it may still be observed in final reading. Figure 6 shows the diurnal effect across three days. Note the rise and fall in hydrogen concentration across each day correlating with the temperature. While these effects can be observed when highly zoomed in on

the data plot, they are well within the specifications for the analyzer. **Adding the optional pressure sensor can greatly reduce or remove this effect.**

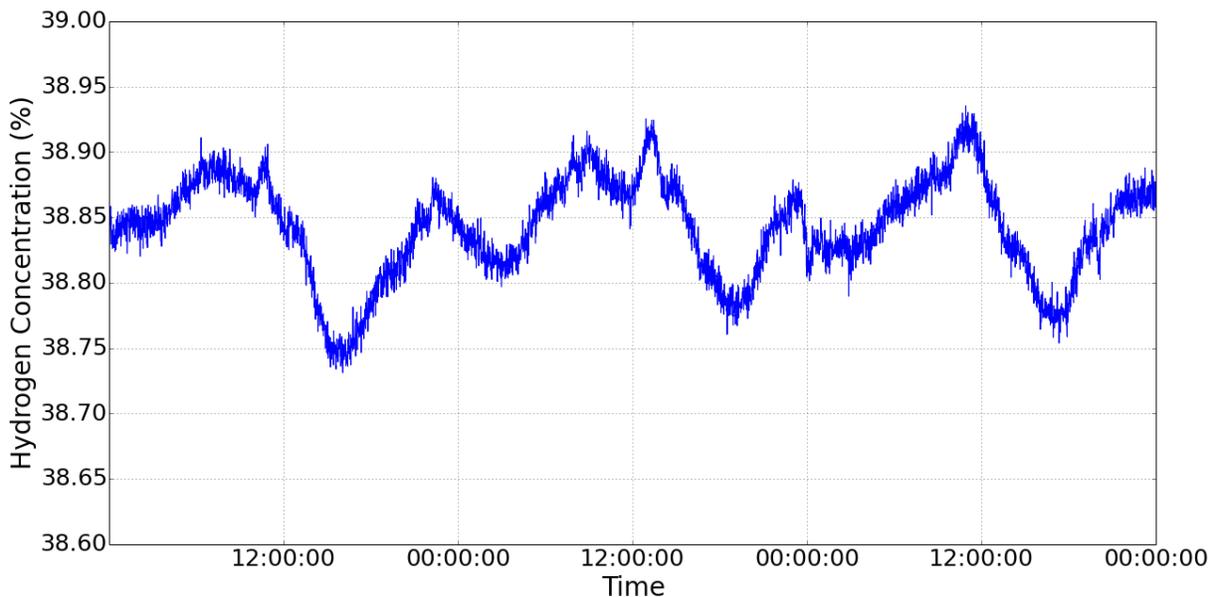


Figure 6: Diurnal Effect

5.3 General Troubleshooting

Here are some general questions to answer if problems are encountered with the analyzer.

1. Is the analyzer reporting %H₂?
 - Check all connections and flow paths.
 - Reduce process or calibration gas stream pressure to 1.0 atm and power cycle the analyzer.
2. Is the pressure and the flow stable?
 - Unstable pressure or flow can cause the analyzer to behave erratically. Ensure the process gas stream is properly regulated. A pressure sensor can be used to compensate for some changes in pressure and to improve accuracy, see Section 3.2 Pressure Sensor for details. The analyzer is less sensitive to changes in flow but a flow rate of 1.0 slpm is recommended.
3. Is the sensor stable?
 - Expose the analyzer to a calibration gas (40-100% H₂, but not exceeding 10% H₂ in the model 2710) overnight while recording the %H₂ reading from the serial port (most terminal software allows saving the session to a log file).
 - Plot the %H₂ reading. (You may use spreadsheet software such as Microsoft Excel). Assuming a constant pressure, temperature, and flow rate, the %H₂ line for the most recent data should be flat with no perturbations outside the defined specifications for the analyzer. If it is not yet stable, leave the analyzer exposed to the calibration gas for another 24 hours or until stability is observed.
 - Once the sensor is stable, perform a field calibration with two gases.
 - If the sensor does not stabilize, contact H2scan for support.

5.4 Command Terminal Messages

The last column in the display of the terminal shows status messages.

In this section `_XXX` refers to a number

ramp_up

This indicates the sensor temperature is ramping up to the operating temperature

Warmup_XXX

Warmup_XXX is displayed when the sensor is turned on or reset. It will start at a time programmed at the factory and count down to 0.

Settle

When the analyzer is waiting for the die temperature to stabilize, “Settle” is displayed. The settling time varies depending on the sensor and local conditions and could take up to five minutes.

Wait_XXX

This message usually appears counting down a delay.

For example, during field calibration the analyzer is expecting the gas to be applied for a certain length of time. In this case WAIT_XXX will appear counting down the remaining time.

Wait_100 continuously displayed is a special case. It appears when the analyzer is waiting for an event that will not occur at a particular time. Once this event occurs it changes to a counter initialized to some value (Wait_XXX) and counts down from there.

If it is displayed for more than five minutes, cycle the power to the analyzer. It should return to normal operation.

htroff

The “htroff” error could be caused by one of several error conditions that cause the analyzer to turn off the sensor heater. Sometimes the error occurs because of a transient condition (“glitch”). If “htroff” is displayed, cycle the power to the analyzer. It should return to normal operation. If the error is permanent, the analyzer must be returned to H2scan for examination.

Error_XXXX

The following table lists possible errors and the code numbers that could appear on the display. These codes are hexadecimal numbers representing 16 bits with each bit representing an error. If more than one error occurs concurrently, their values add. For example, if the sensor temperature is out of range and there is a configuration error, the error code will be 4040. Many of these errors could lead to a “htroff” error.

Error	Code (hex)
PCB temperature is too high	8000
Sensor temperature is out of range	4000
H2 resistor value is out of range	2000
Data not valid	0800
Pressure is out of range	0400
Sensor temperature fault	0100
Configuration error	0040

5.5 Serial Communication Troubleshooting

This troubleshooting guide assumes the ICP DAS model 7561 USB adapter and FoxTerm terminal emulation program are used. More information can be found on-line at www.icpdas.com. It is important that the RxD, TxD, and Gnd connections for RS-232 communication are made correctly. Gnd must be connected to the DC ground

line of the power supply. Avoid using a USB-Serial adaptor that has a long cable between the two ends as it can easily pick up electrical noise that will interfere with communications.

FoxTerm Error 015: The port 'COMx' does not exist: Determine which COM port is available for use.

Garbage Characters: If strange characters are seen in the FoxTerm window, either on their own or in response to pressing **Enter** then **ESC**. Verify the serial connections and FoxTerm Settings.

No H2scan: Prompt: If pressing **Enter** then **ESC** does not show the H2scan: prompt, and FoxTerm is connected to the correct COM, port refer to the Section 5.5.6 Analyzer Command Line for further instructions.

No Response to Pressing Enter: If the H2scan: prompt is present and command characters are echoed but pressing **Enter** has no affect then confirm the Newline Behavior setting for FoxTerm is "CRLF".

USB Adapter not recognized: If a USB adapter is used, Administrator Rights may be required for the computer to install and use it. Contact your network administrator to resolve this issue.

5.5.1 Connections

Review the wiring connections between the analyzer, power supply, and USB Adapter as indicated in the Operation manual. Then confirm that the power supply is on and within specifications with a voltmeter, and the LED is on. An amber LED immediately after turning on power is normal. The LED will change to green or red after the warm up period depending on hydrogen concentration.

5.5.2 COM Port Number

Administrator rights for the computer are required to examine or setup a COM port connection with the analyzer. Open Device Manager by right clicking on My Computer icon, selecting Manage and then choosing the Device Manager option in the left pane. In the right pane select Ports (COM & LPT) and determine which COM port is connected to the analyzer (e.g. COM6). The COM port should be labeled as I-756x (COM__). Make note of the COM port number shown in parenthesis for use in setting up FoxTerm. Note that the COM port number may be different when your computer is reconnected to the analyzer. For best results always use the same USB adapter and plug-in location on your computer.

To confirm that a particular COM port is actually connected to the analyzer: Open Device Manager; disconnect the USB connector from your computer and verify that the COM port disappears; then reconnect the USB connector and verify that the COM port re-appears. If the COM port is not displayed in Device Manager, unplug the USB cable and look for changes in Device Manager. Plug in the USB cable and see if a new COM port is added to the Ports (COM & LPT) section. If so, this is the COM port to use with FoxTerm.

5.5.3 USB Adaptor Device Driver:

If the COM port is not correctly displayed in the Device Manager then look for yellow warning symbols that indicate a device is not working correctly under the Universal Serial Bus (USB) controllers section. If this warning symbol goes away and returns as the USB cable is disconnected and reconnected then the device driver for the USB adapter is not installed correctly. To re-install the device driver, double click on the Warning line to bring up the properties window for the device; select the Driver tab and click on the Uninstall button. After the Uninstall is complete unplug the USB cable and reboot your computer. Re-install the driver from the CD (or internet) then plug in the USB cable and confirm that a new device is found and the driver is loaded without error. Go to the beginning of this section and determine which COM port has been assigned for the analyzer.

5.5.4 Rebooting

Sometimes when the connection between the Computer and the COM port cannot be established even after following the above procedures, the problem may be that the Computer has not released the COM port from a previous use. Reboot your computer and then use the above procedure in identifying the correct COM port

number. In such cases it is best to avoid disconnecting and reconnecting the USB adaptor until the entire data download activity is complete.

5.5.5 Terminal Program

Problems with FoxTerm are best resolved by opening FoxTerm then issuing a (File|Close Session) command from the menu bar. This closes all open terminal windows and prepares FoxTerm to setup a new COM port connection. If prompted to **Save** the session select **No**. The next step is to issue the (File|New COM Port Connection...) command from the menu bar. Now fill out the New Connection dialog box with the correct COM port and settings. Click the OK button to open the terminal window. The title bar for the window shows the COM port and indicates whether it is Connected or Not Connected. If Not Connected there is something wrong with the COM port connection on the computer, or another program is using the COM port. Confirm the correct COM port is being used. Reboot the computer if the Not Connected message does not disappear. If the terminal window is connected continue to the next section to get an H2scan prompt.

5.5.6 Analyzer Command Line

The analyzer is sending data to the serial port as measurements are made which is typically every second.

Pressing the **Enter** then **ESC** keys should show the H2scan prompt. Sometimes the **ESC** key needs to be pressed twice to get the prompt. If the prompt is not displayed then press the following keys to establish communication with the analyzer:

N Enter

1 Enter

If the analyzer does not respond turn off power for 10 seconds before turning it back on. A Power-on-Reset message should be displayed in the terminal window when power is applied.

User commands like “D0” are issued from the H2scan prompt. These commands are followed by the **Enter** key to initiate the operation. If the prompt is displayed and the user command is echoed but pressing **Enter** doesn't initiate the command then the “**Newline Behavior**” setting in FoxTerm must be changed to “**CRLF**”.

5.6 Analog Output Troubleshooting

Sometimes the analog output shows unexpected values, such as negative hydrogen. Negative hydrogen values are never reported. This section assumes 4-20mA is the analog output. Systems with 0-5V have similar operations.

5.6.1 Verify the hydrogen values

Check the %H2 column of the serial port output to read the actual hydrogen measurement. The analog output is derived from this hydrogen value. If the actual hydrogen measurement is OK, but the analog output does not agree with the %H2 column check the following items.

5.6.2 Verify the H2 range

If the H2 range is set much wider than the operating range used, errors and noise can be exaggerated. Check the range with the **D1** command.

```
User configuration is:
Hydrogen reporting range 0.0000-20.0000 %H2
Isolated Output is enabled: 4.000 to 20.000 mAmps
Error output is 3.000 mAmps
Not-Ready output is 2.000 mAmps
```

In this example 4mA = 0ppm and 20mA=20%. This is an appropriate range if the hydrogen values of concern are between 0 and 20%. This would not be an appropriate range if the hydrogen values range from 1.5 to 10%.

If the range needs adjustment, use the **H** command and follow the prompts as shown below.

```
Hydrogen reporting range 0-0.2000 %H2
Enter new H2 low range: 1.5
Enter new H2 high range: 10
New Hydrogen reporting range 1.5000-10.000 %H2
Save these values (Y/N)?
```

In this example the range was changed so 4mA=1.5% and 20mA=10%.

5.6.3 Verify the Analog Output

Disconnect the analog wires from the SCADA system. Using a calibrated meter, verify the current is correct. The equation is:

$$I = \frac{(H2read - H2low)}{(H2high - H2low)} * (AoutHigh - AoutLow) + AoutLow$$

where H2high is the H2 value at 20mA, H2low is the H2 value at 4mA, AoutLow is the lowest measurement analog output, AoutHigh is the highest measurement analog output, and H2read is the hydrogen measurement.

For example, for H2high=2%, H2low=0%, and H2read=1%, the current should be 12mA +/- 0.01mA.

5.6.4 Verify the SCADA analog input

If the current from the analyzer is correct, perhaps the analog input channel is measuring it incorrectly.

Inject a current from a calibrated source and verify the SCADA analog channel measures it correctly.

If it does not measure the current correctly, see the SCADA manual for information regarding calibration and adjustment.

5.6.5 Calibrate the Analog Output

If the range is correct and the analog output is inaccurate, it may require calibration.

Use the “**ci**” command. See Section 3.5.3 CI Command (Calibrate Analog Output) for more information.

Appendix A: Foxterm Setup

Installation

These instructions refer to FoxTerm, but the concepts are the same in all terminal emulators.

Download FoxTerm from www.foxterm.net.

Create a folder in “My Documents” called “H2scan”.

Unzip the FoxTerm files into the H2scan folder.

Setup

Start FoxTerm

Close the default session window (if needed).

Open a new session window.

Select the correct port as determined above (COM3 in this example).

Setup the session as shown below

Select a log file name and location. The file name should start with the current date (YYYYMMDD) followed by any particular information required. This way, the files will be easy to sort. For example “20110920Yukon6.log” would be the file name for the “Yukon6” analyzer that had logging started September 20th, 2011. The “.log” extension is the default, but any extension could be used.

Newline Behavior must be set to “CRLF”.

Click OK.

Save the session as “H2scan.xml” in the FoxTerm program location.

The setup should look similar to that shown.

