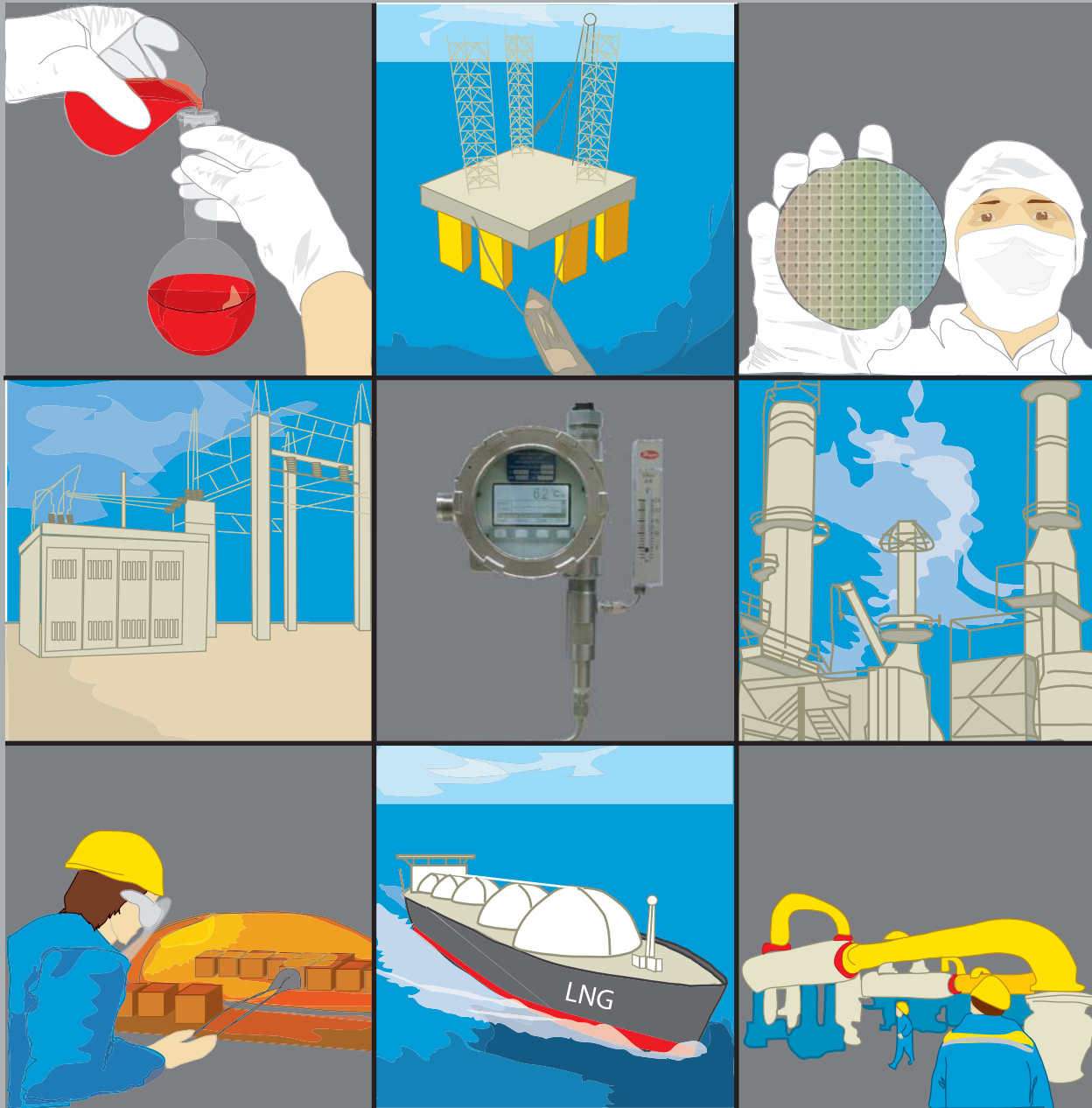


PhyMetrix®



PhyMetrix Explosion proof Moisture analyzer Model ExMa User's Manual

Read this manual before using the analyzer. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this analyzer.

Please visit our website at www.phymetrix.com for other products that may be applicable to your needs.

Every effort has been made to ensure accuracy in the contents of this manual. Should there be any doubts to the accuracy of the content please contact Phymetrix.

The contents of this manual are subject to change without notice.

The instructions, procedures, drawings, specifications and concepts contained in this manual are the property of Phymetrix Inc., and shall not be used as the basis for the manufacture or sale of apparatus or services, or reproduced or copied or transmitted in any form or by any means without written permission.

Warranty

This instrument is warranted, to the original end-user purchaser, against defects in materials and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the analyzer, at the sole discretion of the manufacturer. Batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If Phymetrix determines that the equipment was defective, the warranty period is:

- one year from delivery for electronic or mechanical failures
- one year from delivery for sensor shelf life

If Phymetrix determines that the equipment was damaged by misuse, improper installation, the use of unauthorized replacement parts, or operating conditions outside the guidelines specified, the repairs are not covered under this warranty.

Normal wear and tear, parts damaged by abuse, misuse, negligence or accidents are specifically excluded from the warranty.

Purchaser acknowledges that in accepting and using this analyzer, notwithstanding any contrary term or provision in the purchaser's purchase order or otherwise, the only warranty extended by Phymetrix is the express warranty contained herein. Purchaser further acknowledges that there are no other warranties expressed or implied, including without limitation, the warranty of merchantability or fitness for a particular purpose; that there are no warranties which extend beyond the description of the face hereof; that no oral warranties, representations, or guarantees of any kind have been made by Phymetrix, its distributors or the agents of either of them, that in any way alter the terms of this warranty; that Phymetrix and its distributors shall in no event be liable for any consequential or incidental damages, including but not limited to injury to the person or property of the purchaser or others, and from other losses or expenses incurred by the purchaser arising from the use, operation, storage or maintenance of the product covered by the warranty; that Phymetrix's liability under this warranty is restricted to repair or replacement of defective parts at Phymetrix sole option; and that Phymetrix neither assumes nor authorizes any other person to assume for it any other warranty. The warranty shall be void if serial numbers affixed to the products are removed, obliterated or defaced.

Return Policy / Procedures



If equipment malfunction is suspected or it is determined that the analyzer needs recalibration, please contact Phymetrix.

Communicate the instrument model number, serial number, application including dewpoint range being measured, and the details of the problem.

If the analyzer needs factory service you will be issued a RMA and shipping instructions.

The factory will diagnose the equipment and upon determining the problem will notify you whether the terms of the warranty cover the required repair. If the costs are not covered you will need to approve the estimated cost in order to proceed with the repair.

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1 Introduction

Thank you for purchasing the state-of-the-art Phymetrix Explosion proof Moisture Analyzer model *ExMa*. This User's Manual describes the functions of this analyzer as well as the operating methods and handling precautions. There are also some sections that review general knowledge and concepts of water vapor science. Read this manual thoroughly before using the analyzer. Check our website "www.phymetrix.com" for latest versions of documentation regarding these analyzers.

After reading this manual, keep it easily accessible for future reference. It may come in handy when there are some challenging measurements to be performed.

Conventions used in this manual:

- When using the word "*system*" in this manual we are referring to the user's system in which the moisture content is being measured. This could be a simple configuration of a pressurized gas bottle with a pressure regulator, or a complex system of dryers, filters, regulators, long tubing, valves etc.
- When referring to text that is displayed on the analyzer screen, it is presented in this manual using a font that makes it **stand out**.

The analyzer part number is displayed upon power-up and in the *About* screen, the dash numbers following the main part number signify options as follows:

-**I** : Explosion Proof certification, -**P** : internal pressure sensor, -**A** : analog output 4/20mA, -**R** : Alarm Relays, -**L** : loop powered, -**D** : Modbus RS485, -**S** : Self-Calibrating Solenoid, -**E** : external pressure sensor (measures pipeline pressure)

Check to see that your analyzer has arrived intact with all accessories that were ordered.



Model: ExMa

shown with *optional* filter(w/drain valve), pressure regulator and exhaust flow meter

Save the packing materials until you have verified that there is no concealed damage, they may also be useful for future transportation.

2 Important Principles of Operation

2.1 Sensor Operating Principle

The nanopore sensor utilized in this analyzer measures the amount of water vapor molecules that have entered its pores. This amount is directly proportional to the partial water vapor pressure in the gas surrounding the sensor, and the partial water vapor pressure is dependent on the water vapor content of the gas and the total pressure of the gas. Thus to compute the water vapor content of the gas under measurement the analyzer has to “know” the total pressure of the gas. If the analyzer was purchased with the pressure sensor option then the total pressure is measured and utilized by the analyzer, if there is no built-in pressure sensor then the user should enter the total pressure into the analyzer, this can be easily done by entering atmospheric pressure (the analyzer default setting) and measuring at atmospheric pressure by allowing the outlet (exhaust) port to vent without restrictions. Measuring near atmospheric pressure is the recommended method for most applications (refer to section 5.5).

2.2 Sampling Operating Principle

The analyzer is equipped with a built-in sampling system which has the required tight seals to measure low moisture content; it consists of a stainless steel 100 micron filter and a flow control orifice, which may be placed at either the inlet(factory default) or outlet of the sampling cell or removed. The gas under measurement is exposed only to the stainless steel walls of the sampling system.

3 Precautions

- Observe the appropriate electrical safety codes and regulations. Consult with National Electrical Code, and/or other nationally or locally recognized procedures relevant to your location.
- When measuring flammable, explosive or toxic gasses; vent the sample outlet to a safe and appropriate location.
- When measuring high pressure samples (do not exceed 5000 psia); be sure that the system is depressurized before connecting or disconnecting the sample tubing.
- Corrosives such as Ammonia, HCl and Chlorine should be avoided; H₂S and SO₂ can be present if the moisture content is below 10 PPMv.
- Avoid extreme temperatures, pressures and mechanical vibration, refer to specifications.
- Do not disassemble the analyzer.
- Do not use with contaminants and liquids, refer to section 5.2 for sample conditioning.
- Avoid exposing the sensor to ambient air as it may require long dry-down for the next measurement.
- The ExMa is weatherproof as long as the cover is tightly closed, and the conduit ports are appropriately sealed.
- Designs with circuitry activated by relay contacts should consider noise from contact bounce, an option for debouncing is placing an appropriately rated capacitor across the relay contacts.

4 Moisture System Considerations

This section is offered as background information. There are several considerations in keeping your system at a stable and pure moisture level, free of contamination from ambient air moisture:

- The integrity of the materials isolating the pure gas from the external air, including leaks from poorly secured fittings.
- The back diffusion of moisture through the exhaust outlet, the exhausts of both the analyzer and the user system under measurement should be considered.
- The effects of temperature on the equilibrium of moisture and the surrounding materials, often observed as diurnal cycles in the measurement.

4.1 Integrity of the Materials of the User's System

Before considering the materials of a system where a specified dewpoint level must be maintained, one should review two concepts.

- Compared to the structure of solids the water molecule is much smaller. This is true compared to even the crystalline structure of metals but especially important in the polymer structure of plastics.
- Water vapor pressure in gasses obeys Dalton's law of partial pressures, which states that the overall pressure of a gas is the sum of its constituent gases. And each gas seeks to equilibrate its pressure across gradients of only its own gas pressure.

Let's consider air in a pipe at a total pressure of 100 psia, which has been dried down to -40°C dewpoint. The partial water vapor pressure in the pipe is 0.13mB. If the ambient temperature is 22°C with relative humidity of 30%, then the partial water vapor pressure in the surrounding atmosphere is 7.9mB or approximately 60 times greater than the partial water vapor pressure in the pipe. Thus even though the total pressure in the pipe is much greater than the pressure outside, the reverse is true for the water vapor pressure, and as we discussed earlier the water vapor seeks to equilibrate its pressure thus it "wants" to flow from the outside to the inside and will do so through the cracks in the joints (such as poorly tightened fittings, or NPT threads even if they are properly taped), as well as through the walls of pipes tubes and other vessels. The integrity of the system is extremely important in maintaining a stable low dewpoint; for dewpoints below -60°C always use stainless steel or PTFE, while for higher dewpoints you can use copper or galvanized steel; but never use rubber, Tygon, Nylon or other plastic tubing. Pressure regulators often use rubber diaphragms, check and if necessary replace with a stainless steel diaphragm regulator. Filter bowls should be stainless steel or glass, plastic bowls should be avoided. If a flow meter is placed at the inlet of the analyzer it should have a glass tube and be rated for the expected pressure levels, however in general it is best to place flow meters at the analyzer exhaust. Another material consideration relates to items sealed in the system such as paper filters; these may not contribute to leaks but will greatly slow down the measurement because they will adsorb and desorb water molecules as the system dewpoint is changing.

4.2 Moisture Back Diffusion (backflow) Along the Walls of the Exhaust Tubing

The linear velocity of gas flowing in a tube is close to zero immediately along the wall of the tube. This phenomena, coupled with the previously discussed "need" for the moisture to flow from the higher water vapor pressure to the lower one, allows for water molecules to flow against the total flow through the exhaust outlet into the sampling chamber of the analyzer. The

fact that water molecules are highly polar further enhances their ability to migrate against the gas flow at the sampling chamber outlet. To prevent this backflow of moisture from influencing the measurement, the analyzer should have at least 12" in length of 1/8" dia. stainless steel tubing at its exhaust port, and a minimum flow of 2 SCFH (1 SLPM) should be maintained; higher flows will produce faster equilibrium time and thus are desirable for quick measuring. A small pigtail (coiled 1/8" dia. ss. tubing 12" long) can be connected to the exhaust port of the analyzer. The short tube with attached flow meter also provides protection from back diffusion of moisture.

4.3 Temperature Dependant Equilibrium

The effect of ambient temperature on the gas partial water vapor pressure of a system can change the moisture content of the gas. This is not the temperature sensitivity of the measuring analyzer, rather the actual change of partial water vapor pressure in the user's system due to increase in ambient temperature and thus the increase of energy of the water molecules on and in the walls of the system (tubing, vessels etc...). A typical example would be the observation of a daily cycling of the measurement in a system with tubing or other components exposed to direct sunlight. During the day as the sun transfers energy into the system, the dewpoint will appear to increase, while at night the dewpoint will appear to decrease. There may be other reasons for this daily dewpoint cycling such as the effect of sun/temperature on the efficiency of gas dryers etc. It is possible to minimize this effect using sun shields and tubing insulators. Alternatively one may study the response of the particular system to ambient temperature, by logging data over several days during different seasons, and compensating the measurements for this effect. The temperature effect will vary greatly depending on the size and materials of the system, for example stainless steel walls will have a much smaller effect than brass or copper walls.

5 Sampling Techniques

The amount of moisture measured will be influenced by the system moisture content as well as leaks in the system and transient effects of adsorption / desorption from materials in the system (as described in the previous sections).

5.1 Choosing a Measurement Site

The ExMa has been designed to perform extractive measurements. It is important to choose an appropriate sampling location that is representative of the moisture content of the system of interest.

5.2 Sample Conditioning

Particulate and liquid contaminants can affect the measurement, especially the response time. Sample conditioning may be necessary to remove contaminants and improve the measurement and the longevity of the sensor. Make sure that sample conditioning components are made of suitable materials. Avoid paper or other fiber filter elements, use stainless steel instead. For expected dewpoints below -50°Cdp (39 PPMv), avoid plastic filter bowls, use stainless steel or glass instead. Drain trapped liquids from filter bowls.

If the application is suspect of possible presence of liquids for example:

- Compressed air with possible oil and/or water,
 - Gas Insulated Switchgear or Transformer, SF_6 or N_2 blanket with suspected oil carryover,
 - Natural Gas with possible Tri-Ethylene Glycol carryover,
- Consult with Phymetrix for specialized sampling systems.

5.3 Tubing and Fittings

Make sure all tubing is constructed of materials suitable for low dewpoint measurement, i.e. stainless steel or Teflon, do not use rubber or plastic tubing (refer to section 4.1 for more details). Check for leaks after connecting.

Flow meters can be a source of moisture ingress especially if they have a plastic flow tube; ensure flow meters are connected at the analyzer exhaust, not at inlet. However metering valves should be at the inlet in order to maintain constant atmospheric pressure in the sampling chamber.

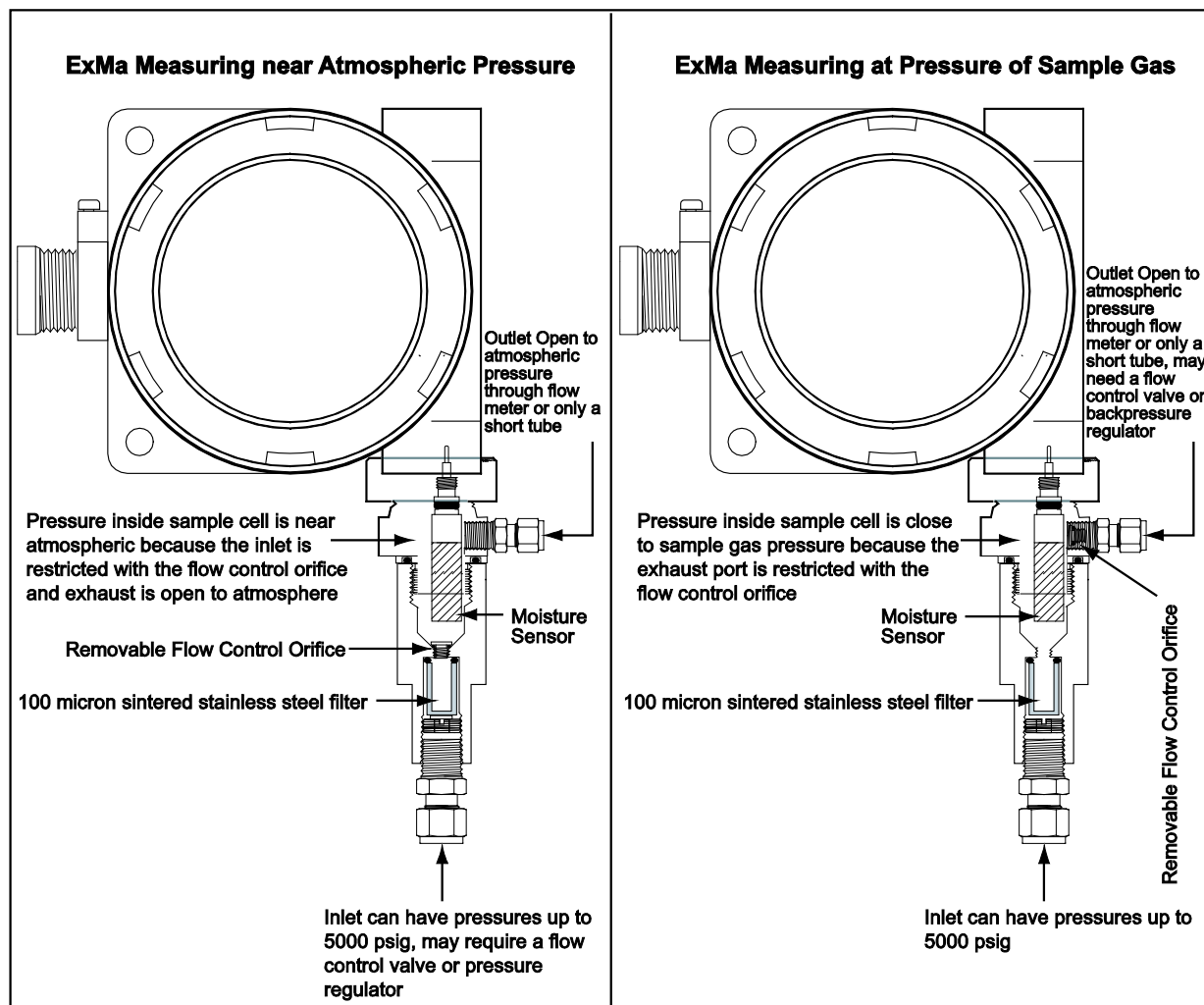
5.4 Sample Pressure

Pressure variations will affect the measurement. Higher pressure is more likely to produce condensation and thus erroneous readings or even damage the sensor. If the sample pressure needs to be reduced use a suitable pressure dropping device such as a stainless steel needle valve or pressure regulator with a stainless steel diaphragm or a flow control orifice. Make sure Joule-Thomson effects do not cool the gas below hydrocarbon and water dewpoints.

5.5 Pressure Considerations

When sampling gases from sources above 50 psia the user needs to exercise some caution.

The model **ExMa** has a built-in orifice. This orifice can be used to regulate the flow from various pressures.



- The sample cell has a built-in filter and flow control orifice at the inlet.
- On Request the orifice can be moved to the outlet to perform measurements at pressure.

For some installations the inlet orifice eliminates the need for any pressure regulators while maintaining sufficient but not excessive flows throughout the pressure rating of the analyzer. In addition when there is a pressure regulator or flow control valve installed the orifice provides a more consistent flow.

For example 0.004” to 0.016” dia. orifices, produces flows described in the following table.

source pressure psia - (Bar)	flow SLPM 0.016” orifice (default)	flow SLPM 0.012” orifice	flow SLPM 0.008” orifice	flow SLPM 0.006” orifice	flow SLPM 0.004” orifice
15 - (1.03)	0.7	0.4	0.17	0.08	0.04
25 - (1.72)	2	1.3	0.6	0.3	0.1
35 - (2.4)	3	1.9	0.8	0.5	0.2
55 - (3.8)	4.8	3.0	1.4	0.7	0.3
75 - (5.2)	6.6	4.1	1.9	1.0	0.4
100 - (6.9)	8.9	5.5	2.6	1.4	0.6
150 - (10.3)	13.4	8.3	3.8	2.1	0.9
200 - (13.8)	17.9	11.0	5.1	2.7	1.1
300 - (20.7)	26.8	16.6	7.7	4.1	1.7
400 - (27.6)	35.7	22.1	10.3	5.5	2.3
500 - (34.5)	44.7	27.6	12.8	6.9	2.9
600 - (41.4)	53.6	33.1	15.4	8.2	3.4
700 - (48.3)	62.5	38.7	18.0	9.6	4.0
800 - (55.1)	71.5	44.2	20.5	11.0	4.6
900 - (62)	80.4	49.7	23.1	12.4	5.1
1000 - (68.9)	89.3	55.2	25.7	13.7	5.7
1500 - (103.4)	134.0	82.8	38.5	20.6	8.6
2000 - (137.9)	178.7	110.5	51.3	27.5	11.4

The grayed boxes are preferred operating points. Other orifices can be provided to accommodate different pressures and flows. Consult PhyMetrix support for its proper sizing.

Measuring with the ExMa, Near Atmospheric Pressure

It is recommended for most applications to perform the measurement at near atmospheric pressure. Placing the flow control orifice at the inlet and allowing the outlet to be unrestricted (other than the exhaust pigtail and flow meter), assures that the analyzer has sufficient but not excessive flow and the pressure inside the sampling chamber is near atmospheric. This approach guarantees safe conditions and eliminates the need for the optional pressure sensor. If there is no pressure sensor the analyzer can be set with atmospheric pressure 14.7psia for the **Mea. at** setting of the pressure correction (refer to section 8.4), the orifice and unrestricted outlet will guarantee repeatable conditions for all pressures within the rating of the orifice.

Measuring with the ExMa, at Pressure of Sample

If it is desired to perform the measurement at the same pressure as the sample, up to the rating of the analyzer (5000 psia standard), then place the orifice at the outlet.

The analyzer is now setup with the orifice at the outlet, thus the measuring chamber will be pressurized to the same pressure as your sample. To perform accurate measurements, you must know the pressure and enter it into the analyzer, or order the optional built-in pressure sensor which will perform the measurement and correction automatically.

It is recommended to avoid measuring at line pressure whenever possible for the following reasons:

- Pressure variations will affect the measurement and in most cases must be compensated.
- The tubing and associated components such as valves, fittings, filter, pressure regulator etc., will be exposed to ambient moisture before they are used. This ambient moisture is several orders of magnitude higher than most gases that will be measured. The higher the pressure for example in the tubing, the more the ambient moisture molecules will be driven into the walls of the tubing. The high pressure also implies low flow velocity therefore it will take much longer to dry out these items, thus the user has to wait possibly for hours or days before they dry out.
- Higher pressure is more likely to produce condensation and thus erroneous readings, or even damage the sensor.
- The effect of corrosives, e.g. H₂S, is accelerated at higher pressures.

If it is necessary to know the dewpoint at line pressure, the pressure correction feature of the analyzer can be setup to measure at near atmospheric pressure and compute the dewpoint at some other pressure e.g. line pressure.

6 Installation

6.1 Mechanical Installation

The ExMa can be mounted directly on the pipe or can be mounted on a panel surface and connected with tubing (recommended method). Refer to Appendix A ExMa Installation Drawing. Connections for inlet and outlet of the gas being measured are made through a variety of available options e.g. 1/8" or 1/4" Swagelok® tubing compression fittings. Refer to Mechanical Installation Drawing Appendix A.

6.2 Electrical Connections: Power, 4/20mA Analog Output, Serial I/O

6.2.1 Powering the ExMa

The ExMa has two (2) standard modes of being powered.

- 1) **AC powered** from 90-260 VAC 47-440 Hz
- 2) **DC powered** from a 12 – 24 VDC 10VA power supply

Optionally the ExMa can be ordered to also operate in **4/20mA Loop Powered** mode.

Refer to the **ExMa Electrical Connection** diagram in Appendix B for the various power modes and the specific wiring for each mode.

6.2.2 Analog Output 4/20mA

The ExMa has an isolated 4/20mA output, which may be connected as a sink in configurations where the power is provided externally, or if the ExMa is actively powered (modes 1&2) the 4/20mA can be configured to source the current.

Refer to the **ExMa Electrical Connection** diagram in Appendix B for the 4/20mA configurations and specific wiring for each.

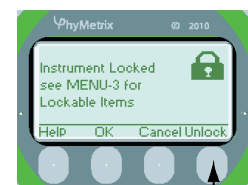
The ExMa status bar will have an **Analog Output Loop Open** message if the 4/20mA output is not connected. The user menus allow the user to force the 4/20mA output to known values for purposes of testing and calibrating the 4/20mA interface.

The following example shows the major user screen steps to setup an ExMa 4/20mA output to where 4 mA = 0 lbs/mm scf and 20 mA = 100 lbs/mm scf.

Setup the 4/20 mA output range:

A) UNLOCK THE ANALYZER TO ALLOW CHANGES

- 1-press the "Menu" key
- 2-press the "Step" key a few times until "Un-Lock" is highlighted
- 3-press the "Goto" key
- 4-if the padlock picture is locked press "Unlock"
if it is already unlocked press "OK"
- 5-press the "Back" key to go back to the main display of the measurements



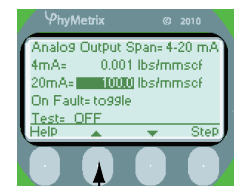
B) CHANGE THE MAIN DISPLAY TO DESIRED UNITS OF MEASURE

- 1-press the "Step" key to highlight the units of measure of the values displayed on the top half of the screen
- 2-press the up or down (▲ & ▼) arrows to change the units to whatever units are desired for the analog output for example (LB H2O/ MM SCF)
- 3-press the "Step" key a few times until there are no highlighted items.



C) MODIFY THE 4/20mA OUTPUT RANGE

- 1-press the "Menu" key
- 2-press the "Step" key a few times until "More->" is highlighted
- 3-press the "Goto" key
- 4-press the "Step" key until "Set Analog Out" is highlighted
- 5-press the "Goto" key
- 6-press the "Step" key until the value next to "4mA=" is highlighted
- 7-use the up and down (▲ & ▼) arrows to change it to desired value for example 0 lbs/mmscf
- 8-press "Step" key until the value next to "20mA=" is highlighted
- 9-use the up and down arrows to change it to desired value for example 100 lbs/mmscf
- 10-press "Step" key to highlight words next to "On Fault="
- 11-use up and down arrows to select what you want the analog output to do if there is a fault
- 12-press "Step" key to highlight the "OFF" next to "Test="
- 13-use up and down buttons to force the 4/20mA output to various states for testing the connection to your system
- 14-press "Step" again and the "OK" button will appear.
- 15-press the "OK" button, if you press the "Cancel" button the analyzer will revert to the settings that were there previously.
- 16 press the "Back" button a few times to go back to the main display



6.2.3 ExMa HART interface

The ExMa is equipped with a HART interface which overlays digital signals on the 4-20mA loop current. Thus the ExMa can be used in any 4-20mA loop and can simultaneously communicate digitally on the same two wires.

The ExMa responds to all of the HART Universal (Common Practice) Commands as well as some important setup and configuration commands.

When wiring the ExMa for use with HART make sure that there is sufficient resistance between the power supply and the ExMa 4/20 interface. Usually there is a 250 Ohm resistor used for sensing the current this is adequate to provide the proper impedance isolation for HART modems to operate properly.

The ExMa HART interface Address is the Instrument Serial Number which can be seen in the About menu. The ExMa can be set up to operate in HART polling mode by selecting a polling address 1-15 in the **HART** user interface menu, in this mode multiple (up to 15) ExMa's or other HART devices can communicate on the same loop, while each device consumes only 4mA.

HART Commands Implemented in the ExMa

HART Command		Description
#	Name	
0	Read Unique Identifier	Read Device identification such as address, manufacturer, revision level etc.
1	Read Primary Variable	Read the measurement of the Primary Variable (P.V.)
2	Read Current and % of range	Read the current that is produced by the Primary Variable and the percent of range it represents. These depend on the command #51 measurement assigned to the P.V., the value of that measurement and the assignments of command #35.
3	Read Dynamic Variables and P.V. current	Read the measurements of up to 4 measurement variables as assigned by command # 51.
6	Write Polling Address	Assign a polling address to a device. An address (1-15) puts the device in fixed 4mA mode for multidrop connectivity. Address 0 puts the device in 4/20mA mode.
11	Read Unique Identifier Associated with Tag	Find device that has the desired textual Tag assigned by command # 18.
12	Read Message	Read information written by command # 17.
13	Read Tag, Descriptor and Date	Read information written by command # 18.
14	Read P.V. Sensor Information	Information on primary sensor Serial Number, range etc.
15	Read P.V. Output Setup	Analog output range, alarms etc.
16	Read Final Assembly Number	Read number written by command # 19.
17	Write Message	For use by owner/operator to identify the device and its use.
18	Write Tag, Descriptor and Date	For use by owner/operator to identify the device and its use. Can search for the Tag, with command # 11, on multidrop connections.
19	Write Final Assembly Number	For use by owner/operator to identify the device and its use.
35	Write Primary Variable Range Values	Setup the measurement units and values that correspond to 4mA and 20mA output of the loop.
40	Analog Out Fixed	Forces the Analog Output DAC to a specified value.
44	Write Primary Variable Units	Select the units of measure for the Primary Variable.
45	Trim DAC Zero	Trims the DAC Zero by difference of Cmnd. #40 and observed value.
46	Trim DAC Gain	Trims the DAC Gain by ratio of Cmnd. #40 and observed value.
50	Read Dynamic Variable Assignments	Read the assignments of command # 51.
51	Write Dynamic Variable Assignments	Assign Measurement Variables to each of the four primary variables reported by the analyzer by command # 3.
53	Write Transmitter Variable Units	Select Units of measure for each Measurement Variable.
108	Write Burst Command Number	Select command number to burst.
109	Burst Mode Control	Enable/Disable burst (continuous) transmissions.

Measurement Variables and [available units]:
00 – Moisture Measurement
°C & °F dewpoint, ppmV, mB H₂O vapor pressure, grams of H₂O / m³ and Lbs H₂O / 10⁶ standard cubic feet in Natural Gas
01 – Temperature of Gas [°C, °F]
02 – Temperature of Board [°C, °F]
03 – Pressure [psi, bar, mbar, kg/sqcm, pascal ...]
08 – Loop Voltage [mV]
09 – Status Bits

A free of charge program may be downloaded from our website www.phymetrix.com that allows communicating with the ExMa HART interface.

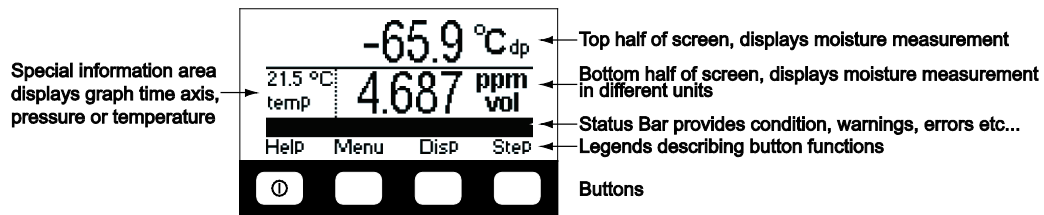
6.2.4 Serial I/O RS485/RS-422 - Modbus

The ExMa can optionally provide a RS-485/422 interface in power modes 1 and 2. Refer to the ExMa Electrical Connection diagram in Appendix B for connections. The default communication port settings are 19200, E, 8, 2; however they can be modified in the **COMs** user interface menu.

Refer to Appendix C for details of the Modbus interface.

7 User Interface Overview

The analyzer user interface consists of a backlit graphic LCD display, an audio sounder and four touch areas on the glass cover of the explosion proof enclosure. These touch areas provide the button functions which are dependant on the required selection choices, thus appropriate legends appear on the display immediately above the touch areas. For ease of discussion we will refer to these touch areas as “buttons” in the rest of the user’s manual. To “press” a button, the user must touch the appropriate **metal colored oval area** on the glass with a finger. It may be necessary to press the finger firmly on the glass to get a wide contact area. When a button is activated a small light will be illuminated immediately above the touch area.



Note: A personal computer Virtual Analyzer program is available on our website (www.phymetrix.com) allowing the user to familiarize themselves with the user interface and train on its operation.

Note that the analyzer distinguishes between long and short presses of the glass touch areas (buttons). Normally to operate the analyzer one must perform short presses (less than 1 second), the button must be released after the beep.

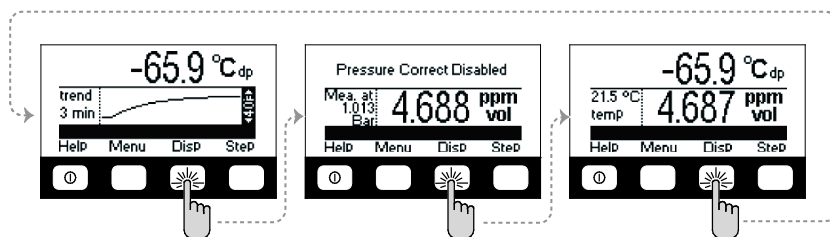
8 Operating the Analyzer

Performing measurements with the analyzer is a simple process:

- Connect the sample gas to the analyzer (refer to section 5 and section 6.1)
- Connect Power and Signals to the analyzer (refer to section 6.2)
- If possible adjust the flow of the gas to be greater than 1 LPM (2 SCFH)
- Select the graphing display mode
- Observe the reading once the graph is stable
- Change the display mode if desired

8.1 The Display Mode

Once powered, the analyzer will enter one of three display modes (whichever was last used) that show the measurements performed by the analyzer. Pressing the **Disp** button will change the display mode. Use the mode best suited for your application.



- Dewpoint Units and Graph of the measured dewpoint in the last 90 minutes is displayed. The graph span (Y-axis above shown 40°Fdp) will automatically resize to accommodate the minimum and maximum measurements in the last 90 minutes. Select between 90 or 3 minute time axis by choosing *Continuous* or *Spot* measurement modes in the **Mode Of Use** option available in **MENU-2**.
- Pressure corrected and at pressure measurements, as well as the gas pressure in the sampling chamber is displayed. The pressure correction selection in this display mode will be also utilized in the other two display modes. If pressure correction is enabled, then the status bar will provide an indication in all three display modes, so that the user is made aware that the displayed measurement is pressure corrected. In the example shown above, the pressure correction is disabled.
- Dual Dewpoint Units and Temperature of gas under measurement is displayed. Allows the user to view the measurement in two different units as well as the temperature in the sampling chamber. In the right most screen in the example above the moisture content is being viewed in $^{\circ}\text{C}$ and in ppm by volume, while the temperature is displayed to be 21.5°C .

8.2 STABLE indication

Normally the right side of the graph shows the vertical span of the graph in degrees F dewpoint. For example if it shows 20°F with arrows up and down; it means that from bottom to top of graph the span is 20°Fdp . The analyzer has three (3) ways of detecting stability of the measurement in order to advise the user that a reading can be taken.

- 1) Measuring the deviation within the horizontal span of the graph (3 minutes in Spot Checking Mode and 90 minutes for Continuous Mode), if the deviation is less than 0.5 °Fdp then the graph is declared Flat-Lined and the “STEADY” indication appears continuously in white letters on a dark background. In this case the vertical span of the graph is 5 °Fdp.
- 2) Detecting an oscillating measurement. For example as it may result when measuring air from a desiccant dryer whose two towers vary in efficiency. Thus the dewpoint of the air cycles each time the towers switch. The analyzer detects that there are at least two peaks and two valleys and that the values of the peaks do not differ from each other more than 0.7 °Fdp and similarly the values of the valleys do not differ 0.7 °Fdp from each other. Note that the difference between the peaks and valleys could be many degrees dewpoint and do not matter in this computation. If these conditions are met the “STEADY” indication flashes in white letters with black background alternating with the span indication. Keep in mind that, if for example the towers are switching every two minutes, to identify 2 peaks and 2 valleys it may take 8 to 10 minutes in order for the analyzer to detect this condition.
- 3) Calculating the absolute value of the first derivative of the dewpoint measurement and declaring it is stable when it is less than a user selected value. For example if the user selected value (from Mode of Use Menu) is 1°Fdp/minute (default), when the dewpoint is changing by less than 1°Fdp/minute, the “STEADY” indication flashes in black letters with white background alternating with the span indication. Showing the “STEADY” in black over white, distinguishes it from the other detections so the user knows the conditions that are causing a steady indication.

If multiple detections of steady occur simultaneously only one is shown, highest priority is given to #1 flat line, then #2 oscillations, then #3 first derivative.

8.3 Units to Display the Measurement

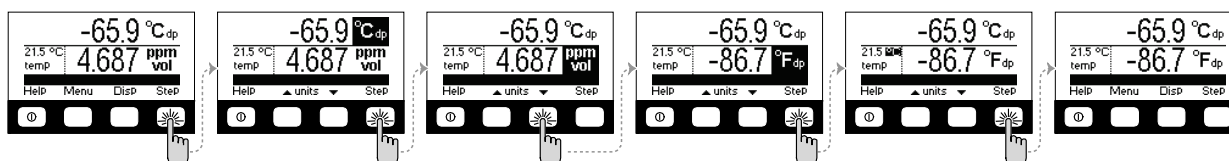
Measuring water vapor content in gasses presents many challenges not the least of which is understanding the units of measuring. Different industries require different units of measure for various reasons some technical some historical. The units typically used are in several categories:

- a) The ratio of the volume occupied by the water vapor to the volume occupied by the other gasses in the mixture. These measurements are expressed in Parts Per Million by volume **PPMv**, or Parts Per Billion by volume **PPBv**, or Volume Concentration %.
- b) The ratio of the weight of the water vapor to the weight of the other gasses in the mixture. These measurements are usually expressed in Parts Per Million by weight **PPMw**.
- c) The density of water vapor in the mixture of gasses, is the ratio of the weight of the water vapor to the volume occupied (at atmospheric pressure) by the total mixture of gasses. These measurements are expressed in grams per cubic meter (g/m^3), or pounds of water per million standard cubic feet (**LbsH₂O/MMSCF**) the analyzer displays these units as $\frac{\text{Lb H}_2\text{O}}{10^6 \text{ SCF}}$
- d) The partial vapor pressure of water vapor – the pressure exerted by the water vapor only, without considering the other gasses in the mixture. These measurements are expressed in units of pressure such a **microBar**, mmHg, or any other pressure units that may be convenient.
- e) The dewpoint of the gas mixture - the temperature at which the water vapor in the gas is saturated. This means that if the gas temperature was above the dewpoint temperature and contained water only in vapor form, then if the gas is cooled, when it reaches the dewpoint temperature the water vapor will just start to form condensation. Dewpoint measurements are expressed in units of temperature such as °C or °F.

There are other measurement categories for expressing water vapor content in gasses however they are not central in the context of this analyzer, and are listed for completeness: Relative Humidity, Mixing Ratio, Absolute Humidity, Humid Volume of Air, Weight concentration %, Delta Dewpoint. Freeware programs compatible with Microsoft® Windows, as well as with Apple and Android smart-phones, are available for downloading at www.phymetrix.com facilitating easy conversions between the above categories of units of measure.

In this analyzer, moisture content of the gas being measured can be displayed in a variety of units: °C & °F dewpoint, ppmV, ppmW, $\mu\text{B H}_2\text{O}$ vapor pressure, grams of $\text{H}_2\text{O} / \text{m}^3$, and Lbs $\text{H}_2\text{O} / 10^6$ standard cubic feet in Natural Gas. Use the **Step** button (right most) to highlight the units of the measurement and use the ▲ and ▼ buttons to change the units to the desired values. If the instrument is unlocked then the unit changes will be permanent even after the analyzer is powered OFF.

The following diagram depicts the button presses required to change the units in which the measurement is displayed on the bottom half of the screen from ppmV to °F.



Similarly the units for the top half of the screen or the temperature can be changed.

If the instrument is locked then the change will last for 5 seconds so the newly selected units can be viewed, then the selection will revert to the original units. The status bar will indicate **Locked-change is temporary** and will produce beeping sounds.

8.4 Pressure Correction

In the previous section the summary of the units of measure for water vapor content reveals that the units can be organized in three groups:

- 1) Proportion of water vapor in the gas is measured in several different categories such as PPMv, PPMw, or Lbs H_2O /MMSCF.
- 2) Pressure exerted by the water vapor.
- 3) Temperature at which the water vapor is saturated in the gas.

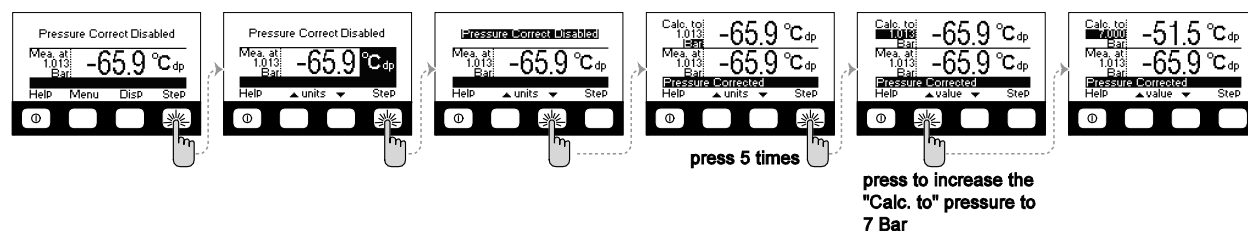
The measurements of group 1 are most intuitive as they can be visualized as a proportion of water in a gas mixture. These units are independent of the pressure of the gas that is being described. For example if we say that the gas has seven pounds of water per million standard cubic feet, we are describing the water content irrelevant of the pressure at which the gas may be. The measurements in group 2 are in units of pressure and may at first seem an unusual way of measuring content but if we recall Dalton's Law of gases it becomes evident of the usefulness of this means of expressing water vapor content in gasses. Note however that if the total gas pressure is increased the partial water vapor pressure will also increase, thus the content of water vapor in a gas is not fully described by the partial water vapor pressure – we would also need to specify the total pressure of the gas mixture.

The measurements in group 3 are units of temperature, describing the water vapor saturation temperature in the gas mixture. This method of expressing water vapor content is also affected by the total pressure; if the total pressure is increased the gas will become saturated at a higher temperature. Thus we would also need to know the total pressure of the gas mixture in order to describe its water vapor content with dewpoint units.

As we discussed earlier this analyzer measures the partial water vapor pressure in the gas and computes the water vapor content in the chosen measurement units to display on its screen. To make this computation the analyzer software needs to “know” the total gas pressure. This pressure can be automatically measured by the optional internal pressure sensor, or if the analyzer was not purchased with that option then the pressure can be entered by the user. To simplify operation the user can enter atmospheric pressure and measure at atmospheric pressure by allowing the exhaust of the analyzer to be unobstructed. As discussed earlier measuring at near atmospheric pressure is preferred for most applications.

Let's consider an example where the gas under test is measured at atmospheric pressure, however the gas is in a pipeline at much higher pressure, and the user wants to know if there could be water condensation in the pipe. Reading the dewpoint at atmospheric pressure does not allow us to compare it to the expected low ambient temperature in order to determine if condensation will occur; we would need to know the dewpoint at the same pressure as is present in the pipeline.

The analyzer can compute this dewpoint by having its Pressure Correction feature enabled, and having the user enter the pressure in the pipeline. This can be done by pressing the **Disp** button until the analyzer displays the Pressure correct mode. By factory default the pressure correction is disabled.



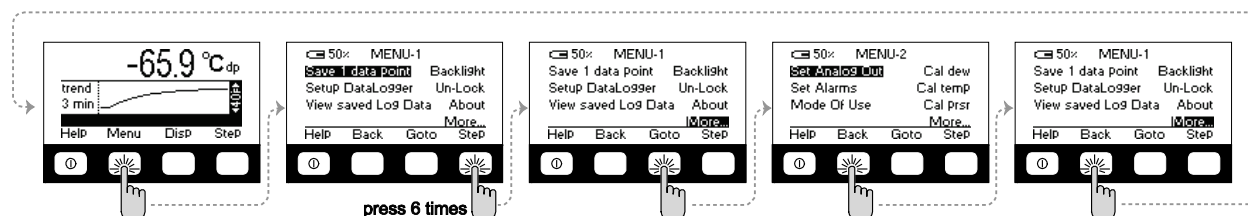
The above diagram depicts the steps required to enable the pressure correction and set up the “Calculated to” pressure to 7 Bar (about 100 psia). This example shows the analyzer measuring the gas at atmospheric pressure (1.013 Bar) to have a dewpoint of -69.5°C, and calculating that the same gas when at 7 Bar will have a dewpoint of -51.5°C.

If the user switches to the Graphing or Dual Units display mode, the displayed measurements will be -51.5°C; there will be a reminder that the computation is being performed with the status bar message **Pressure Corrected**.

To disable the pressure correction computation; while in the Pressure Correct display mode, press the **Step** button until the **Calc.to** pressure *units* are highlighted, and then press the **▲** or **▼** button until the **Pressure Correct Disabled** message appears on the top half of the screen.

8.5 Navigating Through the Menus

While in any of the three display mode screens, press the **Menu** button to go to the **MENU-1** screen. This screen contains seven options; the last one is labeled **More...** press the **Step** button six times until the **More...** option is highlighted, then press the **Goto** button to go to the **MENU-2** screen (refer to example below).



Similarly by accessing the **More...** option of **MENU-2** will navigate to **MENU-3**.

While in **MENU-3** to go back to **MENU-2** press the **Back** button. Similarly navigate back to the **MENU-1** screen and back to the display screen.

If the analyzer is left in any of the MENU modes and the buttons are not pressed for 3 minutes then it will revert back to the display screen.

While in any of the MENU screens press the **Step** button until the desired option is highlighted, then press the **Goto** button to enter the edit / view mode for that option.

8.6 The Functions Available in the Menus

MENU-1

Save 1 Data Point or Start-Stop Log

If Data Logging is setup for *Single Point* logging then this menu choice allows the user to save a single point in the log. If the setup is for *Continuous* logging then this menu choice allows the user to start or stop the logging. In both cases the user can choose the id tag associated with the measurement. *Refer to Data Logging section for more details.*

Setup DataLogger

This menu choice allows the user to select the logging mode to be either *Single Point* or *Continuous*, in addition in the continuous mode it allows selecting the sampling period and the total number of samples to be saved.

View saved Log Data

This menu choice allows viewing the logged data on the analyzer.

Backlight

This menu choice allows selecting the intensity of the backlight. Keep in mind that the lower the intensity the longer will the analyzer operate on a single charge. If the backlight is turned off it will light at a 20% intensity for 10 seconds after a button is pressed.

Un-Lock

This menu choice allows the user to lock or unlock the analyzer. The user can setup the analyzer, using the PhyAI.exe program, to require a password in order to unlock it or can allow unlocking without a password (factory default). A locked analyzer will prevent the operator from making permanent changes.

About

This menu choice provides information regarding the software version and copyright, as well as the analyzer and sensor serial numbers. In addition the date when the analyzer was last calibrated is displayed.

MENU-2

Set Analog Out

For analyzers equipped with the analog 4/20mA output option this menu choice allows setting the measured dewpoint that will correspond to the 4mA and the 20mA values, as well as testing the analog output interface. refer to section 6.2.2

Set Alarms

For analyzers equipped with Alarm Relays this menu choice allows setting the alarm relays.

Mode Of Use

This menu choice allows selecting either *SpotCheck* or *Continuous* modes of operation. Use the **Sel** button to switch between modes of operation. In the *SpotCheck* mode the measurement graph spans 3 minutes to indicate if the reading is stable. When the line seems flattened the reading can be taken. In the *Continuous* mode the measurement graph spans 90 minutes to indicate the recent history of the measurement.

Cal Dew

This menu choice allows the user to enter a single calibration point, by exposing the analyzer to a gas with a known dewpoint and enter that dewpoint value to create a single point calibration (refer to appendix E). For Analyzers equipped with a Self Calibrating Solenoid Valve, this menu choice allows the user to setup the self calibrating schedule (refer to appendix F).

Cal Temp

This menu choice allows setting the slope and offset for calibrating the two temperature sensors in the analyzer. 'Td' is the temperature sensor located at the dewpoint sampling chamber and measures the temperature of the gas being sampled. 'Tb' is the temperature sensor located on the circuit board.

Cal Prsr

This menu choice allows setting the slope and offset for calibrating the optional pressure sensor which measures the pressure of the gas in the sampling chamber.

MENU-3**Lockable Items**

This menu choice allows selecting which items can be locked.

Status Bar

This menu choice allows selecting the items that will be displayed on the status bar.

Time-Date

This menu option allows setting the battery-backed clock calendar, present in self-calibrating systems.

Autoshutoff

This menu choice is provided for commonality with portable analyzers that have battery saver shutoff.

PPMw factors

This menu choice allows the user to select the method of PPMw computations. The user can select measurement in gas and the molecular weight of the gas, or measurement in liquid and Henry's constant associated with the liquid.

Language de fr es

This menu choice allows the user to select the language in which the analyzer menus appear. Available languages are English, German, French and Spanish.

MENU-4

COMs

This menu choice is provided for commonality with portable analyzers

Dig. Out PWM

This menu choice is provided for controlling the pulse width modulation of digital outputs such as relays or solenoids in order to facilitate power savings.

Set Thermostat

This menu choice is provided for on-line analyzers equipped with sample heating for controlling the temperature of an enclosure (refer to section 11).

HART

This menu choice allows selecting the HART polling address.

Modbus

This menu choice allows setting the communications port for analyzers that have serial communications RS-485/422 output options, also provides selections for Modbus operating modes RTU/ASCII as well as the Modbus address. Refer to Appendix C for details on the Modbus interface.

9 Data Logging

The analyzer has a built-in memory capable of storing data. The data can be stored in one of two modes, *Single Point* or *Continuous*.

Single Point data can be viewed on the analyzer screen. A personal computer Microsoft Windows® compatible program PhyAI.exe is available, which allows the user to view and/or erase the *Single Point* or *Continuous* data in the analyzer's memory.

The user can choose the mode (*Single Point* or *Continuous*) of how data should be logged from the **Setup DataLogger** option available on **MENU-1**.

In addition the analyzer can be connected via its serial port or HART interface to a personal computer. By using the PhyAI.exe program, the analyzer can continuously transmit its real-time measurements to an MS Excel® spreadsheet to log the data directly to the PC disk drive as well as plot it in real time. This method of data logging may be useful in stationary measurement installations, or portable uses (with a laptop computer) requiring very large amounts of data logging.

Continuous data logging is useful in studying the moisture content, temperature and pressure of the gas being measured over a long period of time. The analyzer can store over 4000 points of data, at a user selectable period (5 seconds to 1275 seconds), thus data can be gathered with very fine resolution or with coarser resolution that can record data for approximately 2 months. The total number of points to be logged can be limited to be less than the total free memory as to conserve it for other use. When deciding on the choice of sampling period and total number of data points to capture; consider the response time of the system in which the moisture content is being measured as well as what is the desired total time for which data has to be logged.

The **Setup DataLogger** option available on **MENU-1** allows the user to choose the Log type to be *Continuous* and then to choose the period (in 5 second increments up to 1275 seconds). As the period is modified the analyzer will compute and display the total free records in the memory and the amount of time that the data can be logged for using the currently selected period. The

user can also set a limit for the total number of points to be logged depending on the requirements of the application.

Once the analyzer is setup for *Continuous* data logging, the logging can be started from the **Start-Stop Log** option available on **MENU-1**. While *Continuous* data logging is running there will be an indication on the status bar “Logging Data”.

9.1 Retrieving the Data / Clearing the Memory

To retrieve the data from the analyzer memory, it is required to install the PhyAI.exe program on a Microsoft Windows® compatible personal computer with a serial port. Single point data log can be viewed on the analyzer screen from the **View saved Log Data** option available on the **MENU-1**.

9.2 Logging Data Directly into a Personal Computer

The PhyAI.exe program allows the user to log data in real time directly into Excel 2003 via the OLE interface and plot the data in an excel graph. Excel 2007 will also perform data logging however when prompted from the PhyAI program to automatically plot dual axis graphs it will plot only single axis graphs, all other functions will operate properly, dual axis graphs can be plotted manually.

10 Calibration

If necessary to adjust the measurement without having to send the analyzer for recalibration, the user can expose the analyzer to a gas with a known moisture content. The known value can be entered into the program and the analyzer can be set to adjust the measured value such that the reported value is equal to the known moisture content of the gas. Once the single Point Calibration is performed, this adjustment will be applied as a constant offset on the full range of the measurement as long as the Single Point Calibration is enabled; the user can at any time disable or re-enable this calibration point or perform a new single point calibration (changes can be made only when unlocked.) In order to alert the user that the measured value is being adjusted, the status bar will provide an indication when the Single Point Calibration is being applied. When the single Point Calibration is disabled the analyzer will compute the measurements per original factory settings.

Caution! Before a calibration is performed the user should be absolutely certain of the moisture content of the gas that the analyzer is being exposed to. It is also very important that the analyzer is allowed sufficient time to equilibrate with the gas of known moisture content, which can be determined by observing a flat graph line in the continuous mode of measurement.

Refer to Appendix E for Manual Calibration.

If your analyzer is equipped with a solenoid Valve refer to Appendix F for Automatic Calibration.

11 Using the ExMa for temperature control

When the ExMa is installed in an enclosure (for example in a sample system) it can be equipped such that it can control an enclosure heater and or cooler. These functions are controlled through the **Set Thermostat** menu choice in **MENU-4**.

If either a cooler or heater or both are installed, the appropriate fields in this menu will allow the user to select the temperature for each item and hysteresis for cooler, as well as which temperature sensor to use for controlling the temperature (sample gas or circuit board).

The cooler is controlled as a thermostat, while the Heater control is PID.

This menu has up to two rows of data, one for cooler and one for heater, if installed.

For each there are four columns of parameters that may be modified. The *temperature*, the *units* of the temperature, *hysteresis* (for cooler only) and which *temperature sensor* to use.

For example if in the Cooler row the selections are **40 °C +/-2 Board**, this means that when the board temperature sensor exceeds 42°C the cooler solenoid will be energized, and when the board temperature is below 38°C the cooler solenoid will be de-energized.

Use the **Step** key to move the highlight over the parameter that needs to be changed, and then use **▲** or **▼** to change the parameter. To finish, press the **Step** key until there are no highlights. Press the **OK** key so that the analyzer saves the selection or press the **Cancel** key if you are not sure about the selections and would like to leave the menu without making any changes.

Temperature Control			
Task	Set T	Hyst	use T of
Cooler	40 °C	± 2	Board
Help	OK	Cancel	Step

12 Troubleshooting and Maintenance

This analyzer is designed to be maintenance and trouble free. However should problems occur due to process conditions or other factors, use this chapter for troubleshooting purposes. If the encountered circumstances are not discussed in this manual please contact Phymetrix. Spare parts may be ordered through Phymetrix.

12.1 Cleaning

The analyzer enclosure may be cleaned using a moist cloth.

The flow control orifice of the ExMa can be removed and cleaned with solvents.

The sensor is not user serviceable and should not be cleaned by the user. If it is contaminated please acquire an RMA and send the analyzer for repair.

12.2 Self Diagnostics

The analyzer constantly performs self diagnostics to determine if all parts are operating properly. The results of the diagnostics are displayed on the status bar.

Table 1 Status Bar Messages

Status bar Message	Meaning
Pressure Corrected	The analyzer is computing the moisture measurement using pressure correction
AO frozen	The Analog output (4/20mA) is being kept frozen (unchanging) by some part of the program.
Single Point Cal Enabled	Single point calibrations are being performed. Can be disabled from the Cal dew function in MENU-2
Logging Data	The continuous data logging is enabled and running.
Calibration Past Due	The analyzer compared the date since the last calibration to the date in the battery backed clock/calendar and computed that the time exceeded the settings of the number of months between recalibrations.
Max Pressure Exceeded	The pressure sensor inside the sampling chamber is measuring more than rated pressure of the pressure sensor.
Temperature Sensor Error	One or both of the temperature sensors are not operating properly, cable unplugged etc.
Pressure Sensor Error	The pressure sensor is not operating properly, cable unplugged etc.
Analog Output Loop Open	The analog output is not connected to a proper source.
Battery Low	The battery needs to be recharged.
Temp Range Exceeded	The temperature exceeds +70°C
Sensor Range Exceeded	The moisture sensor measurement exceeds the preprogrammed parameters.
Sensor Msr Err=x	The moisture sensor measuring circuit has detected an error.

12.3 Suspected Erroneous Measurements

Some of the most common suspected erroneous conditions are listed in the table on the following page, included are common reasons and suggested remedies.

If the measurement is suspected to be erroneous, before calling for support, it may be helpful to have the following information:

- Type of gas being measured.
- Expected dewpoint.
- Nominal pressure (consider back pressure).
- Nominal temperature.
- Nominal flow rate through the analyzer.
- Flow diagram or description of system, showing items and their materials of construction. Include materials of filter elements, regulator diaphragms, and valve seats.
- Possible contaminants (particulates, liquids, oil, glycol, cleaning solutions, etc.).
- Are the pipes and analyzer purged before measuring? How long? Flow rate? With the same gas that will be measured?
- If other equipment was used to verify the dewpoint, what is the equipment (include model number)? What is its specified measuring range? When was it last calibrated/certified?
- If using bottled gas for reference: Manufacturer? Content and accuracy markings? What is the pressure in the bottle at time of comparison? What is the ambient temperature where the bottle is stored? What are the materials of construction of the pressure regulator, especially the diaphragm?

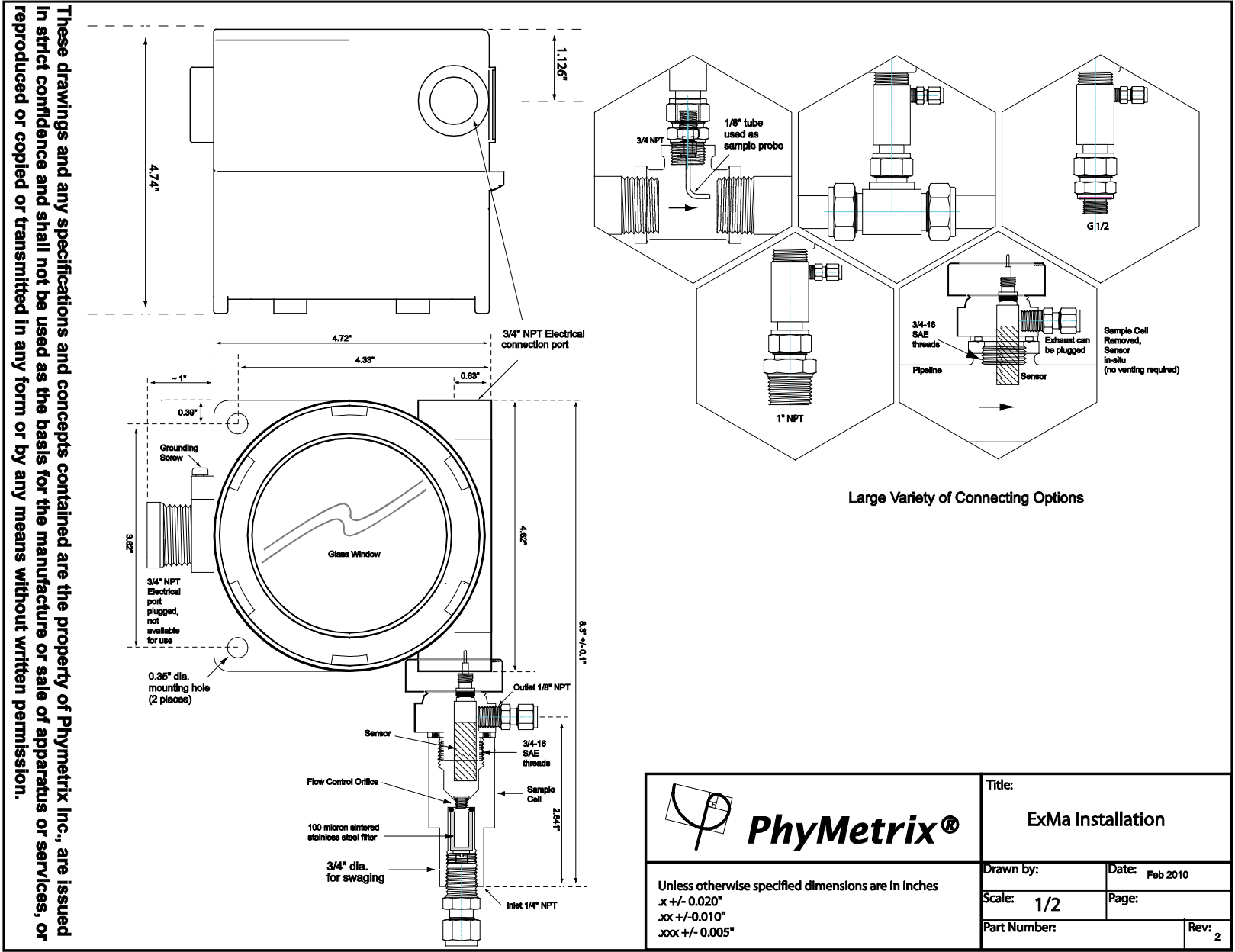
Table 2 Guide to Troubleshooting Measurements

Problem or Unexpected Observation Behavior	Likely Source of Problem	Analysis	Remedy
Measurement is drier than is expected.	Equilibrium	Before concluding that there is an incorrect measurement, make sure that the system is at equilibrium.	Use the graph display and wait for equilibrium.
	Sampling point	Consider if the sampling point could be drier than the rest of the system.	If necessary find a more appropriate sample point
	Damage Corrosion, abrasion	Contaminants can damage the sensor.	Refer to sections: 3 Precautions and 5.2 Sample conditioning.
	Needs recalibration	Depending on the application recalibration may be yearly or in 5 years.	Consult with factory.
Measurement is wetter than is expected.	Equilibrium	Before concluding that there is an incorrect measurement, make sure that the system is at equilibrium.	Use the graph display and wait for equilibrium.
	Sampling point	Consider if the sampling point could be wetter than the rest of the system.	If necessary find a more appropriate sample point
	Condensation	Refer to the “Measurement is not changing ” observation below	
	Damage Corrosion, abrasion	Contaminants can damage the sensor.	Refer to sections: 3 Precautions and 5.2 Sample conditioning.
	Incompatible materials in system with low dewpoint.	Refer to section 4.1 Integrity of the materials of the system.	Replace inappropriate materials.
	Leaks	Check for leaks around all interconnections.	Tighten fittings. Repair the leaks.
	Needs recalibration	Depending on the application recalibration may be yearly or in 5 years.	Consult with factory.
Measurement is changing slower than expected.	Equilibrium	The rate at which the system will reach equilibrium depends on the system particulars, such as ambient temperature, internal pressure, flow rates, system materials of construction, surface area of system internals.	Previous experience may be indicative of the system response time. It is common for systems to take hours to equilibrate.
	Sampling point	Is the sampling point in the direct flow of the system gas, or is it at a dead end of the distribution system?	Sample in the direct flow.
	Contamination	Are there hygroscopic contaminants?	Clean the sensor and install filters.
	Out-gassing	Are there materials in the system that could be out-gassing?	Replace the hygroscopic materials.
	Leaks	Check for leaks around all interconnections.	Tighten fittings. Repair the leaks.
	Large diameter sampling tubing	Larger diameter tubing have larger surfaces.	Use smallest practical tubing diameter, 1/8” recommended
	Low flow rate	Response time is normally greatly influenced by flow rate, but if the measurement value is influenced by flow rate there may be a leak.	Flow rate should be greater than 1 LPM.
Measurement is not changing , always shows a dewpoint close to ambient temperature.	Condensation	Condensation may have occurred from a slug of water or from previous conditions where the gas dewpoint was greater than the ambient temperature. Condensation typically accumulates in filter bowls or other low points in the system. Then evaporates and produces a high dewpoint.	Drain the condensate and allow the system to dry down.
Measurement has a daily cycle	Thermally induced water vapor pressure change.	Refer to section 4.3 Temperature dependant equilibrium	

13 Specifications for Model ExMa

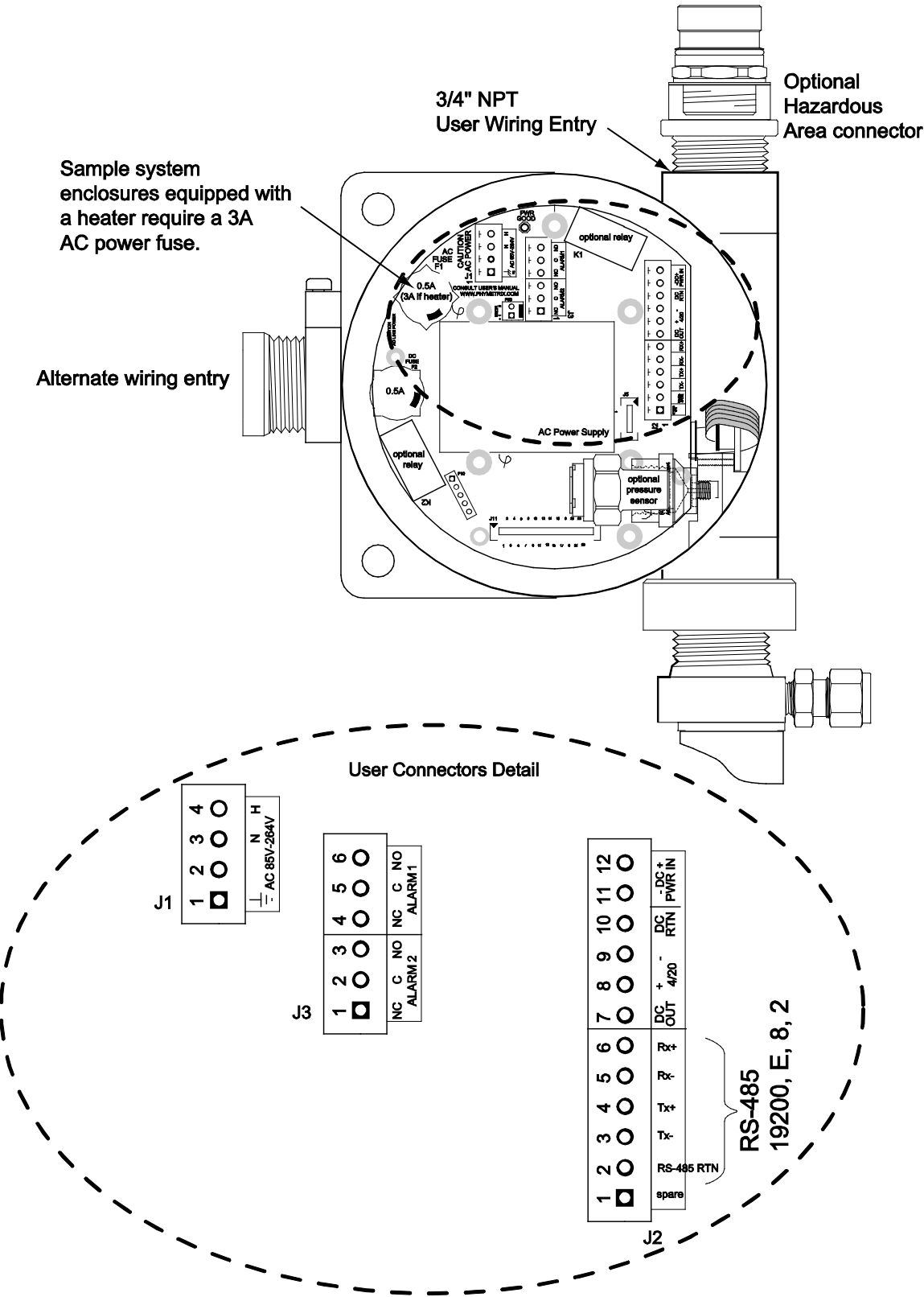
Temperature Range	ExMa Analyzer: -20°C to +60°C Electronics: -40°C to +85°C Moisture Sensor: -20°C to +60°C Pressure Sensor: -20°C to +85°C LCD operating: -20°C to +70°C storage: -30°C to +80°C
Moisture Sensor	Range -110°C to +20°C Accuracy: $\pm 2^\circ\text{C}$ temperature corrected Repeatability: 0.8°C Response time: 95% of step change in 3 min. Sample flow: >1 LPM
Temperature Sensors	-40°C to +70°C $\pm 2^\circ\text{C}$
Pressure Sensor	2 to 1000 PSIA $\pm 1\%$, 316L stainless steel wetted parts (higher pressures can be ordered)
Electrical	3 automatic detection - self configuring power modes: 1) 90-260VAC 47-440Hz or 2) 12-24VDC 10VA or 3) 4/20mA Loop Powered (optional) Power modes 1 or 2 have the following optional I/O: a) RS-422/485 isolated with Modbus interface b) 4/20mA sink or source; isolated; with HART® c) 2 Alarm Relays - 3A, 250VAC / 30VDC contacts
Mechanical	3/4" OD tube and 1/4" NPTF Inlet, 1/8" NPTF Outlet All 316 Stainless Steel wetted parts, small surface area stainless steel sampling chamber for fast response time. Enclosure Aluminum or optional 316 Stainless Steel, Glass lens, IP66 & IP68 FM/CSA Explosion Proof Certified Class I, Div I, Groups B, C And D Class II, III, Div 1, Groups E, F And G ATEX Explosion Proof Certified ATEX 2 GD, Exd I & IIC; IECEx, Exd I & IIC Dimensions SS enclosure- L: 8.7" (221mm) W: 5.8" (147mm) H: 4.8" (122mm) Weight Total: 8.4 Lbs (3.8 Kg) Pressure: 5000 PSIA (345 Bar) Flow Control Orifice can be placed at Inlet(default) or Outlet; Built in serviceable/cleanable 100 micron Filter
Miscellaneous Features	Through the glass user interface buttons, allow operation while enclosure is closed NIST traceable calibrations Units of measure: °C & °F dewpoint, ppmV, ppmW, $\mu\text{B H}_2\text{O}$ vapor pressure, grams of H_2O / m^3 and Lbs H_2O / 10^6 standard cubic feet in Natural Gas Virtual Analyzer PC software for training and evaluation, allows the user to experience the exact interface on their own PC with voice explanations

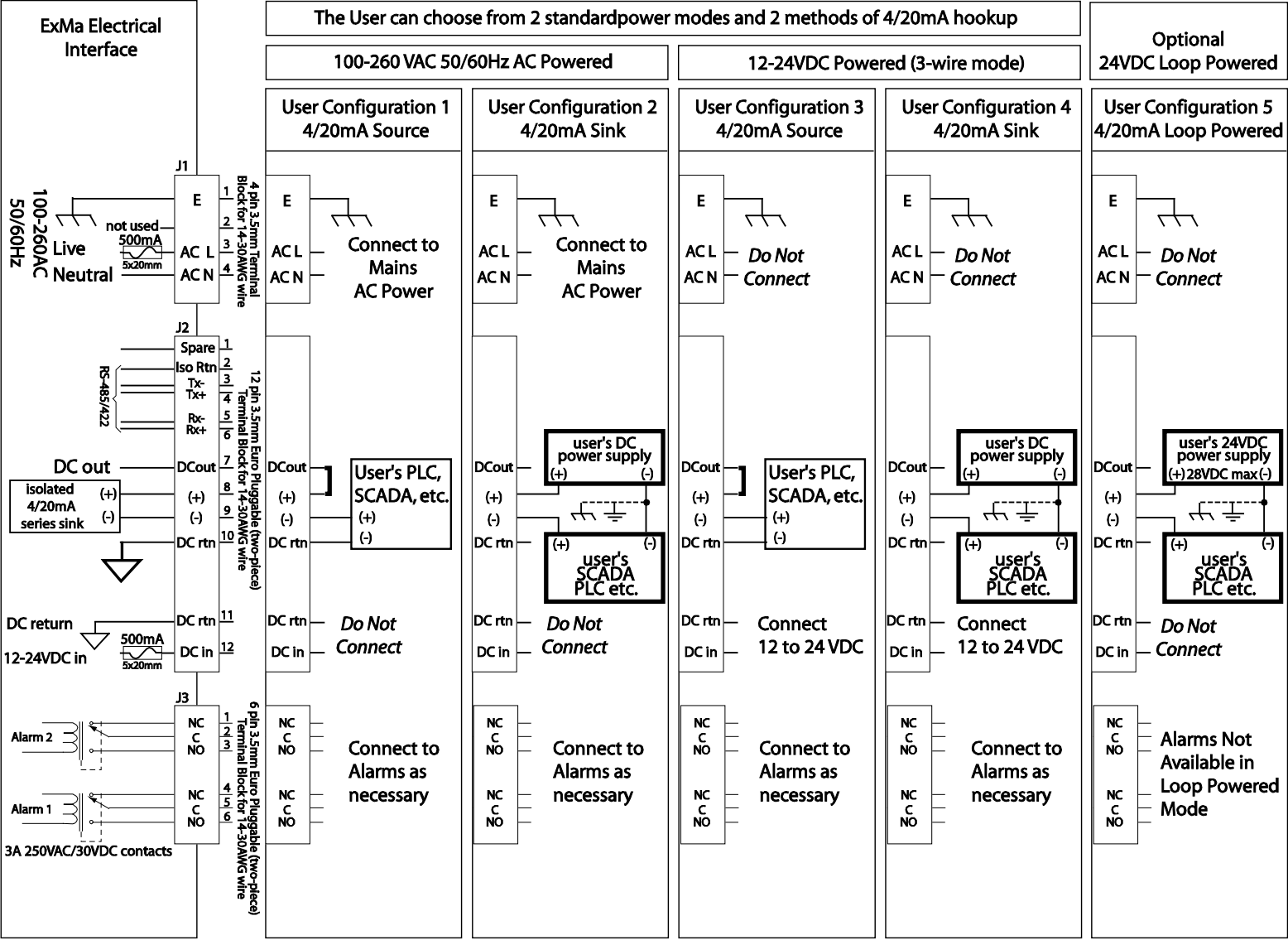
Appendix A ExMa Installation Drawing



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Appendix B ExMa Electrical Connections

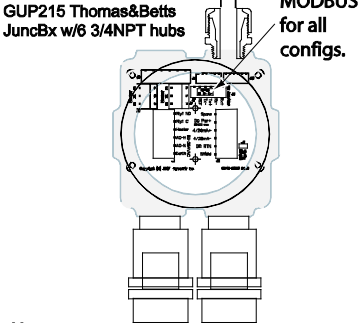
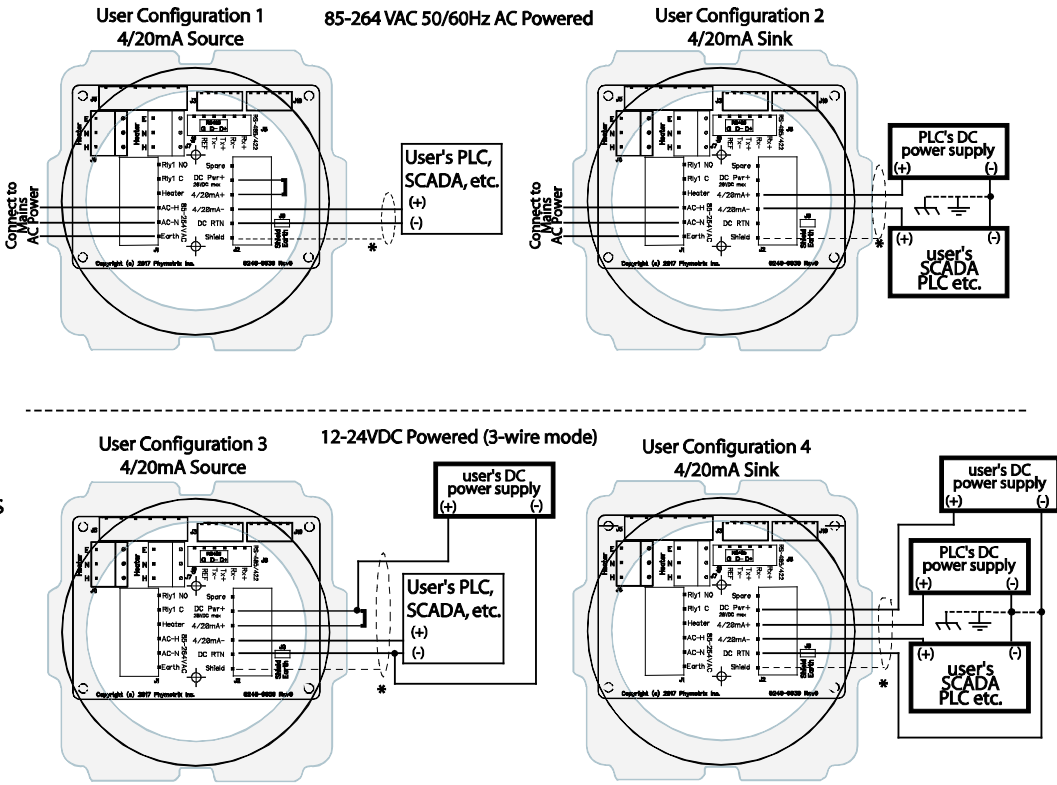




Appendix B ExMa Electrical Connections


When the ExMa is equipped with the optional hazardous area connector and junction box with cable, then connect facility wiring to the junction box

can be the same supply, two shown in case they have to be isolated dashed lines show possible but not necessary connections



- Notes:
- * To minimize electrical noise on the 4/20mA loop, use twisted pair shielded wire
 - * Designs with circuitry activated by relay contacts should consider noise from contact bounce, an option for debouncing is placing a capacitor across the relay contacts.
 - * Sample system enclosures equipped with heaters use the Relay terminal positions for the heater connection.

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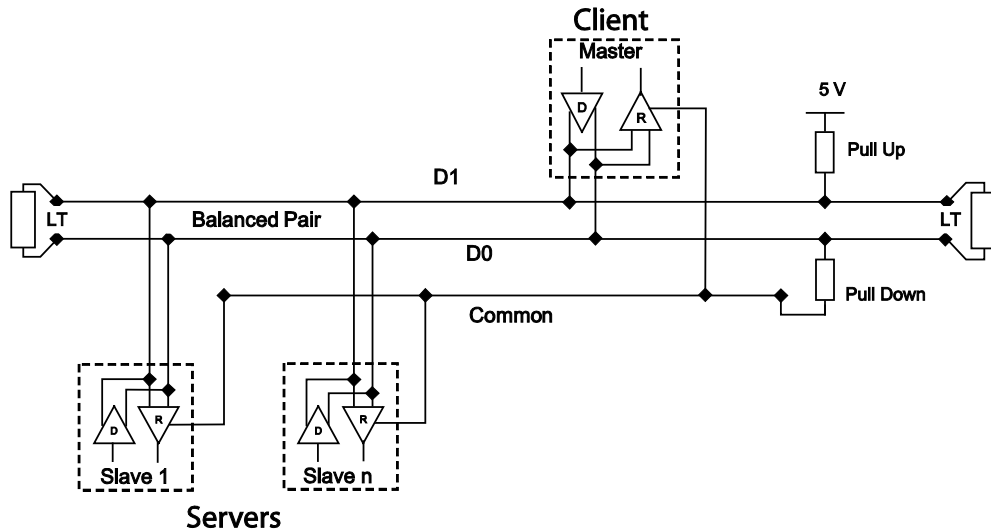
 PhyMetrix®	Title: ExMa explosion proof junction box electrical connection diagram		
	Drawn by:	Date:	
	Scale:	Page:	
	Part Number:	Rev:	

Unless otherwise specified dimensions are in inches
x +/- 0.020"
xx +/- 0.010"
xxx +/- 0.005"

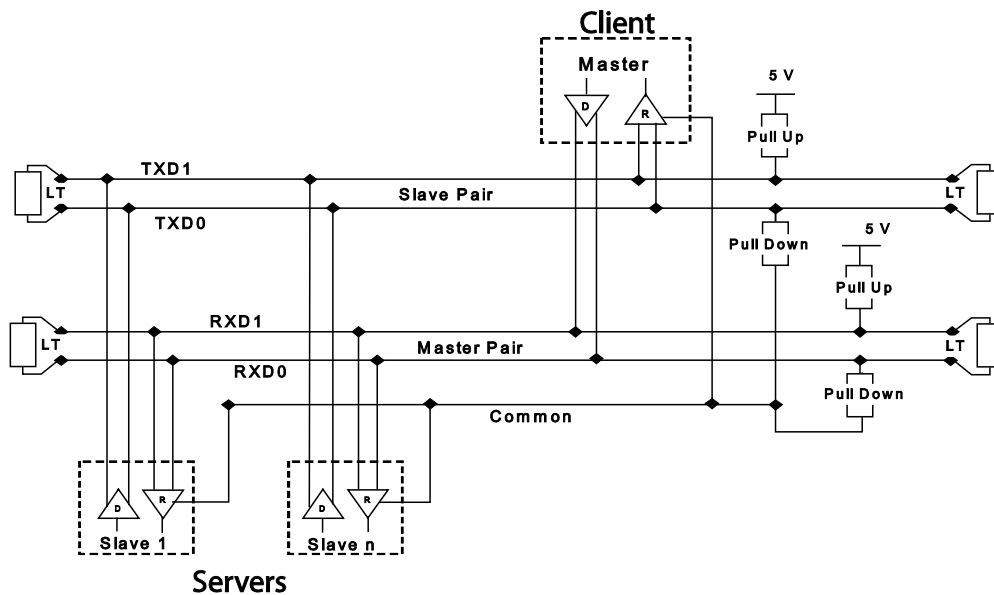
Appendix C Notes on Modbus Interface

Modbus Physical Layer

Phymetrix analyzers with software version 5.3 and higher are equipped with serial Modbus protocol capability. If the analyzer is ordered with "-D" option, it will have an RS-485/422 isolated interface. This interface can be connected in 2-wire or 4-wire configuration, in both point to point or multipoint systems. Note these kinds of isolated serial interfaces require an additional Common wire for a zero volt reference. Two or four wire operation is selected by appropriately wiring to the RS-485 pluggable screw terminal connector.



General 2-Wire Topology



General 4-Wire Topology

for a 2-Wire connection jumper the Tx+ to Rx+, and Tx- to Rx-

On the Menu-4 screen of the analyzer, the Modbus choice allows the operator to select ASCII or RTU mode, the analyzer Address and the communication parameters such as baud rate. Addresses 1-247 can be chosen; baud rates: 1200, 2400, 4800, 9600 & 19200; parity: odd, even or none; bits: 7 or 8; stops: 1 or 2. RTU mode must use 8 bits. Defaults are: mode=**RTU**, adrs=**0x57**, baud=**19200**, parity=**Even**, bits=**8**, stops=**1**

MODBUS Setup			
Mode:	RTU		
Address:	087 decimal, 57 hex		
COM:	19.2K	even	8 1
Help	OK	Cancel	Step

Modbus Protocol

The Phymetrix Modbus interface can operate in ASCII or RTU mode and implements Functions Codes 3, 4 and 6 ONLY.

Holding registers and Input registers are overlaid thus functions 3, 4 and 6 all operate on the same address space. The Modbus Client (e.g. PLC) can read either the Holding or Input registers, the result will be the same.

Function 3 is used to read Holding Registers so that the Modbus Client can read the measurements made by the Analyzer.

Function 4 is used to read Input Registers so that the Modbus Client can read the measurements made by the Analyzer.

The results from reading with function 3 and 4 are the same.

Function 6 is used to write to some eeprom locations of the analyzer so that the Modbus Client can select the units in which to read the measurements.

The Registers are mapped as shown in Table 1.

Once the wiring is interconnected and the communications parameters are setup as outlined in the previous section, the analyzer should be ready to be used via the Modbus interface. Make sure you have properly chosen baud rate, parity, bits, as well as the RTU or ASCII mode and the device address. By default the address is hex 0x57 (decimal 87). Also by default the units of measure will be the ones chosen by the operator on the front panel user interface. One can select specific units of measure independent of the operator front panel choice, by writing into units registers using function 6, refer to Table 1.

Using function 3 or 4 a reading can be performed from starting address 0.

Reading 3 registers will provide only the moisture measurement and its units of measure, this is the minimum amount of data to obtain the primary value provided by the analyzer.

Reading 11 registers will provide all of the analyzer readings and status. It is up to the user to decide if 3 or 11 registers should be read.

Readings can be periodically repeated to get the latest analyzer measurement.

The moisture (dewpoint), temperature and pressure measurements are each sent back in two consecutive registers in IEEE floating point format, ms byte first.

The units of measure are sent in a single register as an unsigned number. Note that by default the units of measure will be the same as chosen by the front panel setting. For example if the operator has chosen to view the moisture measurement in pounds of water per million standard cubic feet (Lbs/MMSCF), the value of the register at address 0x0002 will be 0x0085 because the code for Lbs/MMSCF is 5 (from Table 2) and bit 7 is set to indicate that the units are selected by the operator. If it is desired to setup such that the analyzer reports the moisture measurement independent of the operator choice on the front panel; then write (using function 6) into register at address 0x0002 the value from Table 2 corresponding to the desired units. For example: if it is desired dewpoint to be reported in deg.C, then write 0x0001 into the register at address 0x0002. On the next reading, no matter what the operator selects in the front panel user interface, the moisture content will be reported in degC dewpoint and register 0x0002 will be equal to 0x0001.

Any valid values written into registers at addresses 0x0002, 0x0005, 0x0008 and 0x0012 will be stored in the analyzer eeprom and will be retained even after a power loss.

Please observe that the calculated to Pressure units (cp_units) determine if pressure correction is applied to the reported dewpoint. Pressure correction and its use is discussed elsewhere in the user's manual. Please make sure that this selection is made appropriately.

Table 1 Phymetrix Modbus Interface Register Map							
Address decimal	Address Hex	Name	source	format	function code		description
					read	write	
0	0x0000	dew_point	A	Float	3&4	n/a	moisture measured by analyzer
2	0x0002	dp_units	E	Unsigned 16	3&4	6	units in which the dew point is reported, refer to Table 2
3	0x0003	sens_temp	A	Float	3&4	n/a	temperature measured in sample cell (gas temperature)
5	0x0005	t_units	E	Unsigned 16	3&4	6	units in which the temperature is reported, refer to Table 3
6	0x0006	measuring_pressure	A or E	Float	3&4	n/a	pressure inside moisture sensor sample cell If analyzer has a pressure sensor option then this is the measurement, if no pressure sensor then this is the value set by the user as an assumed nominal pressure in sample cell
8	0x0008	mp_units	E	Unsigned 16	3&4	6	units in which the pressure is reported, refer to Table 4
9	0x0009	status 32 bit word	A	Long 32	3&4	n/a	32 bits representing the analyzer status, refer to Table 5
16	0x0010	calculated_pressure	E	Float	3&4	n/a	pressure to use for calculating the reported measurement refer to user's manual for pressure correction explanation
18	0x0012	cp_units	E	Unsigned 16	3&4	6	units in which the pressure is reported refer to Table 4
32	0x0020	last_cal_date	E	Long 32	3&4	n/a	last calibration date, refer to Table 6 for encoding
34	0x0022	sensor_serial_num	E	Long 32	3&4	n/a	serial number of sensor
36	0x0024	analyzer_serial_num	E	Long 32	3&4	n/a	serial number of analyzer
60	0x003C	reserved for PLMa					
61	0x003D	reserved for PLMa					
62	0x003E	reserved for PLMa					
63	0x003F	reserved for PLMa					

Notes:

source A = computed by analyzer based on measurement E = retrieved from eeprom, and saved in eeprom if written to with function 6

format Float = IEEE Floating Point number, made up of 2 consecutive register locations (ms byte first)
 Long 32 = 32 bit unsigned long, made up of 2 consecutive register locations (ms byte first)
 Unsigned 16 = 16 bit unsigned, single register

function code in the write column n/a designation means writing is not available for the referenced register
 a number in either read or write column refers to the Modbus function code that can be processed

Table 2	
value (decimal)	units for reporting moisture measurement
0	not assigned
1	deg Cdp
2	deg Fdp
3	ppmV
4	ppmW
5	Lbs/MMSCF Natural Gas
6	gm/m3
7	uB vapor Pressure
255 default	Use units selected on analyzer front panel user interface (see note)

Table 3	
value (decimal)	units for reporting temperature measurement
0	deg F
1	deg C
255 default	Use units selected on analyzer front panel user interface (see note)

Table 4	
value (decimal)	units for reporting pressure
0	Pressure correction disabled (valid only for cp_units)
1	PSI absolute
2	BAR absolute
255 default	Use units selected on analyzer front panel user interface (see note)

Table 5	
status word bit #	status bit meaning, these will also appear on the analyzer display
0	High Alarm Relay active
1	Low Alarm Relay active
2	Pressure Corrected
3	Cal Solenoid ON
4	Purge Solenoid ON
5	Self-Cal Timeout
6	Self-Cal Stabilization
7	Self-Verifying
8	Self-Calibrating
9	Analog Output Frozen
10	Heater ON
11	Cool Solenoid ON
12	Sensor in Desiccant
13	Push sensor IN or OUT
14	Logging Data
15	USB Power Connected
16	Calibration Past Due
17	Single Point Cal Enabled
18	Lost External Power
19	n/a
20	Clock Calendar Error
21	Max Pressure Exceeded
22	Temperature Sensor Error
23	Pressure Sensor Error
24	Analog Output Loop Open
25	Battery Low
26	Temp Range Exceeded
27	Sensor Range Exceeded
28	Moisture Sensor Error
29	Error, code displayed
30	Cal Aborted using prior Cal
31	Unknown

Table 6 Encoding of Last Calibration Date (bits and use)																			
Most Significant Register								Least Significant Register											
31	28	27	24	23	20	19	16	15	14	13	12	11	10	9	8	7	6	5	4
0	0	0	0	0	0	0	0	month: 1-12				day: 1-31				year: 0-127 add 2000			

Note that for the units enumerations of tables 2, 3 & 4, writing value 255 sets up the interface to use the units selected by the operator on the user interface of the analyzer front panel. However when reading back the units, the value returned is not 255, the value returned is the code corresponding to the units selected by the operator with bit 7 set to indicate this condition. The default setup for all 4 units registers is 255.

Appendix D Notes on ExMa use in low power applications e.g. solar power

For all power consumption calculations it is assumed that the ExMa will be powered by 12VDC, unless otherwise noted.

Power connections:

+12VDC to J2 pin 12

RETURN (Gnd) (-) to J2 pin 11

Analyzer Power Consumption

The ExMa (with the display backlight OFF) will draw about 13 mA from 12VDC power.

The display backlight will draw an additional 2.5 mA at 100% and proportionally lower on the other settings, which can be user selected. The backlight can be turned OFF, but each time the user presses a button on the screen the backlight will turn on to a low setting (~ 0.5 mA) for a few seconds. In addition if the analog output is configured as 4-20mA source it will draw power, and if there are energized relays they will draw power, see below.

Analog Output Power Consumption

The Analog output will use 4 to 20 mA depending on the measurement. It is also possible to order the ExMa with voltage output 1-5V, which will further reduce current consumption by avoiding the 4-20 mA.

Relay Power Consumption

It is better not to have Alarm Relays for solar Powered Application, but if they are needed, in order to conserve current there is a pulse width modulator for the Alarm Relay drive. The Relays will each draw about 37 mA at 100% PWM, and proportionally less e.g. at 55% about 21 mA.

The Relay PWM percentage can be user selected. (go to MENU-4)

Be sure to configure the relay polarities in such a way that power consumption is minimized. For example if only one Relay will be used then configure the other to a very high dewpoint and select the polarity such that the relay is not energized. For the Relay that is used select the polarity such that current draw is minimized, but also consider that having the Relay energized while conditions are “GOOD” provides a fail safe operation in that if the analyzer loses power the relay will signal an alarm condition.

Appendix E Manual Single Point Calibration/Verification Notes

Phymetrix ExMa Analyzers can be single point calibrated either Automatically or Manually, similarly they can be single point verified.

Automatic Single Point Calibrations can be performed by ExMa analyzers equipped with a solenoid valve. They can periodically switch the analyzer to a gas stream from a bottle with a known moisture content and perform a calibration completely unattended (refer to Appendix F).

A **Manual Single Point Calibration** is intended to be performed in the field by the user of the analyzer; it corrects the whole measurement range of the analyzer by adjusting it at a single point. This is accomplished by exposing the analyzer to a gas with a known moisture level. Similarly a single point verification is intended to validate the accuracy of the analyzer.

The gas can be any clean inert gas such as Air or N₂ or Ar etc, or can be the gas that is being measured verified by a recently NIST traceable calibrated portable analyzer such as model PPMa.

If a certified bottle of gas is used, it is preferred that the moisture level is close to the expected moisture level that the user normally measures but it does not have to be.

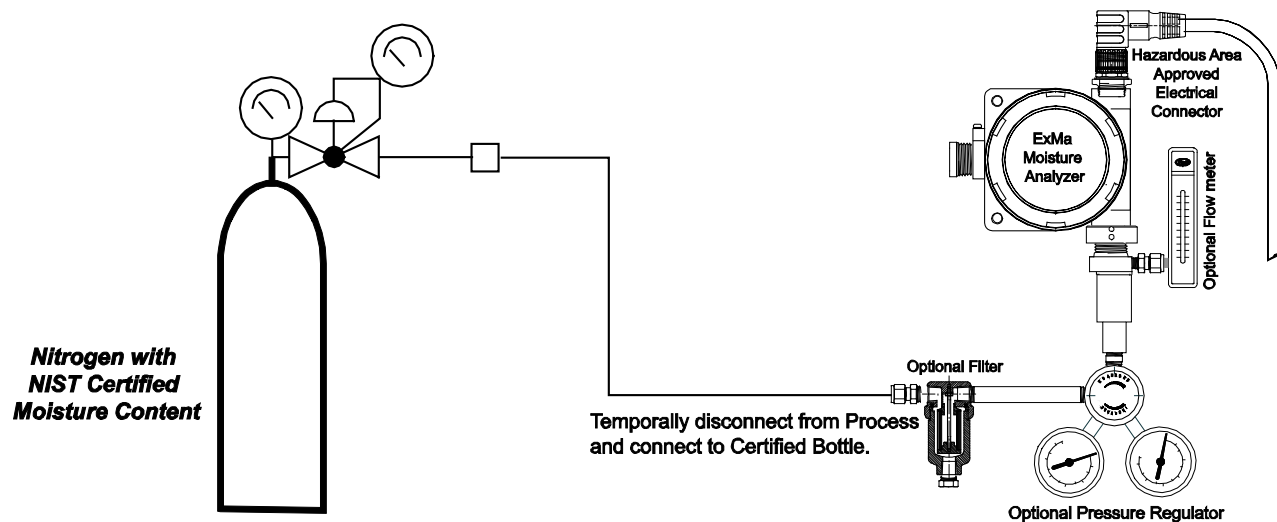
Usually bottles of gas can be purchased with known moisture levels from 1 ppm to 100 ppm. Be careful to differentiate known exact moisture level of the bottle of gas vs. a bottle of gas with a guaranteed maximum moisture level which is normally how gas is sold. Thus a bottle of bone-dry Nitrogen guaranteed to have less than 1 ppm of moisture may actually have 0.5 ppm of moisture thus can not be used for calibration. One has to purchase calibration gas with an exact known moisture level.

The calibration gas bottle will be at some high pressure thus a pressure regulator is required. One must be careful to assure that the pressure regulator has a stainless steel diaphragm so that moisture from the atmosphere does not ingress into the calibration gas stream. Many pressure regulators can have a stainless steel body but a rubber diaphragm, and rubber is “transparent” to water vapor molecules. The gas being supplied to the analyzer should be just above atmospheric pressure, so there is at least one or two liters per minute flow. Refer to drawing titled *Typical Calibration Setup*.

Once the analyzer is exposed to the calibration gas and measures a stable value, or if a portable analyzer PPMa is used and the reading has stabilized; the known moisture amount can be entered into the ExMa analyzer and a single point calibration can be performed. Refer to drawing titled *ExMa Calibration Procedure*. Alternatively if performing a validation the measured value can be compared to the known value to establish accuracy. Note that for low dewpoints (below -40°C) it could take many hours before the readings are stable enough to perform a calibration.

Factory calibration is performed at a calibration laboratory such as we have at our facility. In this case the analyzer is exposed to many different (usually 10) moisture levels that are verified by a NIST traceable standard (e.g. chilled mirror) and the analyzer is corrected at each of these points.

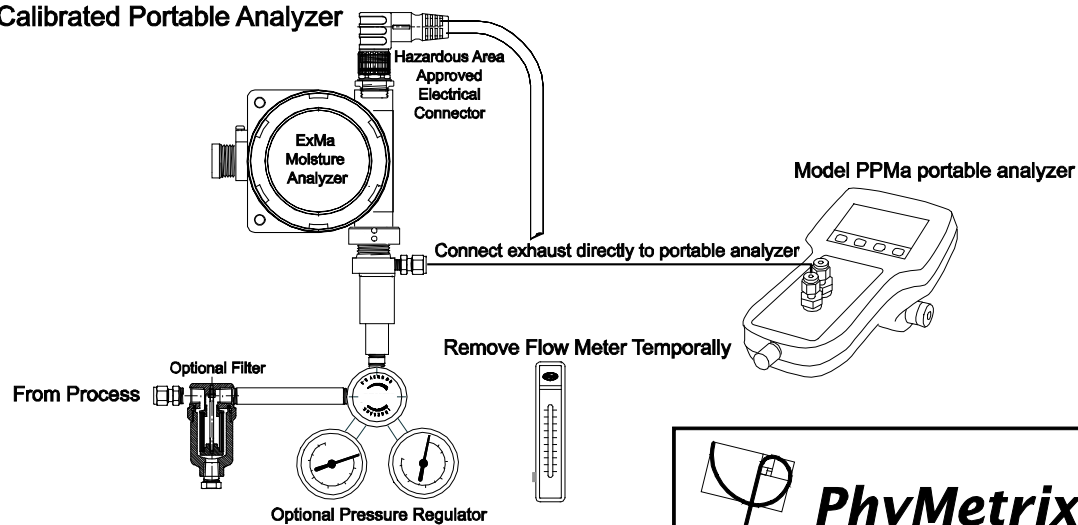
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Using a Certified Bottle of Gas

or

Using a Calibrated Portable Analyzer



PhyMetrix®

Unless otherwise specified dimensions are in inches
 .x +/- 0.020"
 .xx +/- 0.010"
 .xxx +/- 0.005"

Title:

Typical ExMa
Calibration Setup

Drawn by: BB

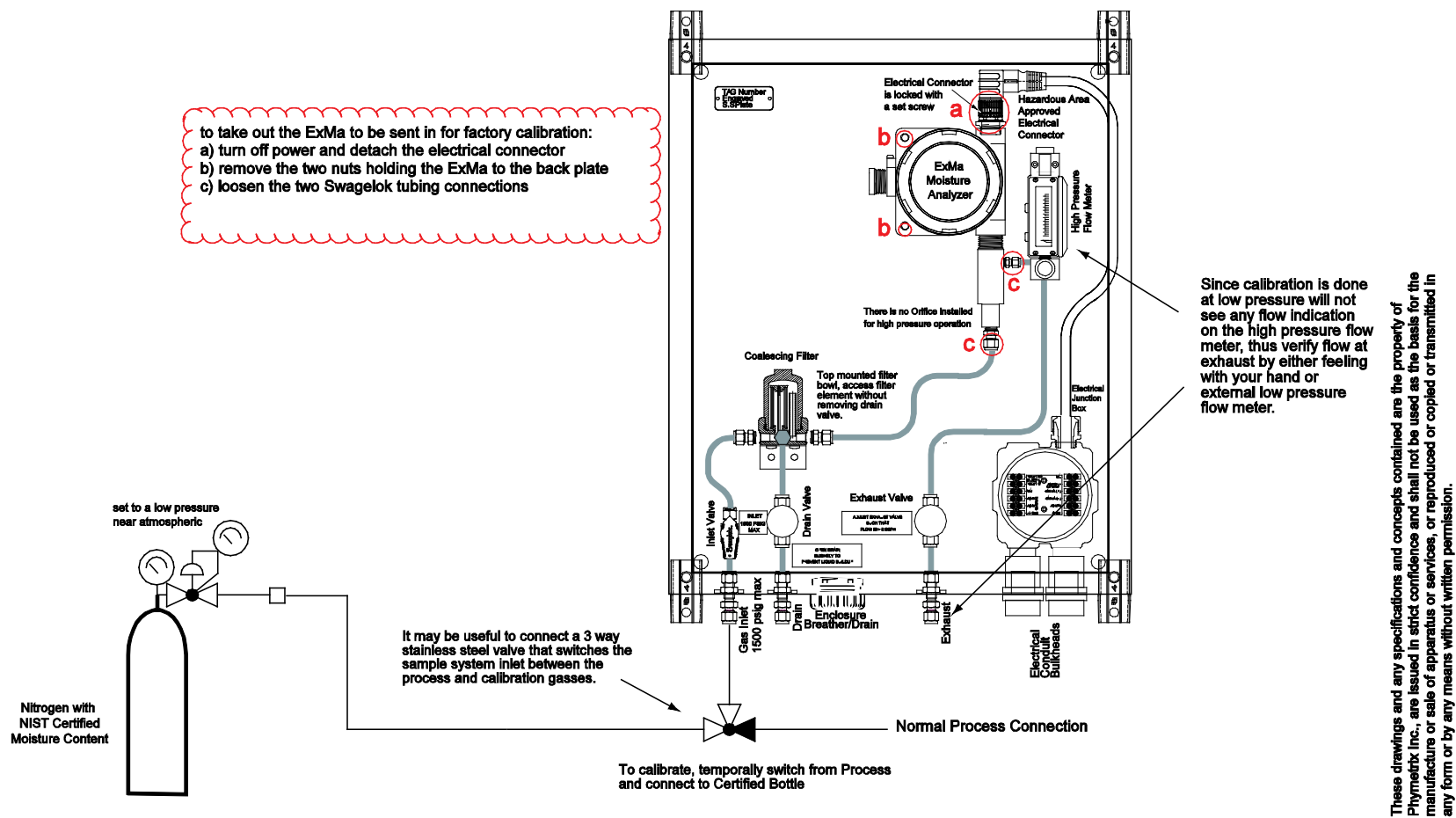
Date: 5/10/2009


Scale: N/A

Page: 1 of 1

Part Number:

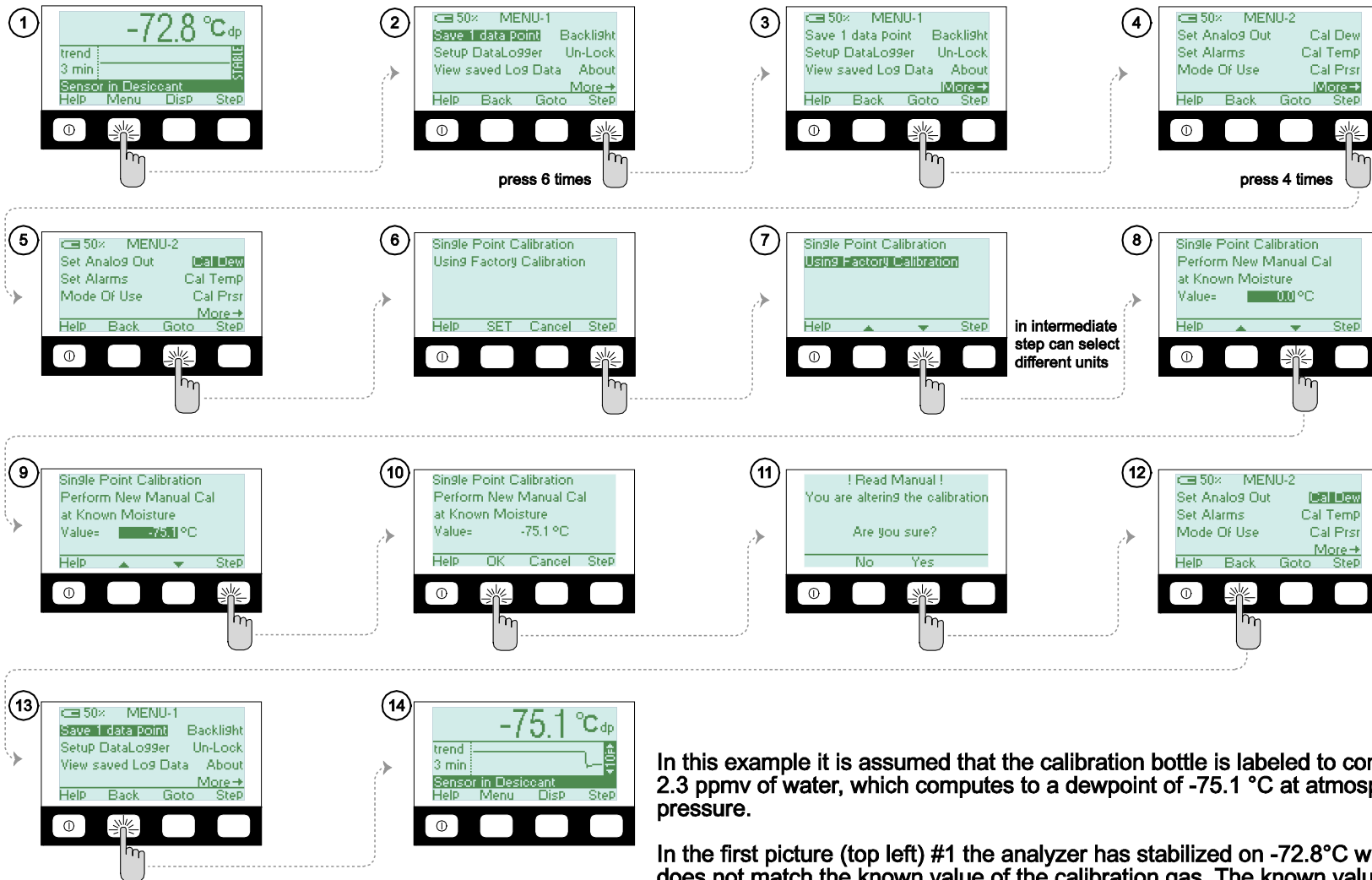
Rev: 1



 PhyMetrix®		Title: Calibrating Natural Gas Sample System with High Pressure Outlet	
Unless otherwise specified dimensions are in inches fractional $\pm 1/32"$ $x \pm 0.020"$ $xx \pm 0.010"$ $xxx \pm 0.005"$		Drawn by: BB	Date:
		Scale: 1:4	Page: 1/1
		Part Number:	Rev

Manual Calibration Procedure

Step-by-step example of performing a single point calibration on a Phymetrix Analyzer

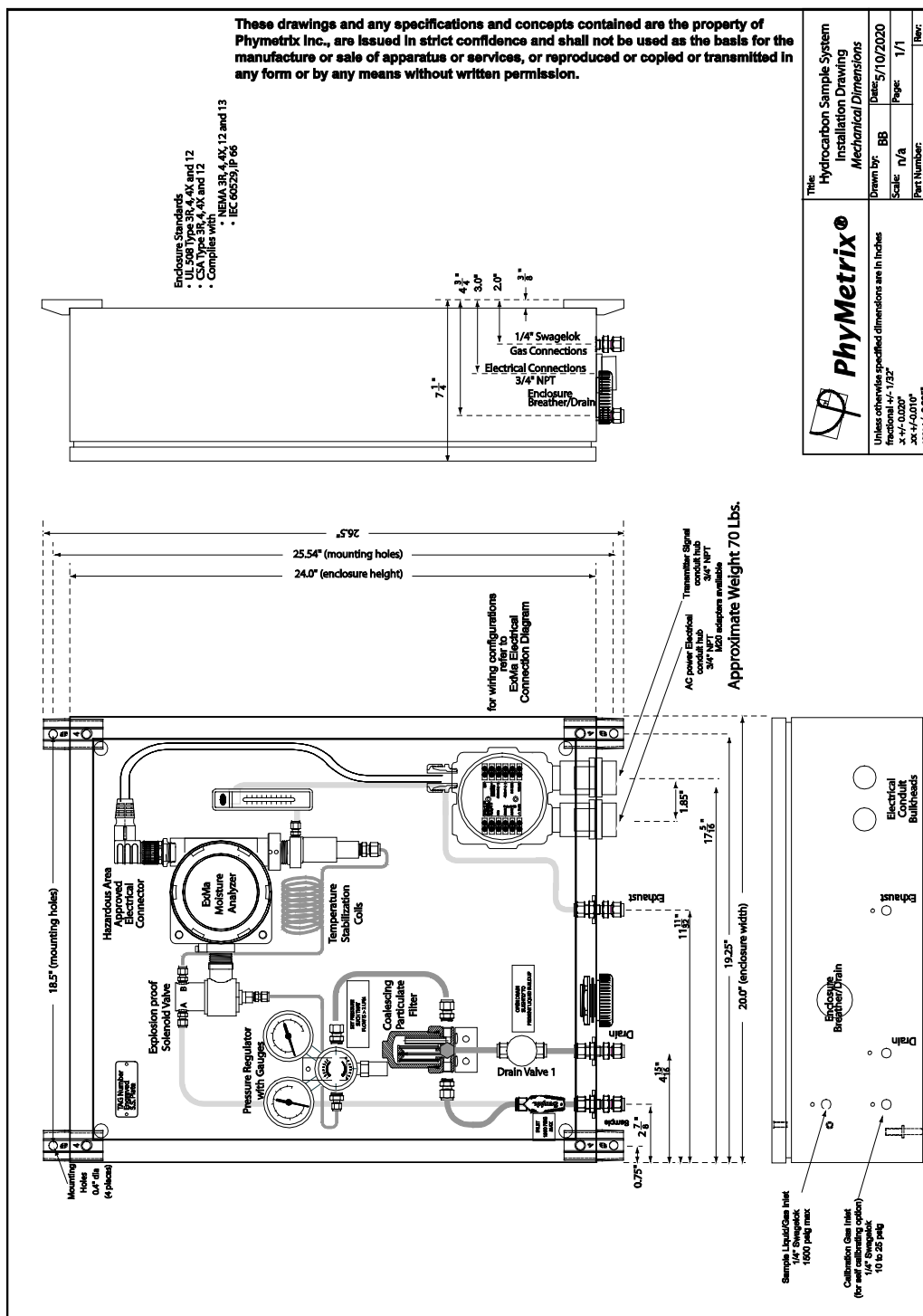


In this example it is assumed that the calibration bottle is labeled to contain 2.3 ppmv of water, which computes to a dewpoint of -75.1 °C at atmospheric pressure.

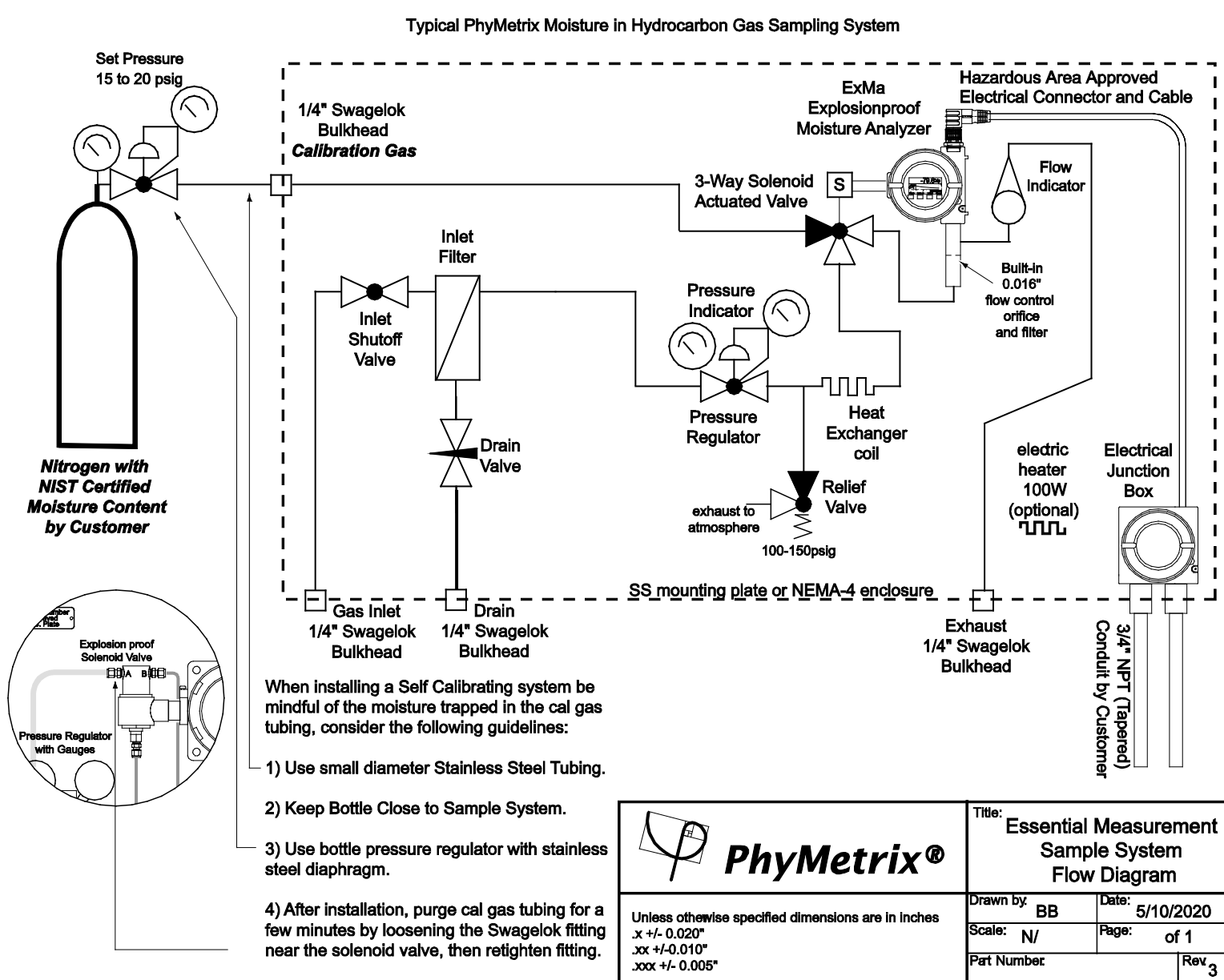
In the first picture (top left) #1 the analyzer has stabilized on -72.8°C which does not match the known value of the calibration gas. The known value of -75.1°C is entered in steps 8&9 by using the up and down arrows. In the last picture #14 the analyzer is reading the corrected value.

Appendix F Automatic Self-Calibration/Verification Notes

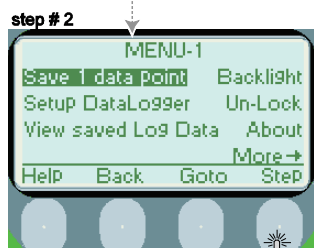
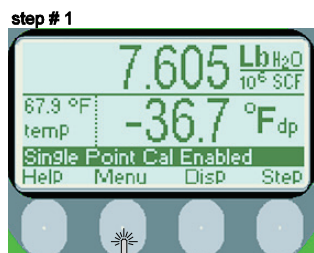
Automatic Single Point Calibrations can be performed by ExMa analyzers equipped with a solenoid valve, as shown in the installation drawing below. They can periodically switch the analyzer to a gas stream from a bottle with a known moisture content and perform a calibration completely unattended.



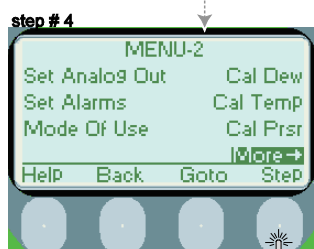
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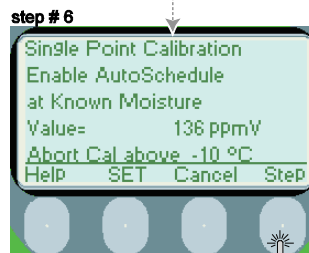
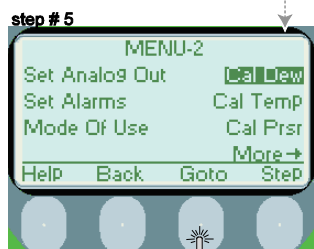
Procedures for setting up a Phymetrix ExMa Moisture analyzer for Self-Calibrating



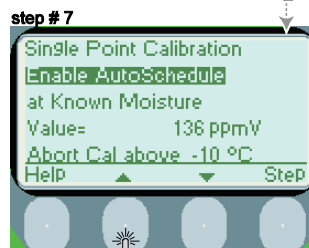
(6 times)



(4 times)

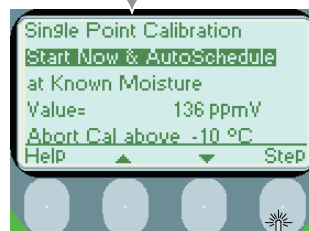


In general pressing the "Step" button causes a highlight (dark background) to step from variable to variable, then the ▲ & ▼ buttons allow the user to make changes to the highlighted item.

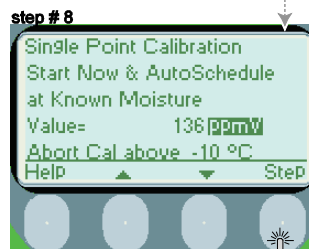


Use the ▲ & ▼ buttons to Select "Enable AutoSchedule". This will setup the analyzer so that a calibration will be performed at the date/time specified in step #12, and then will perform the next calibration according to the set schedule (e.g. next one in 7 days from the date in step #12).

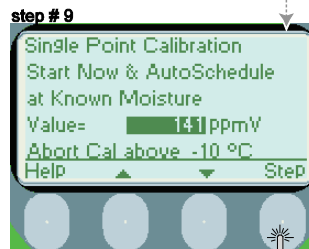
OR



Use the ▲ & ▼ buttons to Select "Start Now & AutoSchedule". This will setup the analyzer so that a calibration will be performed at this time and then will perform the next calibration according to the set schedule (e.g. next one in 7 days).



Use the ▲ & ▼ buttons to Select the units to use when specifying the moisture content of the cal gas. For example the cal gas bottle may be labeled 141 ppmV, thus select units to be ppmV.




Use the ▲ & ▼ buttons to Select the value of the Cal Gas.

to page 2



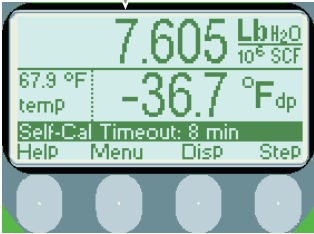
from page 2

step # 20

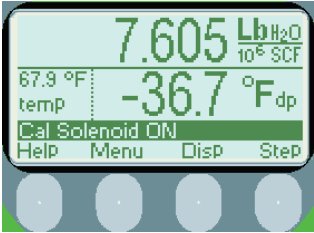


Back out of the Menu Screens.

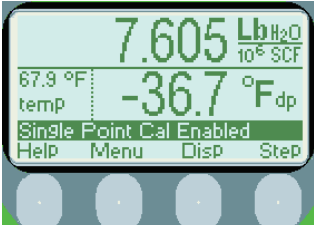
(2 times)



The STATUS line (black background) indicates that the Calibration is in progress and the amount of time left to complete.



Also shows that the Calibration solenoid is activated.



After the Calibration is completed the STATUS line reminds the user that a Calibration point is being used.

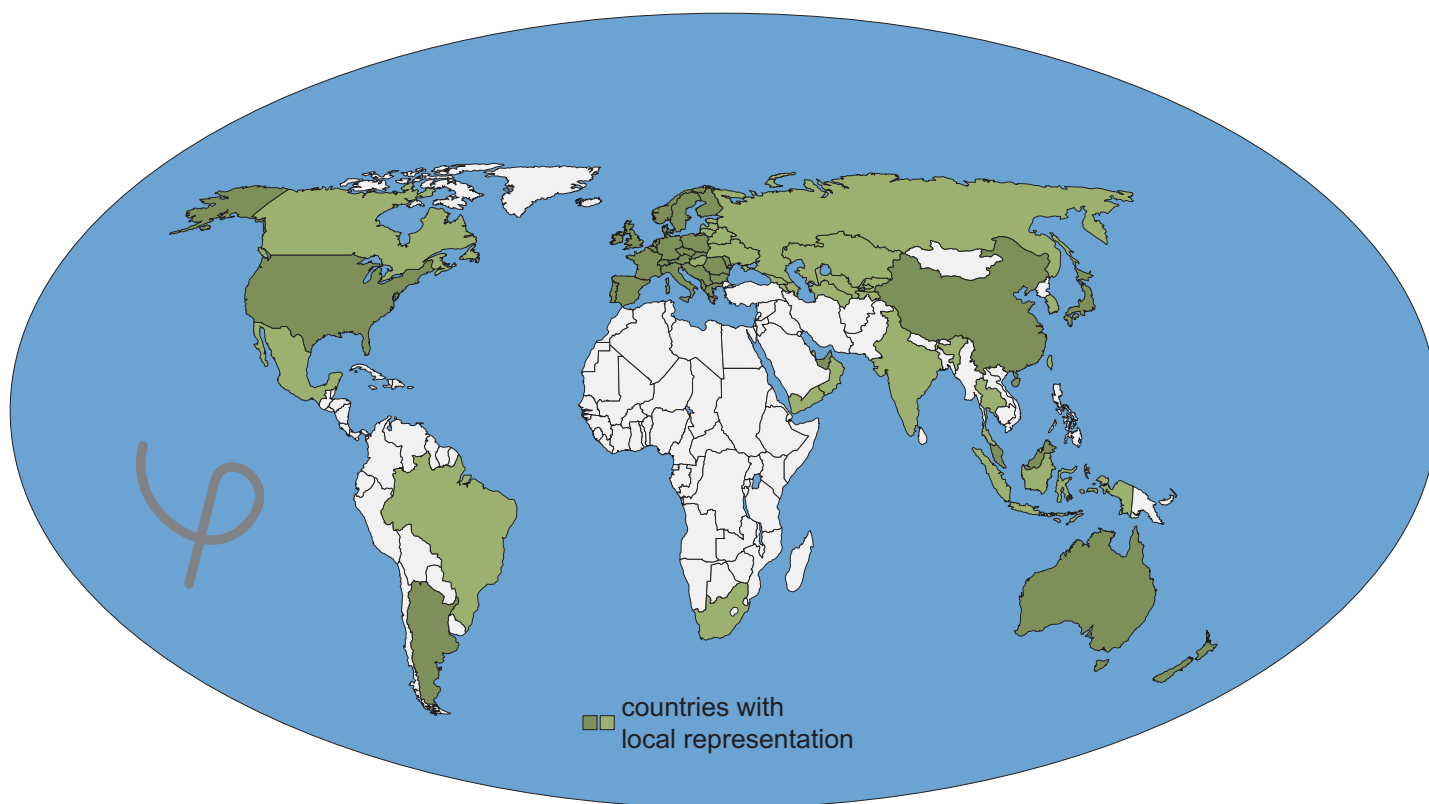
Analyzer Serial Number: _____
Sensor Serial Number: _____

Sensor Serial Number: _____

[illegible][illegible]

Moisture Measurement Innovation at Work

Integrating nanotechnology into moisture measurement



PhyMetrix Inc., 28C Industrial Blvd. Medford, NY 11763, USA, Tel:1-631-627-3950 Fax:1-631-627-3949



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