EXCELLENCE IN MAGNETICS AND CRYOGENICS

MODEL 174 LIQUID LEVEL TRANSMITTER

INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS

American Magnetics, Inc.

PO Box 2509, 112 Flint Road, Oak Ridge, TN 37831-2509, Tel: 865 482-1056, Fax: 865 482-5472

Rev 2, Feb 2001

Introduction

The American Magnetics, Inc. (AMI) Model 174 Liquid Level Transmitter is a ruggedized, microprocessor-based instrument designed to provide accurate and reliable level monitoring of virtually any cryogenic liquid.

Capacitance-based level sensing

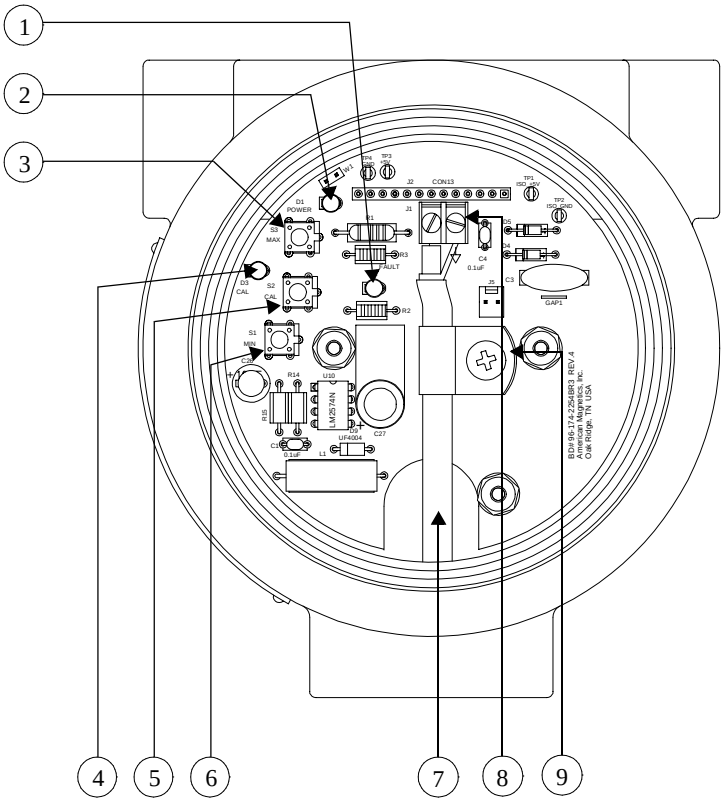
The system consists of a Model 174 instrument, AMI liquid level sensor, and connecting coaxial cable. The instrument sensing element is normally a 3/8 inch (9.5 mm) OD cylindrical capacitor constructed of stainless steel which allows a cryogenic fluid to become the dielectric between the concentric plates. The instrument measures the sensor capacitance which is directly related to the percentage of the sensor immersed in the cryogenic liquid. The sensors are normally constructed in overall lengths of up to 20 feet (6.1 m).

Push-button calibration

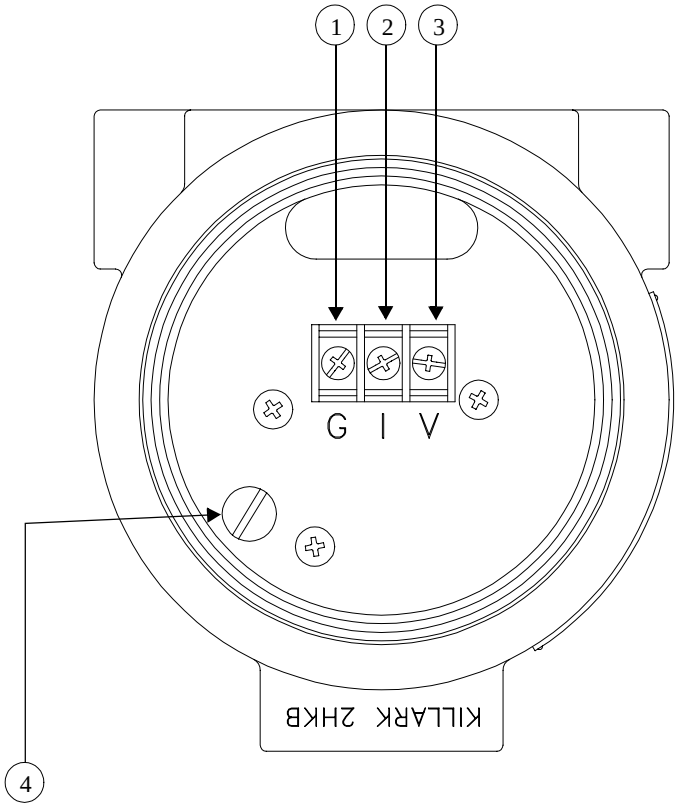
The Model 174 instrument provides push-button calibration which automatically scales the 4-20 mA output to a 0-100% liquid level for any length sensor. No potentiometer adjustments are required to specify zero or span.

Remote monitoring

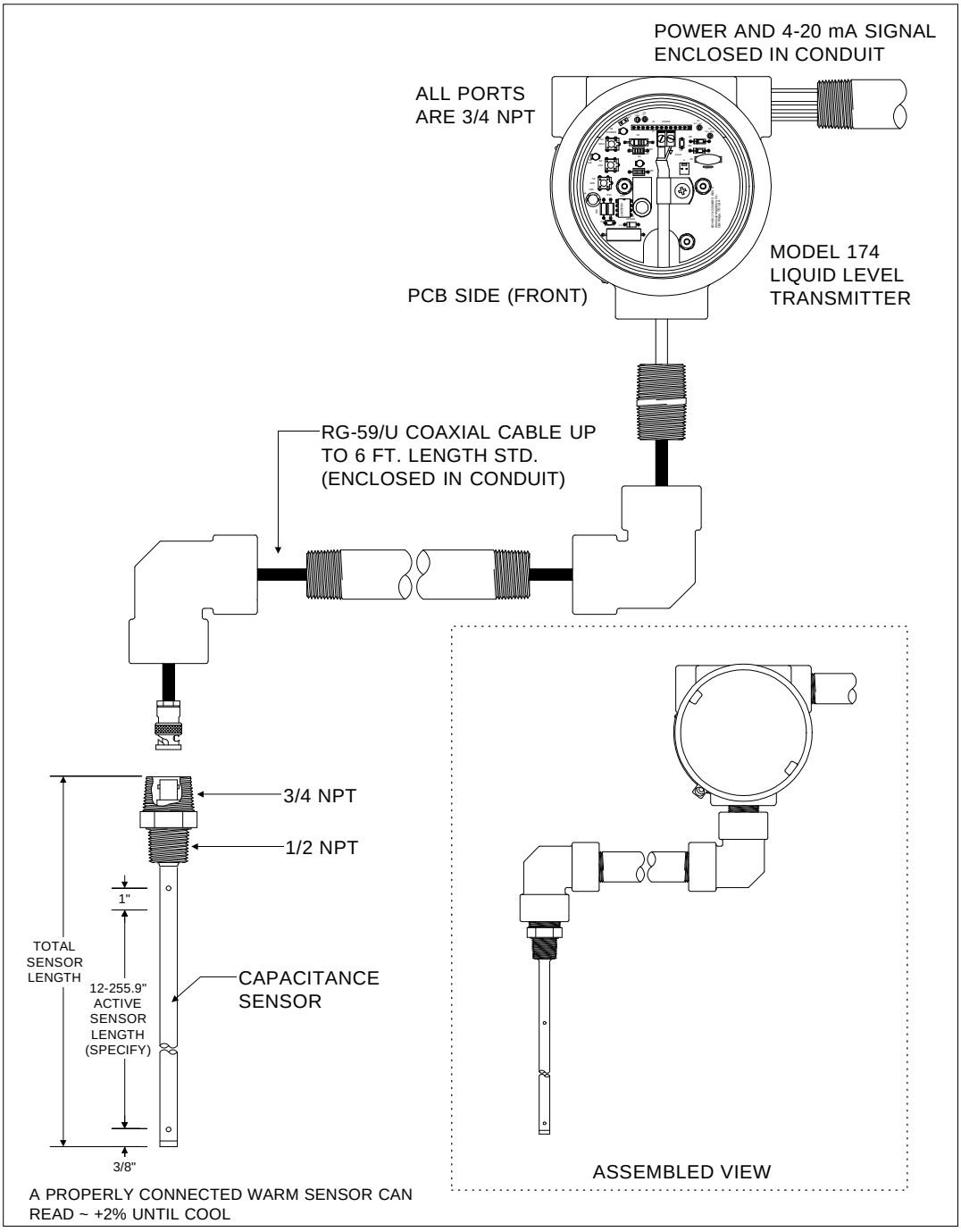
The Model 174 instrument is equipped with a 4-20 mA current loop output.



1	Red current loop fault LED	**6**	MIN calibration push-button
2	Green power indication LED	**7**	Coaxial cable from sensor
3	MAX calibration push-button	**8**	Coaxial input connector J1
4	Yellow calibration LED	**9**	Coaxial cable strain relief
5	CAL calibration push-button		



1	***G*** : Power supply return lug	**3**	***V*** : Power supply input lug
2	***I*** : 4-20 mA current output lug	**4**	Safety ground



A typical Model 174 instrument and sensor system diagram.

Instrument Specifications

Input voltage, V_{in}	14 - 32 VDC
Dimensions	4.75" W x 5.25" H x 5.7" D
Weight	4.5 lbs.
Operating environment	0 - 60°C

4-20 mA Output Specifications @ V_{in} = 24 VDC and 25°C

Integral non-linearity	± 0.012%
Resolution	16 bits
Total error	± 0.5%
Current drift (4-20 mA)	75 ppm/°C
PSRR	10 µA/V
Output compliance	V_{in} – 5.5 V

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product or personal injury.

Hazardous voltage symbol.

Warning

The Warning sign denotes a hazard. It calls attention to a procedure or practice, which if not correctly adhered to, could result in personal injury. Do not proceed beyond a Warning sign until the indicated conditions are fully understood and met.

Caution

The Caution sign denotes a hazard. It calls attention to an operating procedure or practice, which if not adhered to, could cause damage or destruction of a part or all of the product. Do not proceed beyond a Caution sign until the indicated conditions are fully understood and met.

Table of Contents

Table of Contents

1 Installation

Warning

Do not modify this instrument in any way. If component replacement is required, return the instrument to AMI facilities as described in the Troubleshooting section of this manual.

1. Unpack the instrument

Carefully remove the instrument, sensor, and interconnecting coaxial cable from the shipping carton and remove all packaging material.

Note

If there is any shipping damage, save all packing material and contact the shipping representative to file a damage claim. Do not return the instrument to AMI unless prior authorization has been received.

2. Install the sensor in the dewar

Exercise care when installing the sensor since dents, crimps, bends or other physical distortions in the thin wall capacitor will change the electrical characteristics possibly causing calibration errors and/or disruption of proper instrument operation. Before installing the sensor, the user may want to review the *Calibration* and *Operation* sections to determine what, if any, calibration procedures may be necessary.

Note

All calibration procedures must be performed with a completed installation of the instrument, sensor, and interconnecting coaxial cable.

3. Route the coaxial cable to the AMI sensor

Connect the supplied RG-59/U coaxial cable to the sensor by routing the BNC end of the coaxial cable through all interconnecting conduit between the Model 174 mounting location and the sensor. The cable length between the instrument and the sensor should normally not exceed 6 feet if possible.

Caution

Moisture or contaminants in the BNC coaxial connector can short out the sensor and cause a false 'full' level indication or other erroneous readings. A pack of non-conductive electrical connection lubricant (ECL) has been

included with the liquid level sensor packaging to reduce the possibility of this occurring. If desired, apply a small amount of ECL to any BNC connector that may be exposed to moisture. Mate the doped connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the doped connections with a short section of heat-shrink tubing.

Note: MSDS sheets for the ECL are available upon request.

Caution

In hazardous environments, AMI suggests that all wiring from the sensor to the instrument be housed in conduit which has joints sealed with Teflon® tape or similar sealant to ensure the connections and cabling are protected from the environment.

4. Connect the coaxial cable to the Model 174 instrument if necessary

Note

The Model 174 instrument enclosure should be mounted in such a manner as to avoid direct exposure to cryogenic temperatures, such as temperatures encountered in the direct path of dewar vents.

Caution

Operation of the Model 174 Liquid Level Transmitter with a device other than an AMI Liquid Level Sensor may void the instrument warranty.

If the Model 174 instrument is supplied with an unconnected coaxial cable, first unscrew and remove the cap of the instrument to gain access to the side allowing access to the printed-circuit boards. Prepare the ends of the coaxial cable by routing the cable through the sensor cable entry port and strain relief, cutting the coaxial cable to the correct length for connection to the coaxial input connector J1, and stripping the insulation. Then connect the coaxial cable to the terminals of connector J1 and tighten the screw terminals and the strain relief. See the illustration in Figure 1-1.

5. Connect the 4-20 mA transmitter output

Unscrew and remove the cap of the instrument which allows access to the terminal block. Connect the transmitter output (***I*** lug) and ground (***G*** lug) terminal lugs to the appropriate wiring for your specific installation. The wiring diagram in Figure 1-2 illustrates the proper connection for 4-20 mA output.

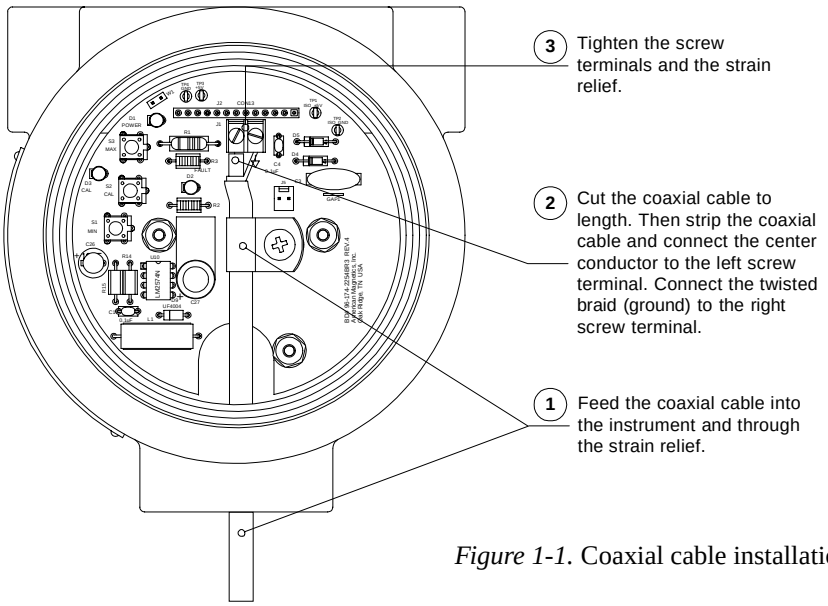


Figure 1-1. Coaxial cable installation diagram.

Caution

It is extremely important to observe all polarities and to not exceed +32 VDC for the loop power supply in order to prevent damage to the 4-20 mA driver circuit.

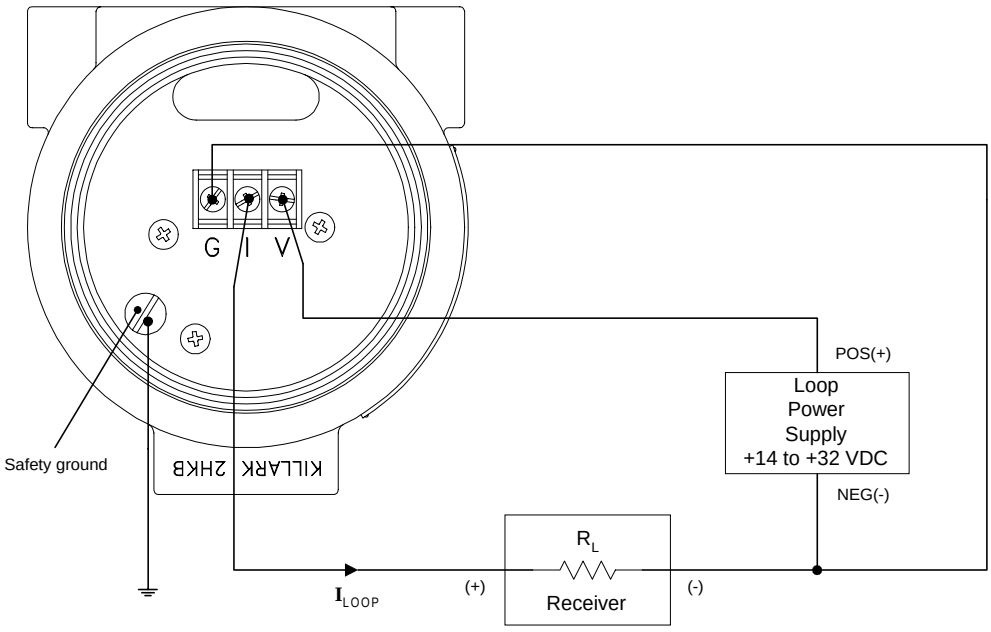


Figure 1-2. Wiring diagram for 4-20 mA output and power supply.

6. Connect the Model 174 instrument to the appropriate power source

Caution

The Model 174 instrument is designed to operate from a +14 to +32 VDC power source.

Connect the power supply voltage input (***V*** lug) and power supply return (***G*** lug) to the terminals of the Model 174 instrument as illustrated in Figure 1-2 above. As soon as power is applied, the Model 174 will begin operating. Before using the 4-20 mA output in a remote application, perform the calibration procedure if necessary and verify proper operation.

7. Seal any unused port in the Model 174 instrument enclosure

If an unused port remains, seal the port with the provided plug and thread sealant such as Telfon® tape.

2 Calibration

Relationship between calibration and sensor length

The capacitance-based method of measuring the liquid level operates by measuring the period of an oscillator, which is contained within the Model 174 instrument. As the liquid level varies, the value of the sensor capacitance varies linearly which causes a proportional change in the period of the oscillator. Since the dielectric properties of liquids vary and the component tolerances for the sensor and oscillator introduce capacitance variations, a calibration is required to assure maximum accuracy for a specific sensor immersed in the target liquid. The calibration MIN and MAX settings correspond to the minimum and maximum oscillation period, respectively, for a given sensor and target liquid configuration.

Determining if the instrument has been calibrated at the factory

If AMI performed a calibration of the Model 174 instrument and sensor system, the yellow calibration LED will not be energized when power is first applied to the instrument. Verify that the system is operating properly before using the transmitter output in a remote application. A calibration sticker is also affixed to the inside of the terminal block cap indicating the calibration length and liquid.

> **Note**
>
> *If for any reason the RG-59/U coaxial cable which connects the sensor to the instrument is altered (shortened, replaced, etc.), the instrument should be recalibrated.*

If the instrument has not been calibrated by AMI due to custom installation requirements, the yellow calibration LED will be continuously energized when power is first applied to the instrument. The calibration sticker will also indicate N/A. If this is the case, the customer is *required* to perform the calibration after installation is complete. Even if AMI has performed a factory calibration, the customer may also choose to perform the calibration again if the instrument is to be used in a pressurized application (AMI cannot perform accurate factory calibration for pressurized applications or for liquids other than liquid nitrogen).

Variations in the dielectric with changing density

For cryogenic liquids the dielectric of the liquid will change with a change in density. The amount of change is dependent on the properties of the specific liquid. Figure 2-1 illustrates the variations in dielectric for nitrogen vs. pressure under *saturated* conditions.[1] Since the instrument uses a capacitance-based method for determining liquid level, such a change in the dielectric of the liquid will result in a shift in the level reading of the instrument. The calibration procedures described herein are most accurate when applied in situations where the operating conditions of the cryo-vessel

1. Data obtained from NIST Standard Reference Database 12.

are relatively constant, i.e. the operating pressure and temperature of the cryo-vessel are relatively constant.

To minimize the effects of shifts in the dielectric of the target liquid, perform the calibration at the expected operating condition of the cryo-vessel if the operating pressure is not at or near 1 atm. For operating pressures at or near 1 atm., an open dewar calibration is sufficient. AMI may also be able to supply equations for saturated equilibrium conditions which provide correction factors specific to an installation if an operating temperature or pressure measurement is available. If any questions exist in regard to calibration issues, contact AMI for assistance in determining the optimal calibration strategy.

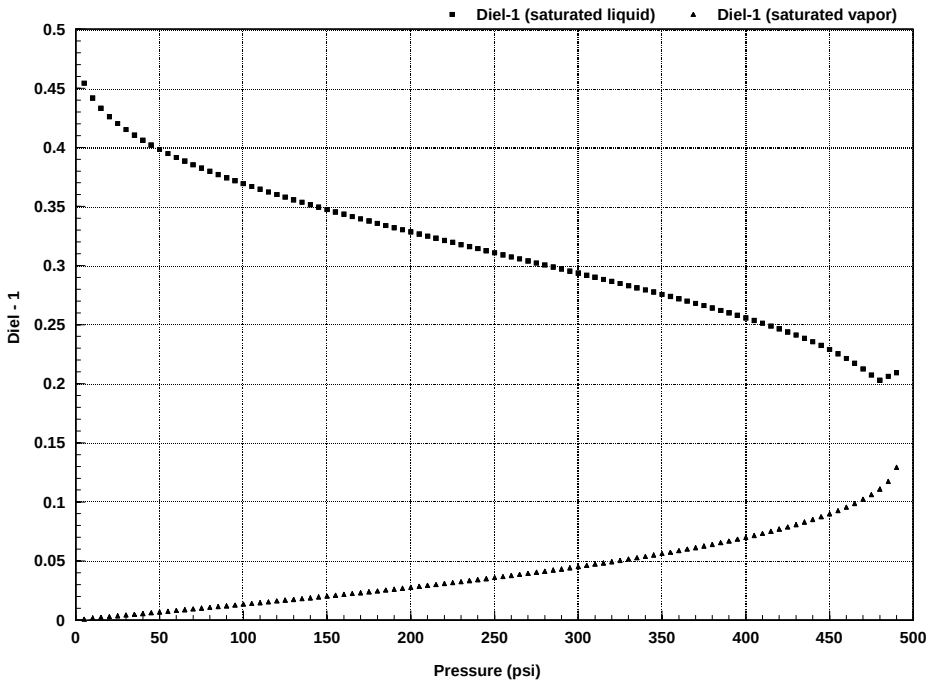


Figure 2-1. Dielectric vs. pressure for nitrogen vapor and liquid under saturated conditions.

Calibration Procedure

Calibration is performed by monitoring the liquid level visually (or by other means such as flow calculations) while transferring the target liquid to (or from) a dewar.

This calibration procedure assumes an empty dewar as an initial condition. However, the MIN and MAX calibration points are independent and may be entered in any order (although MIN and MAX are usually performed as a pair during a calibration procedure). As an alternative to the following procedure, the MAX calibration point can be entered in a full dewar, and the dewar then emptied to perform the MIN calibration.

1. Install the sensor in the dewar and energize the instrument with the sensor connected to the instrument (see the system diagram on page 5).

2. Commence filling the dewar. Once contact between the sensor and liquid becomes readily apparent by visual determination or other means, press the MIN and CAL push-buttons simultaneously. The yellow calibration LED will briefly energize indicating that the calibration point has been accepted. This point is the 0% level of the sensor.

   Note

   If the yellow calibration LED begins blinking, the instrument was unable to write to non-volatile memory. Please contact AMI for further assistance. The instrument cannot be operated when access to non-volatile memory fails.

   Note

   If the sensor is installed in the dewar with some small amount of liquid already in contact with the sensor, then the MIN calibration point can be set before further filling begins. However, note that the active length of the sensor is reduced by the initial level of liquid in contact with the sensor.

3. Continue filling the dewar. Once the maximum desired level of the liquid is achieved, press the MAX and CAL push-buttons simultaneously. The yellow calibration LED will briefly energize indicating that the calibration point has been accepted. This point becomes the 100% level.

   Note

   The maximum liquid level should not exceed the topmost vent hole of the sensor, and preferably should be no higher than 1 inch below.

4. The calibration of the instrument is complete. Verify operation of the 4-20 mA transmitter output by varying the liquid level and verifying proper output from the instrument. See the *Operation* section for further details regarding operation of the instrument.

3 Operation

1. Energize the instrument

After completion of the *Installation* procedures, energize the instrument by connecting a +14 to +32 VDC power supply to the terminal block. The green power LED should be illuminated upon connection of power.

2. Perform a calibration if required

Perform a calibration if required by referring to the procedures in the *Calibration* section. If the yellow calibration LED is illuminated, a calibration *is required*.

> **Note**
>
> *If the yellow calibration LED is blinking, the instrument was unable to store or recover calibration data from non-volatile memory. Contact AMI for further assistance and discontinue use of the instrument until it is repaired.*

3. Monitor the 4-20 mA current loop for liquid level

The 4-20 mA current loop will output a current proportional to the percentage of the sensor immersed in liquid. The 0% level corresponds to 4 mA, and the 100% level corresponds to 20 mA. The microprocessor automatically adjusts to any calibrations to maintain the full 4-20 mA resolution, which always corresponds to 0-100%. No potentiometer adjustments are necessary.

> **Note**
>
> *If the red current loop fault LED is illuminated, check all connections for contact and correctness. If all connections are correct and the red current fault LED is still illuminated, contact AMI for further assistance.*

Sensor contamination

To ensure proper instrument calibration and operation, care must be taken to ensure the sensor is kept free of contaminants and not subjected to any force which would physically distort the sensor. Water or other electrically conducting substances in the sensor will disturb the measured capacitance and therefore instrument response. Physically distorting the sensor in any way will also cause abnormal instrument operation by introducing variations in the sensor capacitance not due to liquid level.

Cold sensors exposed to humidified air can show erroneous high level readings due to the fact that the air contains moisture which can condense between the cold sensing tubes. A small film of water can cause a shorted or partially shorted condition, which

results in false level readings. As the sensor warms, the moisture may evaporate and the sensor will again read correctly. This is a physical phenomenon and does not indicate any problem with your AMI level equipment. Limit or eliminate exposure of cold sensors to humidified air to avoid this condition.

If a sensor should require cleaning, flushing with alcohol is recommended. The sensor cannot be used again until all the alcohol has been evaporated. Under no circumstances should the sensor be disassembled.

4 Troubleshooting

No current loop output

1. Ensure that the instrument is energized from a power source of proper voltage. The green power LED should be illuminated if power is properly connected.

   Warning

   If the instrument has been found to have been connected to an incorrect power source, return the instrument to AMI for evaluation to determine the extent of the damage. Frequently, damage of this kind is not visible and must be determined using test equipment. Connecting the instrument to an incorrect power source could damage the internal insulation and/or the ground requirements.

2. Check the power supply and current loop connections for contact and correctness. See the wiring diagram on page 11 for the proper connections.

Erratic or erroneous current loop reading

1. Verify that the sensor is properly connected to the coaxial cable (see the system diagram on page 5).

2. Verify the coaxial cabling has no breaks or cuts.

3. If the instrument suddenly reads 100% without a corresponding level, there is a possibility of moisture in the connector at the top of the sensor. Disconnect the BNC connection and remove any moisture. Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause a false ‘full’ level indication or other erroneous readings. A pack of non-conductive electrical connection lubricant (ECL) has been included with the liquid level sensor packaging to reduce the possibility of this occurring. Apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture. Mate the doped connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the doped connections with a short section of heat-shrink tubing.

   Note: MSDS sheets for the ECL are available upon request.

4. Ensure that the instrument is not exposed to large temperature gradients such as those that occur near dewar vents. Extreme temperature changes of the instrument can cause readout errors.

5. Rapidly varying or sloshing liquids will sometimes make one think the instrument is in error when it is actually operating properly.

6. Capacitance-based sensors used in cryogenic liquid systems are sometimes exposed to humidified air when the cryogenic vessel is emptied. This often happens when a cold trap runs out of liquid. As the sensor warms, the electronics can show large errors (readings greater than 20% are not uncommon). This is due to the fact that air contains moisture which will condense between the cold sensing tubes. This small film of moisture can cause a shorted or partially shorted condition. The electronics may recognize this as a higher level reading and display some positive level. As the sensor warms over some period of time, the moisture can evaporate and the sensor will again approach the correct reading of 0%. This condition can also be corrected immediately if liquid nitrogen is added to the cold trap freezing the residual moisture. This is a physical phenomenon and does not indicate any problem with your AMI level equipment.

7. Verify the sensor is free of contaminants and not subject to any physical distortion. Disconnect the BNC connector at the top of the sensor and measure the sensor resistance by placing an ohmmeter across the center pin and the outer barrel of the connector. The resistance of the sensor should typically be >10 MΩ.

If the cause of the problem cannot be located, contact an AMI customer service representative at (865) 482-1056 for assistance. Do not send the unit back to AMI without prior return authorization.

Warranty

All products manufactured by AMI are warranted to be free of defects in materials and workmanship and to perform as specified for a period of one year from date of shipment. In the event of failure occurring during normal use, AMI, at its option, will repair or replace all products or components that fail under warranty, and such repair or replacement shall constitute a fulfillment of all AMI liabilities with respect to its products. Since, however, AMI does not have control over the installation conditions or the use to which its products are put, no warranty can be made of fitness for a particular purpose, and AMI cannot be liable for special or consequential damages. All warranty repairs are F.O.B. Oak Ridge, Tennessee, USA.

Return Authorization

Items to be returned to AMI for repair (warranty or otherwise) require a return authorization number to ensure your order will receive proper attention. Please call an AMI representative at (865) 482-1056 for a return authorization number before shipping any item back to the factory.

Index

Index