

# TELEDYNE HASTINGS INSTRUMENTS



## INSTRUCTION MANUAL

HPM-2002-OBE  
VACUUM GAUGE



 **TELEDYNE**  
HASTINGS INSTRUMENTS  
A Teledyne Technologies Company



**ISO 9001**  
CERTIFIED

# Manual Print History

The print history shown below lists the printing dates of all revisions and addenda created for this manual. The revision level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new revision is created, all addenda associated with the previous revision of the manual are incorporated into the new revision of the manual. Each new revision includes a revised copy of this print history page.

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**Visit [www.teledyne-hi.com](http://www.teledyne-hi.com) for WEEE disposal guidance.**



**CAUTION:** The instruments described in this manual are available with multiple pin-outs. Ensure that all electrical connections are correct.



**CAUTION:** The instruments described in this manual are designed for INDOOR use only.



**CAUTION:** The instruments described in this manual are designed for Class 2 installations in accordance with IPC standards

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Hastings Instruments reserves the right to change or modify the design of its equipment without any obligation to provide notification of change or intent to change.

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# 1. General Information

The Hastings HPM-2002-OBE is a small, low cost electronics module which provides the user with accurate vacuum measurements over a wide range of pressure. The HPM-2002-OBE uses the same rugged HPM-2002s transducer tube as the HPM-2002 bench top instrument. This tube features two sensors; a patented thin-film Pirani sensor and a piezoresistive sensor combined in a single tube with a matched EEPROM (Electrically Erasable/Programmable Read Only Memory).

The HPM-2002-OBE electronics module combined with the HPM-2002's tube provides accurate vacuum measurement from  $1 \times 10^{-4}$  Torr to 1000 Torr. The HPM-2002-OBE is designed for quick, easy installation and will provide the user with long lasting, trouble free, reliable vacuum measurement.

## 1.1. Features:

- Low-Cost Electronics Module
- Wide Dynamic Range  $1 \times 10^{-4}$  Torr to 1000 Torr
- Combined Sensors in a Single Tube
- Input Voltage (11.5-30 VDC)
- Connector: 15-pin high-density male "D"
- Optional 4-digit LED Display
- Optional Outputs (Dual 0-10 volt analog or RS232/485)

## 1.2. Model 2002 Sensors

The Model 2002 transducer tube is comprised of an ion implanted piezoresistive, direct force sensor and a thin film Pirani type sensor. The Pirani sensing element is a Pt thin film serpentine element deposited on a 1 micron thick  $\text{Si}_3\text{N}_4$  membrane. The membrane is peripherally supported by a Si box shaped die and is covered by a thick Si lid parallel to the membrane and open on two ends. The piezoresistive unit is an ion implanted Wheatstone bridge in a 50 micron thick Si membrane peripherally supported by a Si box shaped die which has been anodically bonded to a Pyrex substrate.

The dual sensor assembly is encased in a corrosion resistant 316 stainless steel tube shell. The durable tube design withstands high pressure (150 psig/10.2 bar) and high pressure surges. Since the Pirani sensor is miniaturized and employs a Pt thin film on a  $\text{Si}_3\text{N}_4$  membrane (instead of a conventional long fragile wire), the transducer can withstand high levels of mechanical shock.

The Model 2002 is designed for fast response. The micro machined sensing elements have a very small mass and operate in a constant temperature (Pirani) and a constant current (piezo) feedback mode. This makes response time very fast as compared to other commercially available sensors which have to change the temperature of a significant mass to reflect pressure changes and have a large internal volume which must equalize in pressure with the system before the sensor can reach its final value. The transducer's small internal volume (<1.5 cc) permits rapid pneumatic response to system pressure changes. Further, the small geometry of the transducer prevents thermal convection currents which allows the sensor to be mounted in any orientation without calibration shifts.

## 1.3. HPM-2002-OBE Analog Output Module

The analog output (0-10 V) module consists of a power conversion/sensor transducer board, microprocessor board and a user interface option board. Two 0-10 Volt linear outputs are generated for the user via the high-density 15-pin "D" connector. The first of these outputs covers the pressure range from 0 to 1024 Torr. The second output covers the range from 0 to 1000 mTorr. A four digit floating-point LED display is standard.

## 1.4. HPM-2002-OBE Analog Output (4-20mA) Module

(Identical to 1.3, except replace 0-10 V with 4-20 mA)

## 1.5. HPM-2002-OBE RS232/485 Output Module

The RS232/485 module consists of a power conversion/sensor transducer board, microprocessor board and a user interface option board. Serial communication is conducted via an RJ-11 type connector. With RS232 option (EIA-232 Rev. E) communication can easily be established between the module and the serial port of a PC. The RS485 option allows the user to address multiple units and allows operation at distances of up to 4000 feet. The RS232/485 module includes a four digit floating-point LED display.

## 1.6. HPM-2002-OBE DeviceNet Module

The DeviceNet module consists of a power conversion/sensor transducer board, microprocessor board and a user interface option board. All communication is conducted via a 5-pin “Micro” style with center pin, male pin contacts. The module has passed the ODVA DeviceNet test and conforms to the vacuum/pressure gauge device profile, an Electronic Data Sheet (EDS) with limited features is also available upon request.

## 1.7. Specifications



Measuring range .....	1x10 <sup>-4</sup> to 10 <sup>+3</sup> Torr
.....	1.3x10 <sup>-4</sup> to 1.3x10 <sup>+3</sup> mbar
Accuracy (N <sub>2</sub> , T=23°C) .....	+ 20% of reading (1 x10 <sup>-3</sup> to 50 Torr)
.....	+ 1.5% of reading (50 to 1000 Torr)
Ambient temperature operating range.....	0° to 50°C
Process control .....	2 TTL outputs (1 TTL remote zero command input)
Digital readout.....	Four digit LED
Equipment operating ranges .....	12-30 VDC
Transducer mounting .....	Any position without recalibration.
Transducer internal volume .....	< 1.5 cc
Wetted material .....	Au, Si <sub>3</sub> N <sub>4</sub> , Si, Pyrex™,
.....	Kovar™, 316 stainless steel and
.....	High Temp/Low Outgassing UHV Epoxy
Weight (OBE & HPM-2002s tube) .....	12 oz (1/8” NPT tube)
Calibrated for nitrogen .....	Conversion Factors for other gases are selectable
Burst Pressure (Tube).....	150 psig
Proof Pressure (*) .....	30 psig
Nominal Operating Pressure (Tube) .....	1x10 <sup>-4</sup> to 10 <sup>+3</sup> Torr
Input Operating Range .....	11.5 to 30 VDC
Input Power.....	24 VDC @ 125 mA

\* Maximum pressure above which may cause permanent damage.

# 2. Installation

This section is designed to assist in getting a new pressure gauge into operation as quickly and easily as possible. Please read the following instructions thoroughly before installing the instrument.

## 2.1. Receiving Inspection

Carefully unpack the Hastings Model HPM-2002-OBE Instrument (part # HPM-2002-OBE), and transducer tube (part #HPM 2002s-xx). Inspect all items for any obvious signs of damage due to shipment. Immediately advise the carrier who delivered the shipment if any damage is suspected.

Compare each component shipped against the packing list. Ensure that all parts are present (i.e. transducer, electronics module, hardware, etc.). Optional equipment or accessories will be listed separately on the packing list.

## 2.2. Quick Start

- Unpack and inspect all items for any obvious signs of damage due to shipment. Immediately advise the carrier who delivered the shipment if any damage is suspected.
- Wire the 15-pin “D” connector according to cable pinout (see Table below) using 24 AWG or other suitable wire.
- Using a unipolar DC Power Supply, set the desired operating voltage within the range of 12 VDC to 30 VDC.
- Connect the HPM-2002-OBE module to the HPM-2002s transducer tube.
- Note that the connector is keyed.
- A finger tight connection is all that is required for adequate operation.
- Transducer tube may be installed in any orientation. However, if condensation is likely to occur, then the tube port should be orientated downward.
- When installing 1/8” NPT style transducer tube, use the 7/16” wrench flats.
- Attach cable.
- With the vacuum chamber at atmosphere, turn on the power supply (typically +24 VDC. Gauge is now reading pressure.
- For best accuracy, the gauge should now be zeroed. Pump the vacuum system down to low ( $10^{-6}$  Torr) pressure if possible. Ideally the gauge should be operated in this condition for one hour before setting the “Zero”.
- To set the “Zero”, place the HPM-2002-OBE in the “CAL” mode by using the “SELECT” button.
- Using a small flat head screwdriver, rotate the “ADJUST” rotary encoder until the unit flashes between “0.0” and “-0.0”.
- Return to the “RUN” mode by using the “SELECT” button

## 2.3. Transducer Installation

The transducer tube may be installed in any orientation. Although the transducer tube is rugged and will perform well in many harsh environments, the tube should be installed in a clean and careful manner. The tube is configured with the vacuum fitting requested. If your vacuum environment is highly contaminated or has unique fitting requirements, a Hastings filter or special adapter may be needed. Please contact the Hastings Instruments Sales Department for assistance in your system configuration.

## 2.4. OBE Module Installation

- Environment:
- Indoor use
- Altitude up to 2000 meters
- Operating temperature range from 5 to 40°C

- Maximum relative humidity: 80% for temperatures up to 31°C decreasing linearly to 50% relative humidity at 40°C.
- Installation category II

HPM-2002-OBE CABLE PINOUT
------------------------------

	Analog Output	Analog Output	Digital Output
Pin No.	0-10 Volt	4-20 mA	RS232/485
1	High Setpoint Output	High Setpoint Output	High Setpoint Output
2	Low Setpoint Output	Low Setpoint Output	Low Setpoint Output
3	Power Input (+12 to 30 VDC)	Power Input (+12 to 30 VDC)	Power Input (+12 to 30 VDC)
4	Power Return	Power Return	Power Return
5	Channel 1 Vout (+)	Channel 1 Iout (-)	NC
6	Analog Return	Analog Shield	NC
7	Channel 2 Vout (+)	Channel 2 Iout (-)	NC
8	Digital Ground	Digital Ground	Digital Ground
9	Remote Zero	Remote Zero	Remote Zero
10	NC	Channel 1 Iout (+)	NC
11	NC	Channel 2 Iout (+)	NC
12	NC	NC	NC
13	NC	NC	NC
14	Rx In (Internal Use)	Rx In (Internal Use)	NC
15	Tx Out (Internal Use)	Tx Out (Internal Use)	NC

## 2.5. Initial Operation

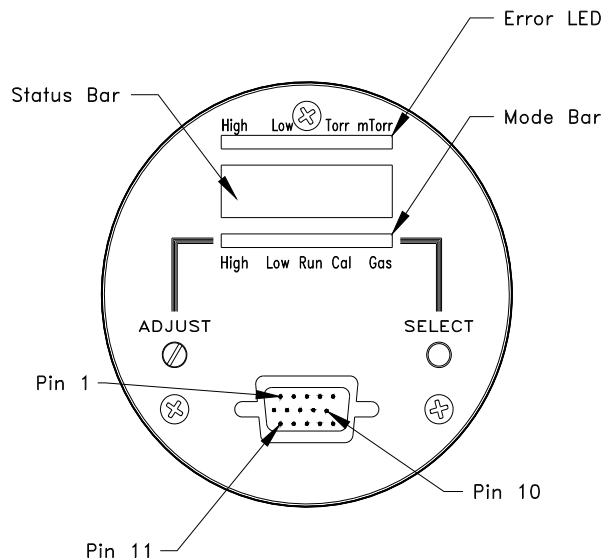
Upon applying power to the control unit a pressure measurement will be given in Torr for nitrogen. However, it is recommended that the user follow the instructions for zeroing and adjusting the output at atmosphere.



# 3. Operating Information

This section contains information on operating the HPM-2002-OBE in any of its various configurations. Refer to the appropriate section for information on the mode in use.

## 3.1. Analog Output (0-10V)



### 3.1.1. Overall Functional Description

The status bar gives information about the condition of the HPM-2002-OBE. High and Low indicate whether the set points are activated. ERROR indicates if there was a problem downloading the EEPROM. Torr and mTorr indicate what pressure regime the gauge is measuring.

The mode bar indicates which mode has been selected. The HPM-2002-OBE has five modes which the user may enter. This is similar to the six modes which can be entered in the bench top/panel mounted HPM-2002, there is no interlock feature; when the user changes the setting within a mode, any adjustments that have been made will be permanent once the mode is exited. To exit without making changes permanent, the user must turn the power off.

### 3.1.2. High and Low Set Point Modes

The HPM-2002-OBE provides TTL outputs for process control. These signals are available on the 15-pin connector (see previous table in Section 2.4).

To view the High set point, place the HPM-2002-OBE in the High mode by pressing the SELECT button until the High mode light is illuminated. The display then shows the set point selected. During normal operation the alarm light will illuminate and the TTL output (pin # 1) will go high (+5V) if the pressure **exceeds** the set point.

Similarly, to view the Low set point, place the HPM-2002-OBE in the Low mode by pressing the SELECT button until the Low mode light is illuminated. The display then shows the set point selected. During normal operation the alarm light will illuminate and the TTL output (pin # 2) will go high (+5V) if the pressure becomes **less than** the set point.

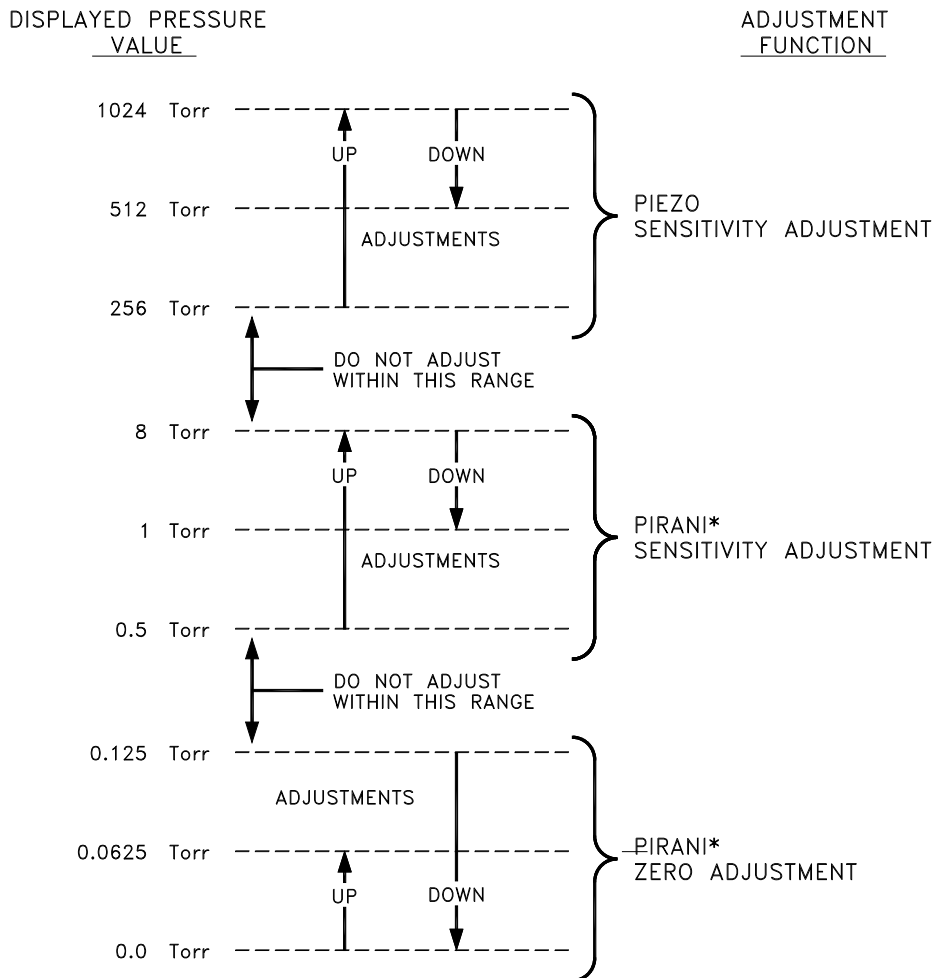
To adjust a setpoint, place the HPM-2002-OBE in either setpoint mode (High or Low). Next, use the ADJUST rotary encoder until the desired setpoint is displayed. Finally, place the HPM-2002-OBE back in the Run mode. The new setpoints are now stored in the HPM-2002-OBE's memory.

### 3.1.3. Run Mode

The HPM-2002-OBE will automatically enter the Run mode upon start-up. This is the mode for normal operation and the mode in which the instrument will spend most of its time. In the Run mode the HPM-2002-OBE will continuously monitor the pressure, update the alarm conditions, and update the display about ten times a second.

### 3.1.4. Cal Mode

Optimal performance of the HPM-2002-OBE is achieved by performing in situ adjustments to the calibration coefficients in the Cal mode. There are three calibration coefficients. These are the zero coefficient, the midrange coefficient, and the atmosphere coefficient. Once a tube has been fully calibrated the midrange coefficient should never need further adjustment, but it may be helpful to adjust the zero coefficient or the atmosphere coefficient under certain circumstances. The CAL MODE presupposes that the operator is applying a known pressure of the correct gas composition (see GAS MODE). The factory calibration points are 800 Torr, 7 Torr, and  $< 10^{-6}$  Torr. The user's calibration points are not required to be exactly those values, but should be somewhat close, and must be within the ranges shown in the following figure. The HPM-2002-OBE detects the voltage signal within the sensor tube, which is converted and displayed as a pressure reading. The resulting pressure reading determines which of the three coefficients will be adjusted.



\*CAUTION: GAS COMPOSITION SENSITIVE

The operator action is the same for adjustment of all three of the coefficients, except that he must apply the proper calibration pressures according to the calibration point he is about to adjust. To adjust a calibration

coefficient, place the HPM-2002-OBE in the Cal mode using the SELECT button. Then turn the ADJUST rotary encoder. The Cal light will begin to flash during adjustment and will continue to flash until the Cal mode is exited using the SELECT button.

To perform a full calibration on the HPM-2002-OBE, first use the Zero Coefficient Adjustment Procedure. Followed by the Midrange Coefficient Adjustment Procedure, and finally perform the Atmosphere Coefficient Adjustment Procedure. Sensor Coefficients are stored in the Sensor's EEPROM upon exiting the Cal mode.

### 3.1.5. GAS Mode

The HPM-2002-OBE can provide true pressure measurements in many gas environments. At pressure levels where the direct force piezoresistive sensor is operative, the instrument is gas composition independent and measures the true pressure regardless of gas composition. The Pirani is gas composition sensitive so the actual composition must be known and the Pirani calibrated in that gas. When the vacuum system's gas composition is dominated by a single gas species (for example, during system venting with an inert gas), the user can enter a gas selection into the HPM-2002-OBE by rotating the ADJUST rotary encoder. To view the gas selection, depress the SELECT button until the GAS light is illuminated. The number on the display corresponds to the gas. See the table below.

<u>Gas Selection Table</u>	
Gas Mode Displayed Number	Gas
00	Nitrogen
01	Argon
02	Helium
03	Water Vapor
04	Custom

### 3.1.6. Analog Output (0-10V)

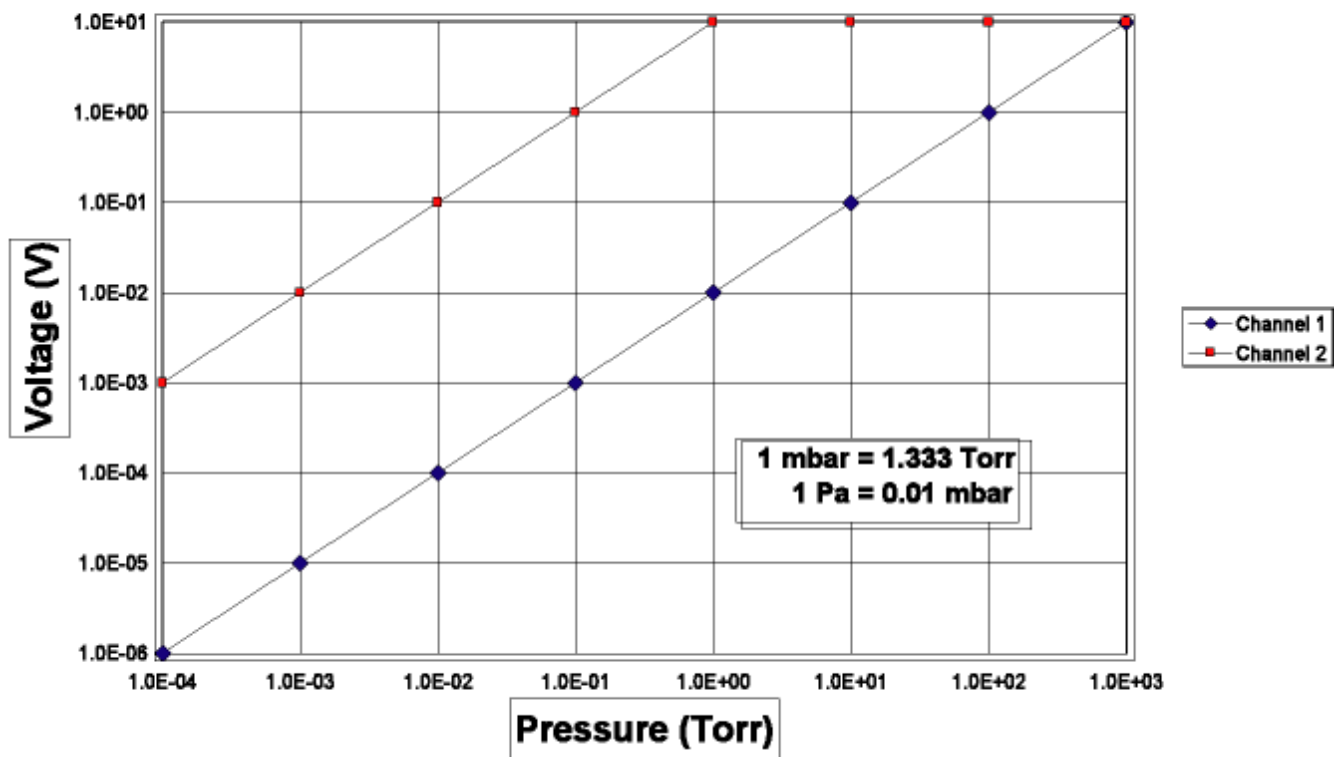
The dual (0 - 10V) output option board provides voltage outputs proportional to the HPM-2002-OBE's pressure reading. The first channel (pin 5) corresponds to the higher-pressure range (0 - 1024 Torr). The second channel (pin 7) corresponds to the lower pressure range (0 - 1000 mTorr). The equation below gives the output voltage on the pressure:

$$V(\text{channel1}) = \frac{\text{pressure}}{100}$$

$$V(\text{channel2}) = 10 \times \text{pressure}$$

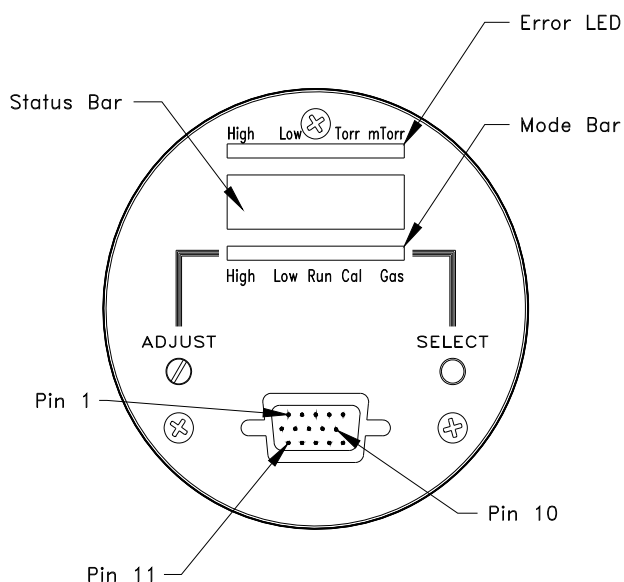
Where V(channel 1) is the voltage between pins 5 and 6, V(channel 2) is the voltage between pins 7 and 6, and the pressure is indicated in Torr.

**HPM-2002-OBE  
10 VDC Analog Output**



### 3.2. Analog Output (4-20mA)

The HPM-2002-OBE with analog output and display is shown in the figure below. The user interface consists of a status bar, a mode bar, and setpoint test jacks.



#### 3.2.1. Overall Functional Description

The status bar gives information about the condition of the HPM-2002-OBE. High and Low indicate whether the set points are activated. Error indicates if there was a problem downloading the EEPROM. Torr and mTorr indicate what pressure regime the gauge is measuring.

The mode bar indicates which mode has been selected. The HPM-2002-OBE has five modes which the user may enter. This is similar to the six modes which can be entered in the bench top/panel mounted HPM-2002, there is no interlock feature; when the user changes the settings within a mode any adjustments that have been made will be permanent once the mode is exited. (To exit without making changes permanent, the user must turn the power off.)

#### 3.2.2. High and Low Set Point Modes

The HPM-2002-OBE provides TTL outputs for process control. These signals are available on the 15-pin connector (see previous table in Section 2.4).

To view the High set point, place the HPM-2002-OBE in the High mode by pressing the SELECT button until the High mode light is illuminated. The display then shows the set point selected. During normal operation the alarm light will illuminate and the TTL output (pin # 1) will go high (+5V) if the pressure **exceeds** the set point.

Similarly, to view the Low set point, place the HPM-2002-OBE in the Low mode by pressing the SELECT button until the Low mode light is illuminated. The display then shows the set point selected. During normal operation the alarm light will illuminate and the TTL output (pin # 2) will go high (+5V) if the pressure becomes **less than** the set point.

To adjust a setpoint, place the HPM-2002-OBE in either setpoint mode (High or Low). Next, use the ADJUST rotary encoder until the desired setpoint is displayed. Finally, place the HPM-2002-OBE back in the Run mode. The new set points are now stored in the HPM-2002-OBE's memory.

#### 3.2.3. Run Mode

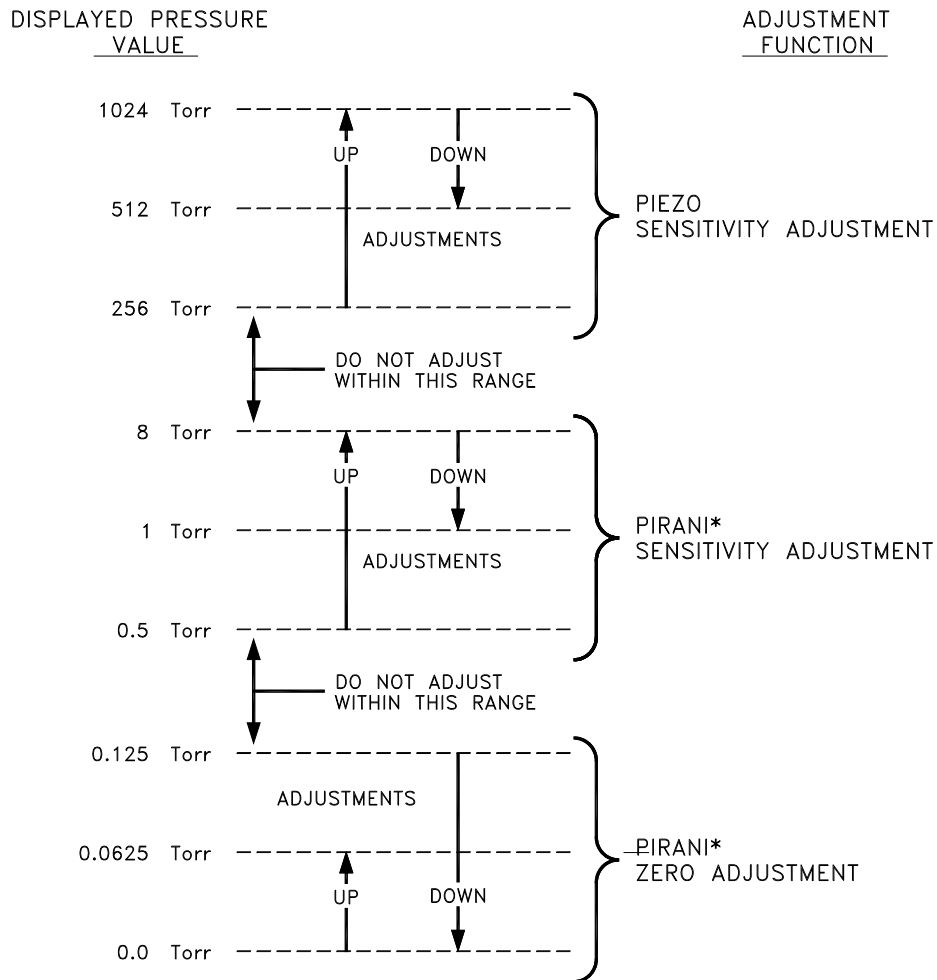
The HPM-2002-OBE will automatically enter the Run mode upon start-up. This is the mode for normal operation and the mode in which the instrument will spend most of its time. In the Run mode the HPM-2002-

OBE will continuously monitor the pressure, update the alarm conditions, and update both analog output channels about ten times a second.

### 3.2.4. Cal Mode

Optimal performance of the HPM-2002-OBE is achieved by performing in situ adjustments to the calibration coefficients in the Cal mode. There are three calibration coefficients. These are the zero coefficient, the midrange coefficient, and the atmosphere coefficient. Once a tube has been fully calibrated the midrange coefficient should never need further adjustment, but it may be helpful to adjust the zero coefficient or the atmosphere coefficient under certain circumstances.

The CAL MODE presupposes that the operator is applying a known pressure of the correct gas composition (see GAS MODE). The factory calibration points are 800 Torr, 7 Torr, and  $< 10^{-6}$  Torr. The user's calibration points are not required to be exactly those values, but should be somewhat close, and must be within the ranges shown in the following figure. The HPM-2002-OBE detects the voltage signal within the sensor tube, which is converted and displayed as a pressure reading. The resulting pressure reading determines which of the three coefficients will be adjusted



\*CAUTION: GAS COMPOSITION SENSITIVE

The operator action is the same for adjustment of all three of the coefficients, except that he must apply the proper calibration pressures according to the calibration point he is about to adjust. To adjust a calibration coefficient, place the HPM-2002-OBE in the Cal mode using the SELECT button. Then turn the ADJUST rotary encoder. The Cal light will begin to flash during adjustment and will continue to flash until the Cal mode is exited using the SELECT button.

To perform a full calibration on the HPM-2002-OBE, first use the Zero Coefficient Adjustment Procedure. Followed by the Midrange Coefficient Adjustment Procedure, and finally perform the Atmosphere Coefficient Adjustment Procedure. Sensor Coefficients are stored in the Sensor's EEPROM upon exiting the Cal mode.

### 3.2.5. GAS Mode

The HPM-2002-OBE can provide true pressure measurements in many gas environments. At pressure levels where the direct force piezoresistive sensor is operative, the instrument is gas composition independent and measures the true pressure regardless of gas composition. The Pirani is gas composition sensitive so the actual composition must be known and the Pirani calibrated in that gas. When the vacuum system's gas composition is dominated by a single gas species (for example, during system venting with an inert gas), the user can enter a gas selection into the HPM-2002-OBE by rotating the ADJUST rotary encoder. To view the gas selection, depress the SELECT button until the GAS light is illuminated. The number on the display corresponds to the gas. See the table below.

<u>Gas Selection Table</u>	
<b>Gas Mode Displayed Number</b>	<b>Gas</b>
00	Nitrogen
01	Argon
02	Helium
03	Water Vapor
04	Custom

### 3.2.6. Analog Output (4-20mA)

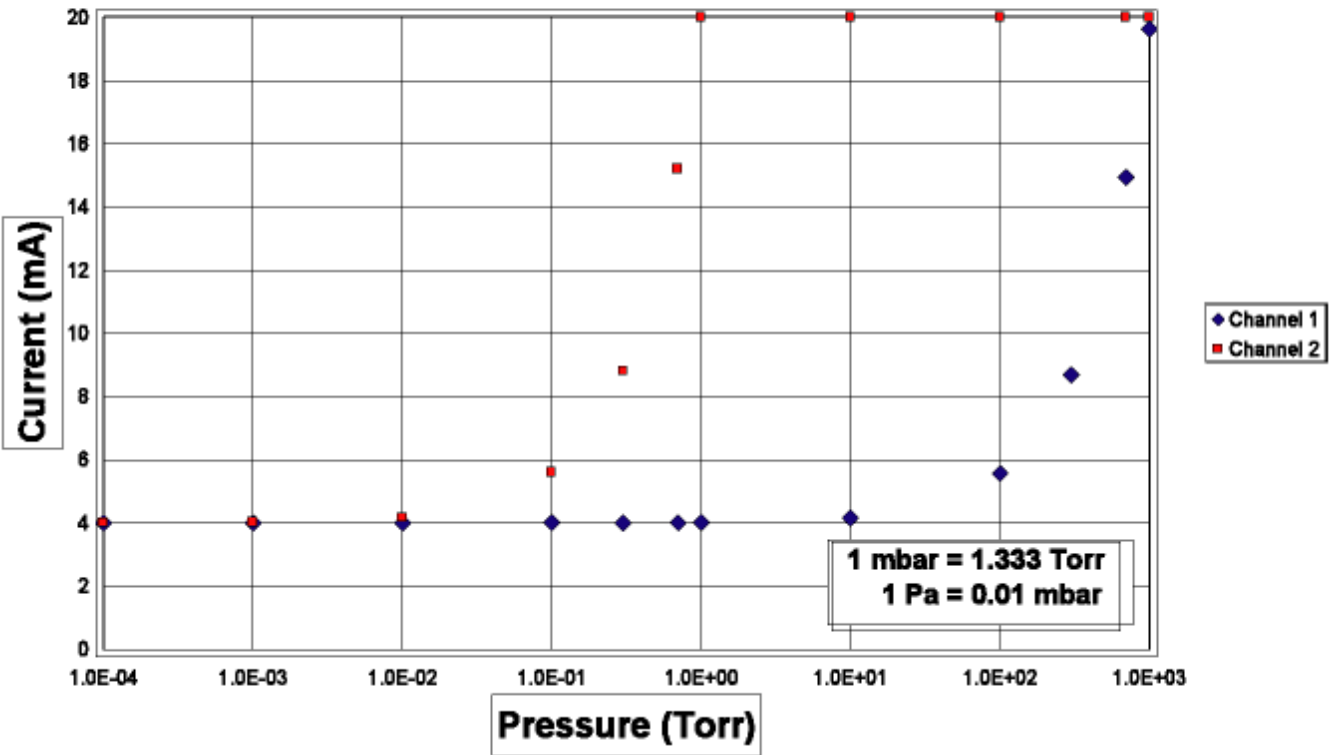
The dual output option board provides current output proportional to the HPM-2002-OBE's pressure reading. The first channel (pins 5 & 10) corresponds to the higher-pressure range (1-1024 Torr). The second channel (pins 7 & 11) corresponds to the lower pressure range (0-1000 mTorr). The equation below gives the output current of the pressure:

$$I(\text{channel1}) = 4\text{mA} + (p(\text{Torr})) * \frac{16\text{mA}}{1024\text{Torr}}$$

$$I(\text{channel2}) = 4\text{mA} + (p(\text{mTorr})) * \left( \frac{16\text{mA}}{1000\text{mTorr}} \right)$$

Note that for both channels, the output is always between 4mA and 20mA specifically, when the pressure goes below 1 Torr, channel 1 current will be approaching its minimum of 4mA and when the pressure is above 1 Torr, channel 2 current will be 20mA.

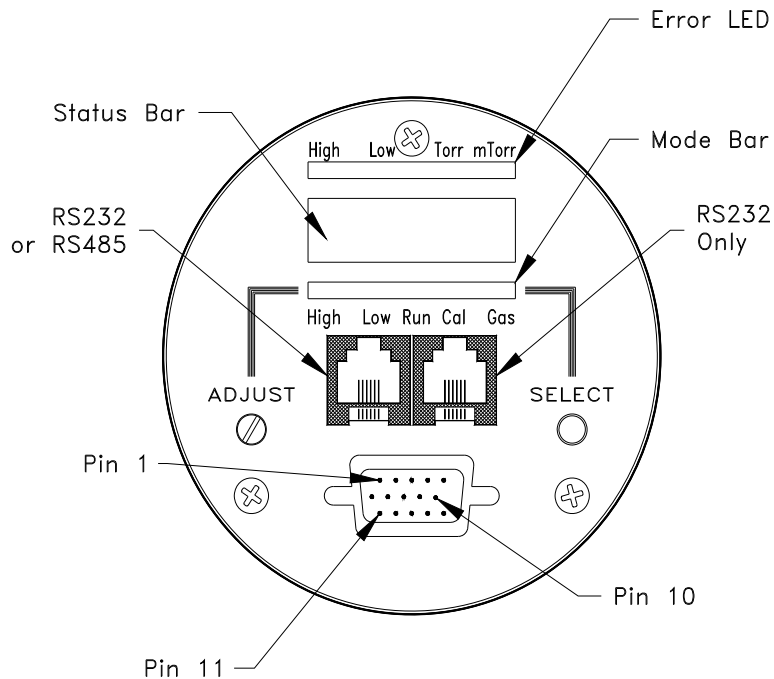
**HPM-2002-OBE  
4-20 mA Analog Output**





### 3.3. RS232/485 With Display

The HPM-2002-OBE with RS232/485 output and display is shown in the figure below. The user interface consists of 4-digit LED display, a status bar, and a mode bar.



#### 3.3.1. Overall Functional Description

The status bar gives information about the condition of the HPM-2002-OBE. High and Low indicate whether the set points are activated. Error indicates if there was a problem downloading the EEPROM. Torr and mTorr indicate what pressure regime the gauge is measuring.

The mode bar indicates which mode has been selected. The HPM-2002-OBE has five modes which the user may enter. This is similar to the six modes which can be entered in the standard HPM-2002, there is no interlock feature; when the user changes the settings within a mode any adjustments that have been made will be permanent once the mode is exited. (To exit without making changes permanent, the user must turn the power off.)

Communication with the serial interface of the HPM-2002-OBE is via an ASCII data string. In the RS-232 mode the command message consist only of a command string and the terminator. The attention character and address string are not required, but if they are used they MUST be valid. If all components of the ASCII data string are valid the command will be accepted and executed. The RS-232 mode is sometimes referred to as point-to-point mode since only one device may be connected to the controller at any given time.

A message to the HPM-2002-OBE in the RS-485 mode consists of an attention character followed by the address string, the command string, and the terminator. If all components of the ASCII data string are valid the command will be accepted and executed. The RS-485 mode is also referred to as multipoint mode since up to 31 devices may be connected to the same controller in a network scheme.

#### 3.3.2. COMMAND SYNTAX

In the following examples of syntax codes, the special characters are explained:

The characters in square brackets [ ] represents a command string, either upper or lower case command characters accepted. All characters must follow each other in the string with no spaces or other characters.

The characters within wavy brackets { } contain choices for the appropriate command.

The characters within the symbols < > are the common abbreviations for the one digit ASCII control codes which they represent, (e.g. <CR> represents carriage return).

When entering more than one command in the same data string, they must be separated by a comma.

All command strings must be followed by the terminator character (carriage return <CR>, also known as ENTER).

When a lower case character is present in an example it represents an option.

Character	Description	Valid Inputs:
a	RS-485 Address (hexadecimal 0-9, A-F)	01 - DF
m	Most Significant Digit Of Mantissa	1 - 9
d	Decimal Digit	0 - 9
e	Exponent	0 - 5
u	Unit Of Pressure	T, M, or P
,	Command Separator (comma)	N/A
<CR>	Command Terminator (carriage return)	N/A

### 3.3.3. Interrogation Commands

<u>Command Description</u>	<u>Format</u>	<u>Sample Response</u>
Transmit Averaged Pressure	P<CR>	Pa: 1.23456e+0 Torr<CR>
Transmit Pirani Pressure	R<CR>	Pr: 1.98765e-3 Torr<CR>
Transmit Piezo Pressure	Z<CR>	Pz: 7.65432e+2 Torr<CR>
Transmit RS-485 Address	A<CR>	Multidrop Address: 01<CR>
Transmit Decimation Ratio	D<CR>	Decimation Ratio: 255<CR>
Transmit Selected Gas #	G<CR>	Gas#: 0<CR>
Transmit High Setpoint	H<CR>	Hi: 1.00000e+1 Torr<CR>
Transmit Low Setpoint	L<CR>	Lo: 1.00000e-2 Torr<CR>
Transmit Device Status	S<CR>	00044<CR>
Transmit Turnaround Delay	T<CR>	Comm Delay: 6<CR>
Transmit Selected Units	U<CR>	Torr<CR>
Transmit Software Version #	V<CR>	Hastings Instruments-OBE 2002 Version 1.4 - (7-21-00) <CR>

### 3.3.4. Paramater Modification Commands

<u>Command Description</u>	<u>Format</u>	<u>Valid Range:</u>
Modify High Setpoint	H={m.dd}E{+e}<CR>	1.00000e-9 to 9.99999e+9
Modify Low Setpoint	L={m.dd}E{-e}<CR>	1.00000e-9 to 9.99999e+9
Modify Selected Gas #	G={d}<CR>	0 to 4 (Decimal)
Modify Selected Units	U={u}<CR>	T, or M, or P
Modify Decimation Ratio	D={dddd}<CR>	63 to 7936 (Decimal)
Modify RS-485 Address	*{aa}A={aa}<CR>	1 to DF (Hexadecimal)
Modify Turnaround Delay	*{aa}T={dd}<CR>	0 to 255 (Decimal)

#### Notes:

The setpoints may also be entered as a decimal number, e.g. [H=760.99<CR>] will be same as entering [H=7.6099E+2<CR>] .

When inputting setpoint data, it should be entered in the same Units of Pressure as the presently selected Units of Measurement (i.e. Torr, mbar or Pascal). The data is only checked to be a valid number with a one digit exponent before being accepted. There are no limit checks on the data; the user is free to choose any value appropriate to his use of the instrument.

The Turnaround Delay and RS-485 address are unique to multipoint communications. In order to prevent inadvertent modifications of these parameters, the multipoint attention character and the Model 2002's present address [**\***{aa}] **MUST** be used and are checked for validity before the command is executed.

If the RS-485 address is unknown, the 'UNIVERSAL ADDRESS' [**\***00] may be used to set the address to a known value, e.g. [**\***00A=35<CR>] will change the RS-485 address to 35.

**Caution:** Since all units will respond to the 'UNIVERSAL ADDRESS', make sure that only the unit to be modified is connected to the RS-485 Bus. If more than one unit is connected, this will result in all of the units being set to the same address.

The 'UNIVERSAL ADDRESS' is used for setup only; (i.e. to set all units to the same gas #) data is never transmitted when the 'UNIVERSAL ADDRESS' is used.

The value entered for the Turnaround Delay is used to modify an internal timer which normally runs at ~8 millisecond, e.g. [**\***{aa}T=10<CR>] will set the delay to ~80 milliseconds.

If the command syntax is not met or if the number is out of range, the HPM-2002 will respond with the ASCII codes for <bell>?<CR>, and the command will be ignored.

### 3.3.5. Calibration Adjustment Commands

<u>Command Description</u>	<u>Format</u>	<u>Valid Range:</u>
Set Full Scale Calibration	CF={m.d}E{e}<CR>	5.12e+2 to 1.023e+3 Torr 6.83e+2 to 1.365e+3 mbar 6.83e+4 to 1.365e+5 Pascal
Set Midpoint Calibration	CM={m.d}E{e}<CR>	4.00e+0 to 7.999e+0 Torr 5.34e+0 to 1.066e+1 mbar 5.34e+2 to 1.066e+3 Pascal
Set Low Scale Calibration	CL={m.d}E{e}<CR>	0 to 1.2499e-1 Torr 0 to 1.666e-1 mbar 0 to 1.666e+1 Pascal

#### Notes:

The calibration adjustment data may also be entered as a decimal number, e.g. [CF=760.99<CR>] will be same as entering [CF=7.6099E+2<CR>].

When inputting calibration adjustment data, it must be within the valid range of the presently selected Unit of Measurement (i.e. Torr, mbar or Pascal). The data is checked to be valid before being accepted.

If the command syntax is not met or if the number is out of range, the HPM-2002-OBE will respond with the ASCII codes for <bell>?<CR> and the command will be ignored.

The 'UNIVERSAL ADDRESS' may be used to calibrate all connected units simultaneously, e.g. [**\***00CF=760<CR>].

### 3.3.6. Reset / Restore Commands

<u>Command Description</u>	<u>Format</u>	<u>Notes:</u>
Escape	<Esc>	Reset Command Buffer (ignore prior Input)
Software Reset	/R<CR>	Reinitialize Software

Restore Factory Defaults	/#<CR>	Restore Calibration Register Default Values
Set Zero	/0 <CR>	Store Present Pressure as Instrument ZERO (if Piezo <32 Torr & Pirani <50 mTorr)
Force Zero	/!<CR>	Override Limit Checks and Store Present Pressure as Instrument ZERO

### 3.3.7. Device Status

When requested to transmit its status the HPM-2002-OBE responds with a five digit number which is explained in the following:

digit#:	1	2	3	4	5
Serial Receiver Overflow	=4				
Main Board EEPROM Error	=2				
Probe EEPROM (any) Error	=1				
Probe EEPROM Not Responding		=8			
Probe EEPROM Read Error		=1			
Probe EEPROM Checksum Error			=4		
Probe EEPROM Verification Error			=2		
Probe EEPROM Identification Error			=1		
Communications Syntax Error				=4	
Piezo Sensor Bad (voltage out of range)				=2	
Pirani Sensor Bad (voltage out of range)				=1	
High Setpoint Alarm (pressure exceeds setpoint)					=4
Low Setpoint Alarm (pressure less than setpoint)					=2
Gas# Changed (not the same as when unit last calibrated)					=1

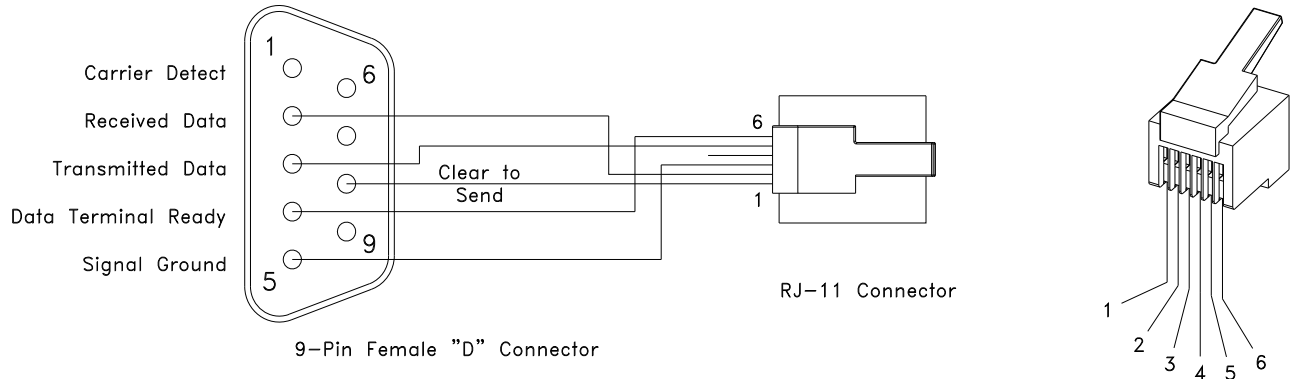
### 3.3.8. Default RS232/485 Specifications

Baud Rate.....	9600
Character Length .....	Eight data bits
Parity .....	None
Stop Bits.....	1
RS 485 Universal Address.....	00

### 3.3.9. Modular Connector Pinout (R2-232) RJ-11 connector on left side.

- Pin #1 ..... Ready to receive (output signal from OBE)
- Pin #2 ..... Data (output from OBE)
- Pin #3 and #4 ..... Common Ground Reference
- Pin #5 ..... Data (input to OBE)
- Pin #6 ..... Clear to send (input signal to OBE)

A common application of the RS232 version of the HPM-2002-OBE is to connect the pressure gauge directly to the serial port of a PC. This is done by first wiring the supplied communication cable in the manner shown below:



### 3.3.10. Modular Connector Pinout (RS-485)

The two RJ-11 Connectors are “Feed Thru” connections, since they are wired in parallel (see above fig.).

RS 485 half duplex		RS 485 full duplex	
Pin #1	_____ T+/R+	Pin #1	_____ T+
Pin #2	_____ T-/R-	Pin #2	_____ T-
Pin #3	_____ GND	Pin #3	_____ GND
Pin #4	_____ GND	Pin #4	_____ GND
Pin #5	_____ n/a	Pin #5	_____ R-
Pin #6	_____ n/a	Pin #6	_____ R+

### 3.3.11. High and Low Set Point Modes

The HPM-2002-OBE provides TTL outputs for process control. These signals are available on the 15-pin connector (see previous table in Section 2.4).

The High set point can be viewed using either the display or the serial connection. To view the high setpoint, place the HPM-2002-OBE in the High mode by pressing the Select button until the High light (on the mode bar) is illuminated. The display then shows the set point selected. During normal operation the alarm light will illuminate and the TTL output (pin # 1) will go high (+5V) if the pressure **exceeds** the set point. To view the setpoint using the serial connection, send “H<CR>”.

Similarly, to view the Low set point, place the HPM-2002-OBE in the Low mode by pressing the SELECT button until the Low light (on the mode bar) is illuminated. The display then shows the set point selected.

During normal operation the alarm light will illuminate and the TTL output (pin # 2) will go high (+5V) if the pressure becomes **less than** the set point.

To view the setpoint using the serial connection, send “L<CR>”.

The set points can be adjusted using either the controls on the gauge or the serial connection. To adjust a setpoint using the manual controls, place the HPM-2002-OBE in either setpoint mode (High or Low). Next, use the ADJUST rotary encoder until the desired setpoint is displayed. Finally, place the HPM-2002-OBE back in the Run mode. The new set points are now stored in the HPM-2002-OBE's memory. Or simply use one of the Modify High Setpoint Commands e.g. “H={m.dd}E{=+e}<CR>”.

### **3.3.12. Run Mode**

The HPM-2002-OBE will automatically enter the Run mode upon start-up. This is the mode for normal operation and the mode in which the instrument will spend most of its time. In the Run mode the HPM-2002-OBE will continuously monitor the pressure; update the alarm conditions, and update the display about ten times a second.

### **3.3.13. Cal Mode**

Optimal performance of the HPM-2002-OBE is achieved by performing in situ adjustments to the calibration coefficients in the Cal mode. There are three calibration coefficients. These are the zero coefficients, the midrange coefficient, and the atmosphere coefficient. Once a tube has been fully calibrated the midrange coefficient should never need further adjustment, but it may be helpful to adjust the zero coefficient or the atmosphere coefficient under certain circumstances. The CAL MODE presupposes that the operator is applying a known pressure of the correct gas composition (see GAS MODE). The factory calibration points are 800 Torr, 7 Torr, and  $< 10^{-6}$  Torr. The user's calibration points are not required to be exactly those values, but should be somewhat close, and must be within the ranges shown in the figure on page 15. The HPM-2002-OBE detects the voltage signal within the sensor tube, which is converted and displayed as a pressure reading. The resulting pressure reading determines which of the three coefficients will be adjusted.

### 3.4. DeviceNet™

The HPM-2002-OBE with DeviceNet option is shown in figure below.



#### 3.4.1. Overall Functional Description

The DeviceNet module consists of a power conversion/sensor transducer board, microprocessor board and a user interface option board. All communication is conducted via a 5-pin “Micro” style with center pin, male pin contacts. The module has passed the ODVA DeviceNet test and conforms to the vacuum/pressure gauge device profile; an Electronic Data Sheet (EDS) with limited features is also available upon request.

#### 3.4.2. DeviceNet description

DeviceNet is a low-level network that provides connections between industrial devices (sensors and actuators) and higher-level devices (controllers). Both power and high speed digital signaling are contained within the same cable. Controller Area Network (CAN) protocol is used to transfer commands and data across the bus. Up to 64 nodes are addressable per network.

Some of the user benefits of using DeviceNet are:

- Reduced hardwiring and reduced start-up time through the use of standardized cables for the Trunk and Branch lines, in addition to standardized Taps for making physical interconnections.
- Ease of integrating products from multiple vendors. More than 250 vendors produce DeviceNet products.

For more information, contact the Open DeviceNet Vendor Association (ODVA) at their web site.  
<http://www.odva.org>

## 3.5. Calibration of the HPM-2002-OBE

### 3.5.1. Zero Coefficient Adjustment

The zero coefficient corrects for the constant power level which is present over the entire pressure range. Typically, this adjustment corrects for low pressure errors. The instrument will need to be re-zeroed often if measurements are being made in the  $10^{-4}$  Torr range, especially if the ambient temperature changes. The transducer may have a temperature coefficient of up to  $2 \times 10^{-4}$  Torr/ $^{\circ}$ C. The instrument remote zero input will allow an external gauge such as an ion gauge to automatically re-zero the HPM-2002-OBE whenever the pressure drops below the desired pressure level (if it has a TTL output).

**NOTE: Do not attempt to zero the Model 2002 in pressures above  $10^{-2}$  Torr; the microprocessor will not accept a zero above this pressure.**

To manually adjust the zero use the following procedure:

1. If possible, evacuate the vacuum system into the low  $10^{-6}$  Torr ( $1.33 \times 10^{-6}$  mbar) range or as low as possible below  $10^{-4}$  Torr.
2. Allow the sensor to operate in this condition for a minimum of 15 minutes.
3. Place the instrument in the CAL mode, using the "SELECT" button, then turn the "ADJUST" rotary encoder. The CAL light will start to flash indicating that the calibration mode has been activated.
4. Use ADJUST until the display reads 0.0 (or 0.0 with an occasional -0.0). OR using the RS232/485 send `"/0<CR>"`.
5. The unit is now fully zeroed. Place the HPM-2002-OBE back in the RUN mode to store the zero in permanent memory.

### 3.5.2. Midrange Coefficient Adjustment

The midrange coefficient corrects for errors in the slope of the power curve of the thin film Pirani. Typically, this is due to the geometry of a particular sensor and will only need to be performed once in the lifetime of the sensor. This adjustment might be needed if a full calibration is being performed in a gas other than nitrogen. **The zero adjustment will need to be performed before making this adjustment.**

To adjust the midrange coefficient use the following procedure:

1. Evacuate the vacuum chamber and refill with the desired gas to a pressure of 7 Torr, as indicated by a reference vacuum gauge.
2. Place the instrument in the Cal mode using the SELECT button.
3. Turn the ADJUST rotary encoder until the HPM-2002-OBE display matches the reading on the reference gauge OR using the RS232/485 send `"CM={m.d}E{e}<CR>"`.
4. Place the HPM-2002-OBE back in the Run mode.

### 3.5.3. Atmosphere Coefficient Adjustment

If a reference high pressure gauge is not available, the ambient barometric pressure acquired from the weather channel or other weather service can be used to adjust the proper reading.

To adjust the atmosphere coefficient, use the following procedure:

1. Backfill with the desired gas to a pressure between 700 and 800 Torr.
2. Place the instrument in the Cal mode using the SELECT button.
3. Turn the ADJUST rotary encoder until the HPM-2002-OBE display matches the reading on the reference gauge OR using the RS232/485 send `"CM={m.d}E{e}<CR>"`. Place the HPM-2002-OBE back in the Run mode.



## 4. Theory of Operation

The 2002s transducer tube is comprised of two very different sensors which provide a span of measurement extending from 1000 Torr down to less than  $1 \times 10^{-4}$  Torr. The piezoresistive device is a direct force sensor which provides pressure indication from 1000 Torr down to less than 1 Torr. The thin film Pirani device is a thermal conductivity sensor that provides pressure indication from 100 Torr down to less than  $1 \times 10^{-4}$  Torr. The two decade overlap in measurement range is convenient for smooth transition either descending or ascending in pressure. Both sensors are small micro machined die that are bonded to a Au coated  $\text{Al}_2\text{O}_3$  preform (stress-isolation) which in turn is bonded to a TO-8 header. The header is resistance welded into a 316 stainless steel envelope as shown in the Figure 4.1.

### 4.1.1.

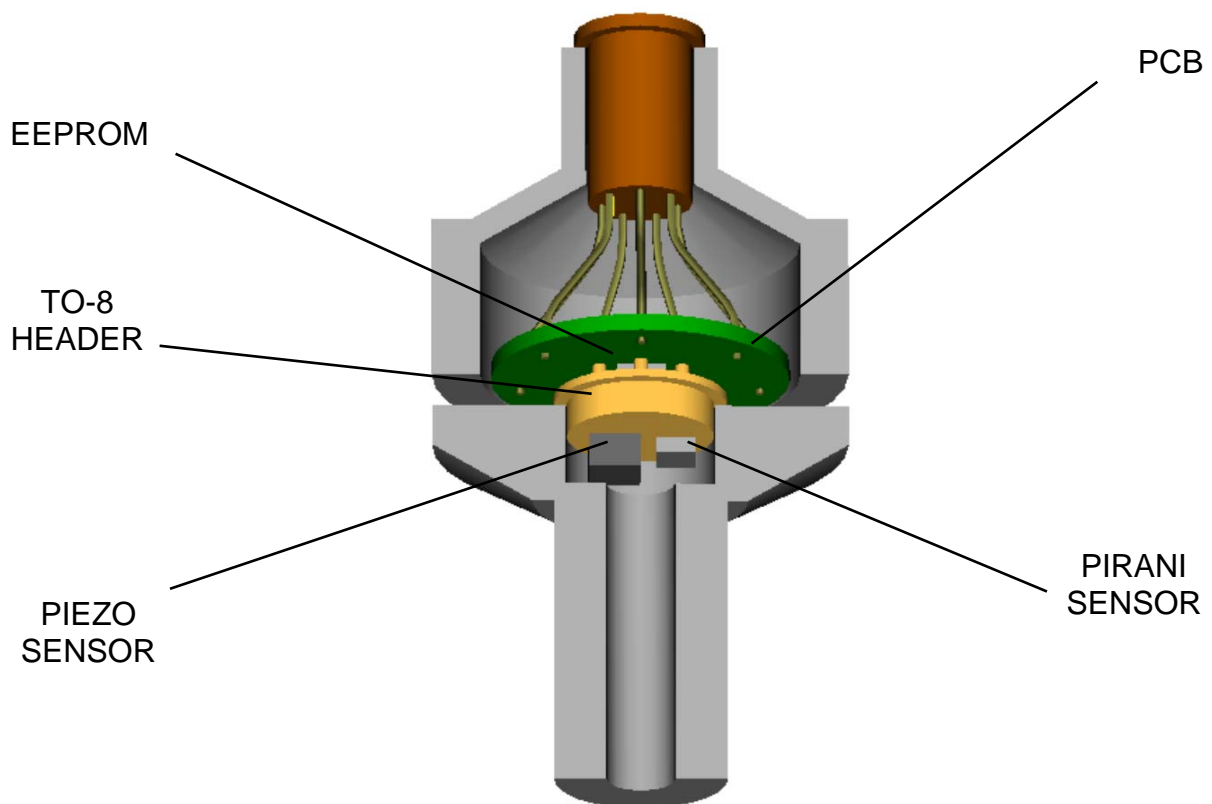


Figure 4.1

## 4.2. Piezoresistive Sensor

Figure 4.2 shows a typical schematic of a Boron ion implanted Wheatstone bridge network in a Si diaphragm inverted box type geometry. The inside of the box is evacuated during anodic bonding to a Pyrex substrate. The membrane has maximum deflection at atmosphere (or higher pressure) and the membrane resistances change value as the differential pressure is decreased during pump down. The resulting differential output is

$$V_o = SPV + V^1$$

where

S is the sensitivity

P is the pressure

V is the applied bridge voltage

V<sup>1</sup> is the no load output voltage

Since the sensitivity changes so dramatically with temperature, some correction is required for compensation. The change in output voltage

$$\frac{dV_o}{dT} = P \left( \frac{SdV}{dT} + \frac{VdS}{dT} \right)$$

To insure temperature invariance,

$$\frac{dV_o}{dT} = 0$$

therefore

$$\frac{1}{V} \frac{dV}{dT} = - \left( \frac{1}{S} + \frac{dS}{dT} \right)$$

which requires for any change in sensitivity to be countered by an equal but opposite change in applied voltage. The temperature compensation is a network of temperature dependent resistive components and fixed temperature compensation current source compensation, TCR = -TCS.

Sensitivity of the sensor is proportional to the sensor factor (K), the strain gauge positioning of the diaphragm ( $\phi$ ) and the diaphragm geometry ( $\theta$ ) thus  $S \propto K\phi\theta$ . Once the defining geometry of the resistive film and piezo membrane have been established, the sensor factor is dependent on the crystal orientation of the membrane material, the doping level and diffusion parameters and the strain gauge geometry. The sensor factor is essentially the change in resistance for a change in strain or,

$$K = \frac{\frac{\Delta R}{R}}{\frac{\Delta L}{L}}$$

Boron ion implanted doped Si matrix resistance elements are employed as shown in Figure 4.2. The die is electrostatically bonded on to a Pyrex substrate in a good vacuum so that the die cavity is evacuated; this provides maximum deflection at atmospheric pressure. When the sensor is exposed to vacuum the deflection becomes less and less as the die cavity pressure and the vacuum system pressure equalizes. Eventually the strain in the membrane due to  $\Delta P$  becomes zero and only the residual strain in the lattice remains. The bridge resistive elements are oriented to give maximum change in bridge resistance which in turn gives maximum voltage out for a given strain.

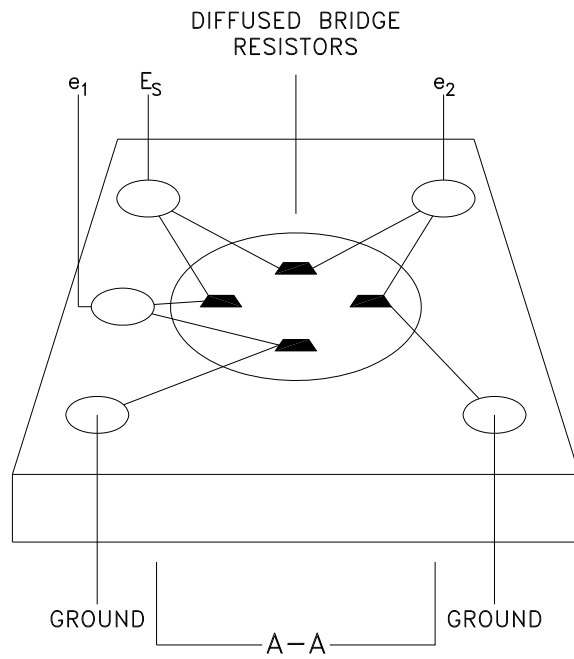
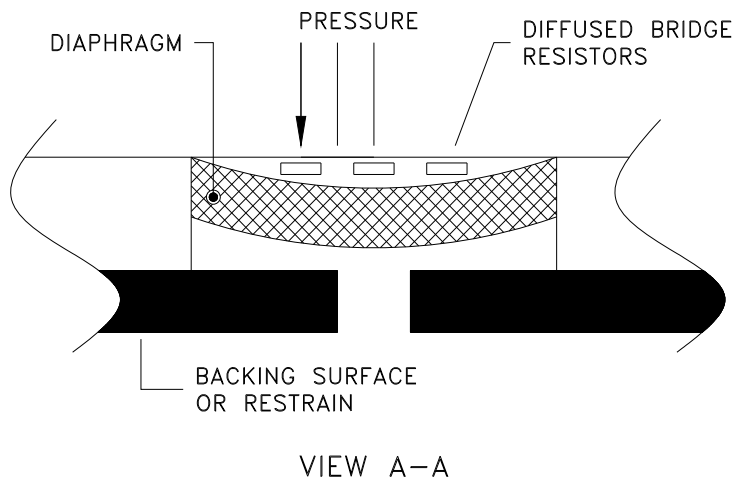


Figure 4.2

### 4.3. Pirani Sensor

Figure 4.3a shows a thin metal film resistive element on a one micron thick  $\text{Si}_3\text{N}_4$  continuous membrane surrounded by a thin film reference resistor on a Si substrate. The membrane is heated to a constant  $8^\circ\text{C}$  above ambient temperature that is monitored by the substrate resistor. The membrane resistor is approximately  $60\ \Omega$  and a constant substrate to membrane resistance ratio is maintained. Figure 4.3b shows the Pirani die in cross section. A parallel Si lid is eutectically bonded to the Au pads and sits 5 microns above the membrane. As shown, this dimension gives a Knudsen number of greater than 0.01 up to atmospheric pressure, which ensures a molecular flow component. At 10 Torr the region above the membrane is totally in the molecular flow regime and thus provides a relatively linear output versus pressure overlapping the linear output versus pressure of the piezo.

The measurement technique is to produce an output signal that is proportional to the power supplied to the heated resistor by using the product of the current and voltage. This rejects errors introduced by resistance changes since the sensor resistance is no longer part of the power equation.

A signal proportional to the power is obtained by multiplying the voltage across the heated sensor and the voltage impressed by the direct current across a constant series resistance. The power supplied to the sensor resistor must equal the heat dissipated ( $E_t$ ). The three main heat loss routes from the heated sensor are thermal conduction through the silicon nitride membrane to the silicon substrate ( $E_s$ ) radiation losses ( $E_r$ ) and thermal conduction through the gas to the silicon substrate ( $E_g$ ); thus, as shown in Figure 4.3b,

$$E_t = E_s + E_r + E_g$$

The first term,  $E_s$ , is dependent on the thermal conductivity of the silicon nitride ( $K$ ), the temperature difference ( $\Delta T$ ) between the heater and silicon substrate and geometric factors ( $A_m$  &  $L$ ).  $E_s$  is given by

$$E_s = (K \Delta T A_m)/L$$

$A_m$  is the membrane cross sectional area through which the heat transfer occurs. This is, approximately, the outer circumference of the membrane multiplied by the membrane thickness.  $L$  is the distance from the edge of ( $R_s$ ) the heated sensor resistor to the silicon substrate.

For any particular sensor, all of the factors, except  $\Delta T$ , are constants dependent on its construction. The  $\Delta T$  is held constant by the control circuit. The thermal loss through the silicon nitride will be a constant value independent of the thermal conductivity and pressure of the gas.

Radiation is another source of thermal losses. It can be determined from

$$E_r = \sigma \epsilon (T_h^4 - T_a^4) A_s$$

where

$\sigma$  = Stefan-Boltzmann radiation constant

$\epsilon$  = thermal emissivity of the silicon nitride membrane

$A_s$  = surface area of the heated portion of the membrane

$T_h$  = temperature of  $R_s$

$T_a$  = ambient temperature

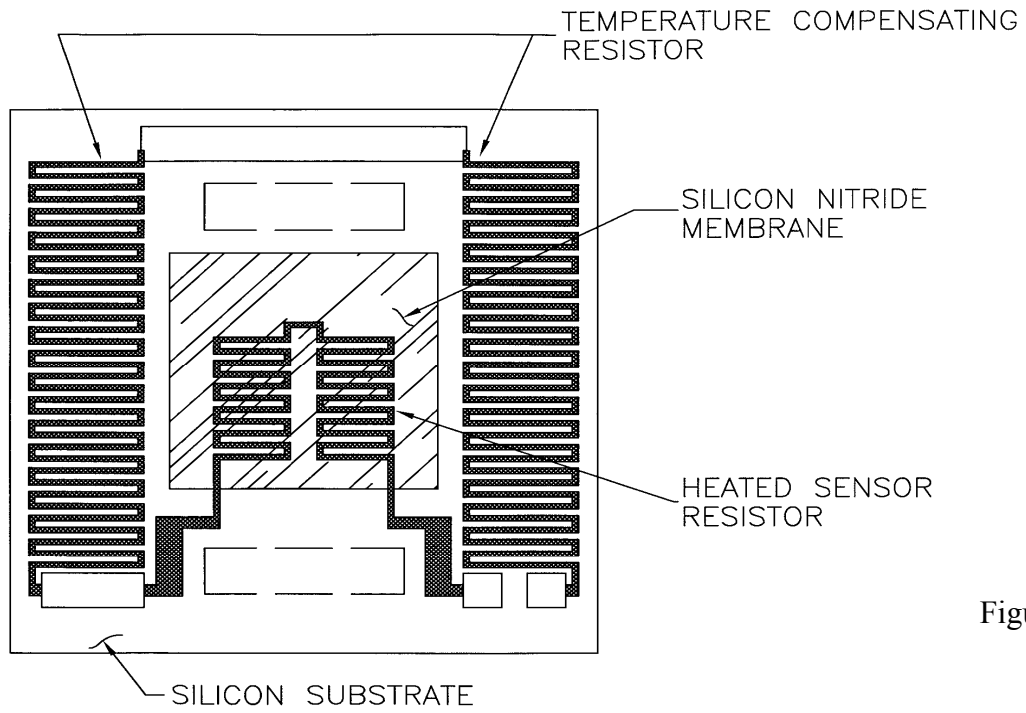


Figure 4.3a

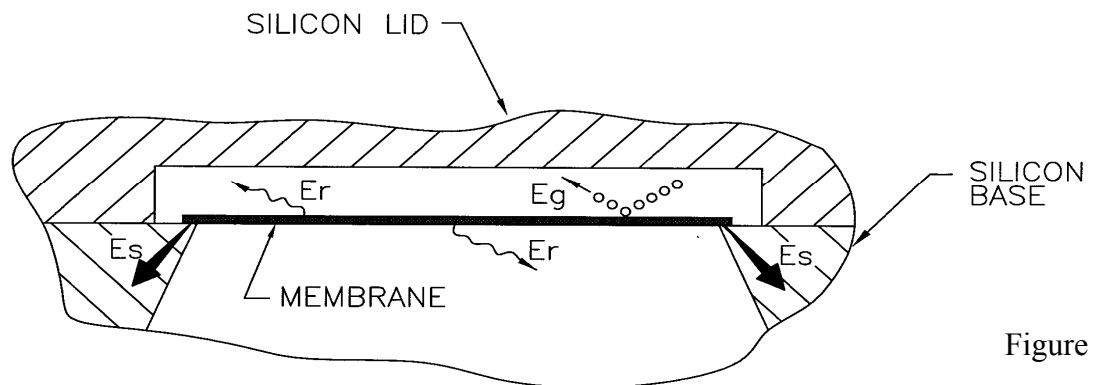


Figure 4.3b

This radiation loss is also independent of the thermal conductivity of the gas. It is somewhat dependent upon the absolute temperature of  $R_s$  and the ambient temperature, but since  $\Delta T$  is kept to less than 20 °C, this

loss is only approximately 10% of  $E_s$ . If ambient changes are small compared to the absolute values of the temperature this loss can be approximated as a constant with temperature.

Since the first two losses are essentially constant at high vacuum for a given sensor, we can measure these losses and subtract them from the input power which leaves only the rate of heat transmission through the gas ( $E_g$ ).

In the viscous flow regime, the  $E_g$  loss is directly dependent on the thermal conductivity of the gas ( $K_g$ ), the surface area of the membrane, the differential temperature and is inversely proportional to distance between the membrane and the lid. It can be written as

$$E_g = (K_g \Delta T A_g) / \Delta x$$

The thermal conductivity of the gas is essentially constant when in viscous flow where the Knudsen number ( $Kn$ ) is less than 0.01. In the viscous flow regime there is no change in sensor output with pressure since all of the losses are constants with pressure.

In the molecular flow regime where ( $Kn > 1$ ) the thermal conductivity of the gas becomes directly proportional to the gas pressure as shown below. We can expect then that  $E_g$  will be constant at high pressures and directly proportional to the pressure at low pressures. The energy loss,  $E_g$ , changes between these two controlling equations as the system passes through the transition region ( $0.01 < Kn < 1$ ).

$$E_g = a_r L_t (273/T_h)^{1/2} (T_h - T_a) A_g P$$

where

$a_r$  = accommodation coefficient

$L_t$  = free molecule thermal conductivity

$T_h$  = temperature of heated membrane

$T_a$  = ambient temperature

$P$  = pressure

$A_g$  = surface area of the heated portion of the membrane

For nitrogen at a pressure of 760 Torr and a temperature of 20 °C the mean free path ( $\lambda$ ) is less than  $1 \times 10^{-7}$  meters and is inversely proportional to pressure. Since the thermal transfer distance ( $\Delta x$ ) is a few micrometers, this sensor will remain in the molecular flow regime at a much higher pressure (10 Torr) than is typical for a thermal vacuum gauge. This extends the linear response part of the output curve up into the 1 Torr range. The nonlinear transition region will extend up to 1000 Torr.

#### 4.4. Dual Sensor Operation

The microprocessor in the control unit continuously monitors the outputs of both the piezoresistive sensor and the Pirani sensor. Figure 4.4 shows representations of the sensors output over the pressure range from  $10^{-5}$  Torr to  $10^{+3}$  Torr. The microprocessor uses the output of the piezoresistive sensor at high pressures ( $>32$  Torr) and uses the output of the Pirani sensor at low pressures ( $<8$  Torr). In the crossover region, a software averaging algorithm ensures a smooth transition between the two sensors.

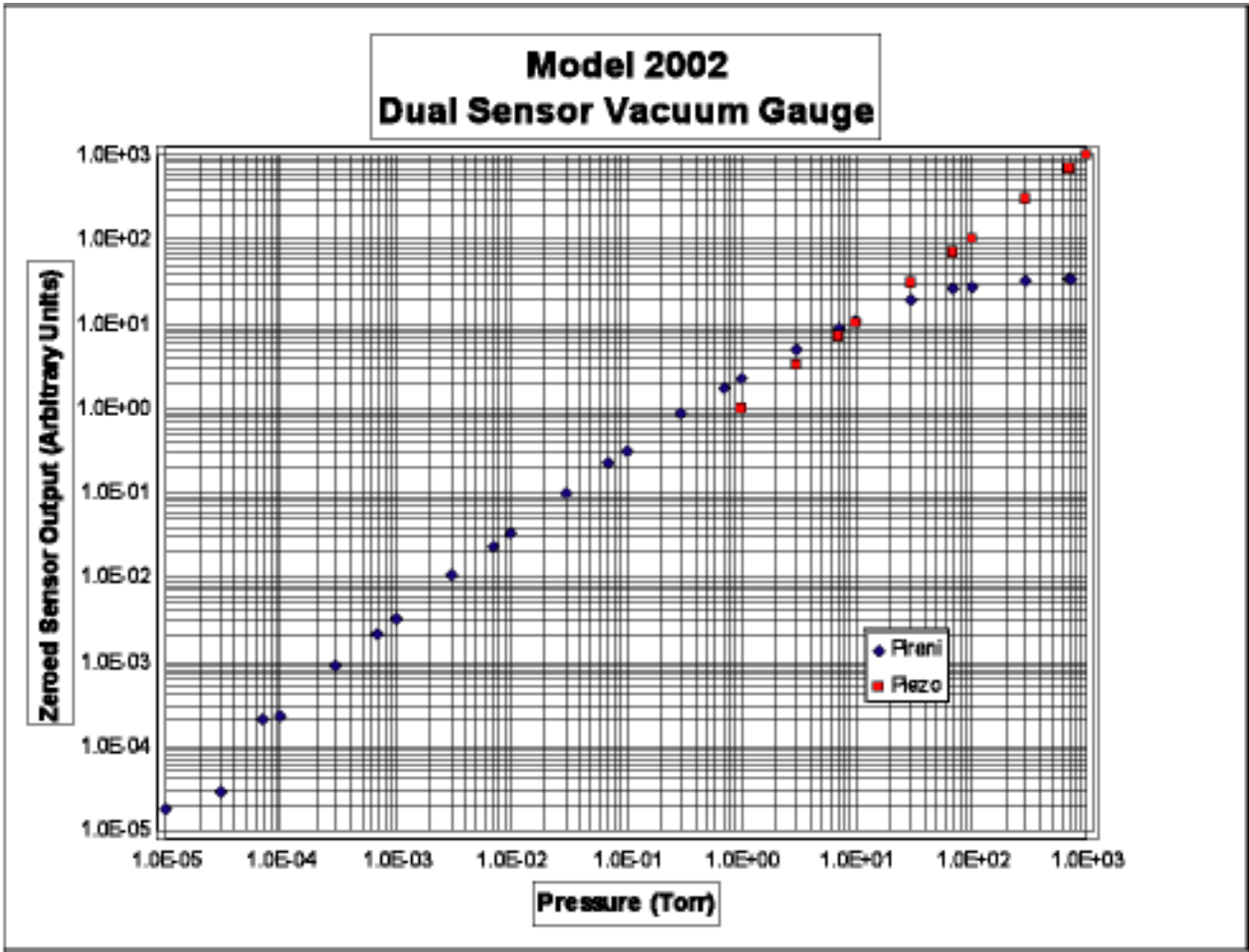


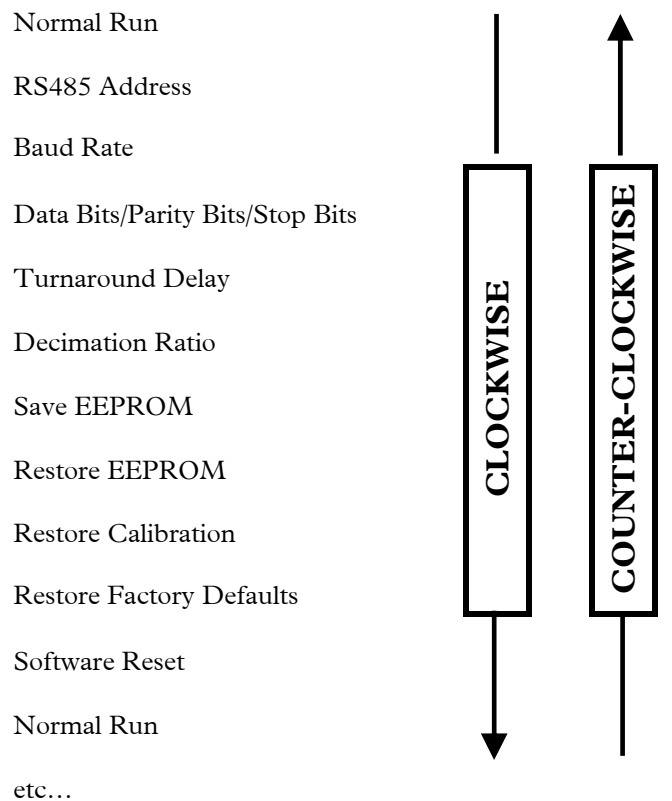
Figure 4.4

# 5. Troubleshooting

## 5.1. Advanced Setup Guide

The HPM-2002-OBE has several setup and control commands which can be accessed by using the ADJUST rotary encoder and SELECT pushbutton and at the same time viewing the display. Note that most of the commands, which are described below, can be accessed using equivalent RS232/485 commands.

The advanced setup is accessed from the Run mode. With the Run light illuminated (and not flashing), each click of the ADJUST rotary encoder in the clockwise direction will advance the display through each command. Once arriving at the desired command, the user can change the parameter (or initiate command) by pressing the SELECT pushbutton. When finished with the advanced setup, the user may return to the normal Run mode by turning the ADJUST counter-clockwise until the pressure is once again displayed. The parameters are not stored upon leaving the command and entering the normal Run mode via ADJUST. To make the changes permanent, the SAVE EEPROM command is used. Note that turning the ADJUST clockwise indefinitely will simply cycle through the commands.



The following list gives a description of each of the commands listed above along with the syntax for the equivalent RS232/485 command. See RS232/485 section for more details.

### RS485 Address

A\_01

Multipoint A\_01, A\_02, ... A\_FE, A\_FF

The RS485 address is the multipoint address of the HPM-2002-OBE. If the unit is configured for RS232, then this parameter must set to a value of E0 or greater.

(Valid multipoint range 01 to DF)

\*{aa}A={aa}<CR>



## Baud Rate

B\_2.4

B\_2.4, B\_4.8, B\_9.6, B\_19.2, B\_38.4, B\_57.6, B\_125, B\_250, B\_500

The baud rate is given in kbaud. For example, B\_9.6 corresponds to a 9600 baud.

Note: There is no equivalent RS232/485 command.

## Data Bits/Parity Bits/Stop Bits

P8n1

8n1, 8n2, 7n2, 7E1, 7E2, 7o1, 7o2, 701, 702, 711, 712

The first character, "8" corresponds to the number of data bits. (e.g. 7 or 8).

Second character, "n" corresponds to the parity bit. (e.g. n- no parity, E- even parity, o- odd parity, 0- space, 1- mark)

The last character, "1" corresponds to the number of stop bits. (e.g. 1 or 2)

Note: There is no equivalent RS232/485 command.

## Turnaround Delay

dt06

dt00, dt01, ...dtFE, dtFF

The turnaround delay is unique to multipoint communications. It is the delay between receipt of an incoming command to transmission of the response. Each increase in the hex value corresponds to an increase in the delay time of approximately 8 ms.

\*{aa}T={dd}<CR>

## Decimation Ratio

dr5F

5F, 6F, ..., FF

The decimation ratio can be used to set the amount of sampling which is performed by the HPM-2002-OBE's A/D converters. The higher the value of the hex number, the more sampling takes place before the pressure reading is updated. More sampling leads to more stability of pressure readings particularly below 1 mTorr. However, the increased sampling increases the response time of the gauge to sudden pressure changes.

D={dddd}<CR>

## Save EEPROM

S\_EE

Save EEPROM stores the calibration parameters which are in the HPM-2002-OBE's CPU into the HPM-2002-OBE's CPU board's EEPROM. The CPU board's EEPROM is not the HPM-2002s tube EEPROM. The CPU board EEPROM stores the gauge setup (baud rate, parity, address, set points, gas selection, etc.). The HPM-2002s tube EEPROM stores the tube's calibration parameters.

EEW<CR>

## Restore EEPROM

r\_EE

Restore EEPROM transfers the setup from the HPM-2002-OBE's CPU board's EEPROM into the HPM-2002-OBE's CPU.

EER<CR>

## Restore Calibration

r\_CL

Restore Calibration transfers the calibration from the HPM-2002s tube EEPROM into the HPM-2002-OBE's CPU.

EEI<CR>

## Restore Factory Defaults

r\_Fd

The Restore Factory Default command is used to place calibration parameters into the CPU. From this point the gauge can be calibrated. After calibration, the calibration parameters are stored in the HPM-2002s tube's EEPROM.

/#<CR>

## Software Reset

rrrr

This command performs a complete reboot of the HPM-2002-OBE. The CPU is reset and the tube's calibration parameters are loaded.

/r<CR>

## **5.2. Frequently Asked Questions**

### Why does my display read, "Err1"?

This message indicates that an error has occurred during transfer of data between the HPM-2002-OBE's CPU and the sensor tube's EEPROM where the calibration coefficients are stored. If this error occurs during initial startup, then the factory default calibration coefficients will be automatically loaded. The factory defaults are often not accurate (typically  $\pm 50\%$  or greater), however they allow the user to calibrate the gauge. If the sensor tube's EEPROM cannot communicate with the CPU, then any new calibration will be lost when the gauge power is disconnected.

Sensor tube EEPROM performance can be verified by use of the RESTORE FACTORY DEFAULTS and the RESTORE CALIBRATION commands in the following manner. After calibration, use the RESTORE FACTORY DEFAULTS command. The pressure reading will shift dramatically. Immediately use the RESTORE CALIBRATION command. The pressure reading will return to the calibration value if the tube EEPROM communication is working properly. See the advanced setup guide (Section 5.1) for more information.

### Why does my display read, "Err2"?

This message indicates that an error has occurred in the CPU's EEPROM where the set points, gas number, and communication port settings are stored. If this error occurs during initial startup, then the factory default values for these settings will be in effect. CPU EEPROM performance can be verified by use of the RESTORE EEPROM command. See the advanced setup guide (Section 5.1) for more information. Caution: Use of the SAVE EEPROM command at this time will overwrite all previously stored values with default values.

Note: An "Err2" message is an exceedingly rare occurrence. If this error occurs then the CPU's EEPROM is most likely defective.

### Why does my display read, "Err4"?

This message indicates that a communications error has occurred between the HPM-2002-OBE and a data acquisition computer. This error is associated with the serial interface (RS232/485) and can indicate a baud rate or parity mismatch, a framing error or an overrun condition. The error can also occur if the data acquisition computer is powered down while the HPM-2002-OBE is still connected.

Modifying as necessary the baud rate, parity, word length and/or the stop bits on either the data acquisition computer or the HPM-2002-OBE, usually eliminates this error. Many operating systems are shipped with a

communications program (e.g. Windows® Hyperterminal) which can be used to communicate with RS232 versions of the HPM-2002-OBE. The Transmit Device Status (“S<CR>”) command will retrieve the HPM-2002-OBE’s status register. A successful read of the status register will clear the “Err4” condition.

### **What are Err3, Err5, Err6 and Err7?**

These are simultaneous error conditions, i.e. Err3 = Err1+Err2.

### **Why does my display read, “U.U”?**

“U.U” stands for unconnected piezo/unconnected Pirani. This message indicates that the voltage readings from the sensors are outside any usable range. Most often this occurs when there is no sensor tube connected to the HPM-2002-OBE. This error will also occur if there is a problem with the user’s DC power supply. Verify that the voltage supplied to the HPM-2002-OBE is within the specified range using a voltmeter at pins 3 and 4 on the power cable. After power verification and with the voltage still applied, hot plug the cable into the HPM-2002-OBE. If the “U.U” still appears, most likely the sensor tube (HPM-2002s) needs to be replaced.

### **Why does my display read, “U.”?**

“U.” stands for unconnected piezo. This message indicates that the voltage reading from the piezoresistive sensor is outside any usable range. While this message can mean that the sensor tube (HPM-2002s) will need to be replaced, it can also indicate that the piezo zero calibration parameter, which is stored in the sensor tube’s EEPROM, has become corrupted or lost. (See next FAQ)

### **Why does my display temporarily show, “U.” as I pump the system down?**

“U.” stands for unconnected piezo. This message may flash near the dual sensor crossover pressure range if the piezo zero calibration parameter has been corrupted or lost.

The RESTORE CALIBRATION command will download the calibration parameters from the HPM-2002-OBE to the sensor tube. See the advanced setup guide (Section 5.1) for more information. If the error persists at the crossover point, then a calibration of the Piezo sensor should be performed. The Piezo Zero is updated when the Pirani pressure is less than 125 mTorr. In order to update and save the Piezo Zero parameter:

- Pump out to 100 mTorr or less
- Using SELECT, step to the CAL function
- Rotate ADJUST one step in either direction and then back to its original position (CAL light starts flashing)
- Using SELECT, exit the CAL function and return to the Run mode

Changing the Piezo Zero will shift the atmospheric reading by the same amount. therefore the atmospheric reading should also be checked and re-adjusted if necessary.

### **Why does my display read, “. U”?**

This message indicates that the voltage readings from the thin film Pirani sensor are outside any usable range. This usually indicates that the sensor is defective and will need to be replaced.

# 6. WARRANTY

## 6.1. Warranty Repair Policy

Hastings Instruments warrants this product for a period of one year from the date of shipment to be free from defects in material and workmanship. This warranty does not apply to defects or failures resulting from unauthorized modification, misuse or mishandling of the product. This warranty does not apply to batteries or other expendable parts, or to damage caused by leaking batteries or any similar occurrence. This warranty does not apply to any instrument which has had a tamper seal removed or broken.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty as to fitness for a particular use. Hastings Instruments shall not be liable for any indirect or consequential damages.

Hastings Instruments, will, at its option, repair, replace or refund the selling price of the product if Hastings Instruments determines, in good faith, that it is defective in materials or workmanship during the warranty period. Defective instruments should be returned to Hastings Instruments, **shipment prepaid**, together with a written statement of the problem and a Return Material Authorization (RMA) number.

Please consult the factory for your RMA number before returning any product for repair. Collect freight will not be accepted.

## 6.2. Non-Warranty Repair Policy

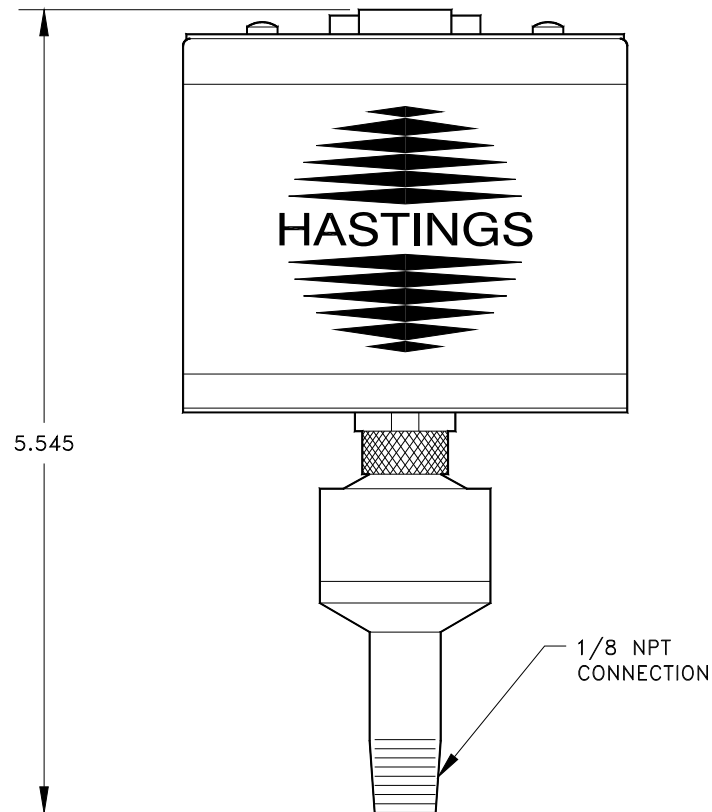
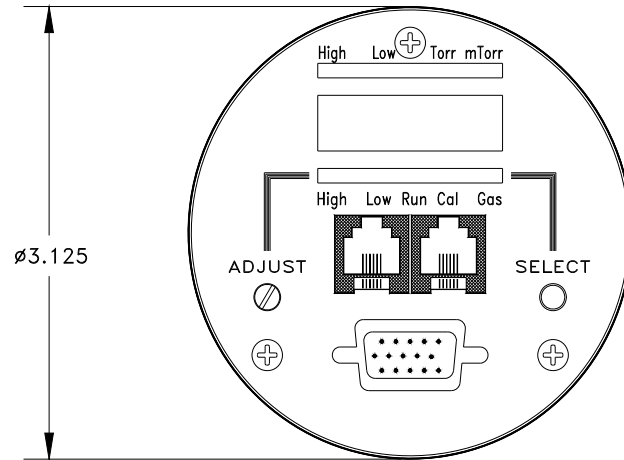
Any product returned for a non-warranty repair must be accompanied by a purchase order, RMA form and a written description of the problem with the instrument. If the repair cost is higher, you will be contacted for authorization before we proceed with any repairs. If you then choose not to have the product repaired, a minimum will be charged to cover the processing and inspection. Please consult the factory for your RMA number before returning any product repair.

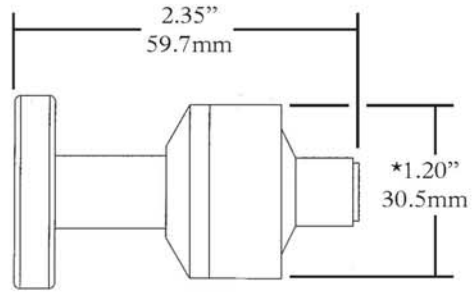
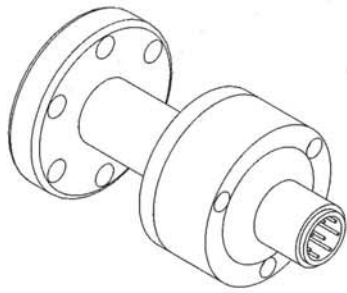
TELEDYNE HASTINGS INSTRUMENTS  
804 NEWCOMBE AVENUE  
HAMPTON, VIRGINIA 23669 U.S.A.  
ATTENTION: REPAIR DEPARTMENT

TELEPHONE	(757) 723-6531
TOLL FREE	1-800-950-2468
FAX	(757) 723-3925
E MAIL	<a href="mailto:hastings_instruments@teledyne.com">hastings_instruments@teledyne.com</a>
INTERNET	<a href="http://www.teledyne-hi.com">http://www.teledyne-hi.com</a>

Repair Forms may be obtained from the "Information Request" section of the Hastings Instruments web site.

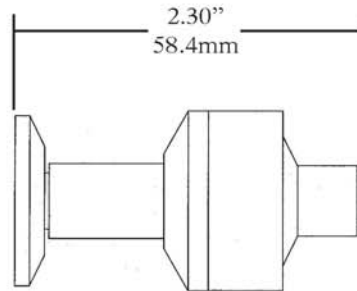
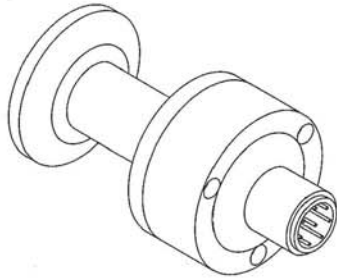
# 7. Diagrams and Drawings



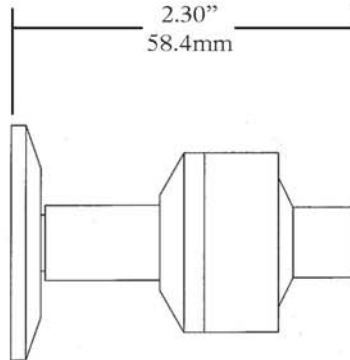
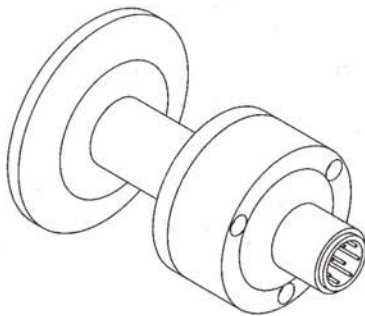


\*1.20 diameter dimension of tube shell is typical on all HPM-2002 series tubes

**Mini Conflat™ (HPM 2002s-03)**

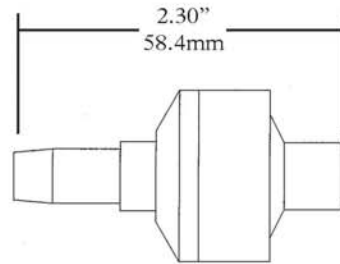
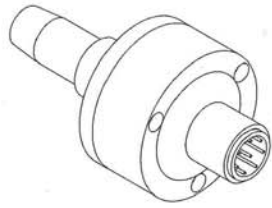


**KF-16 (HPM 2002s-05)**

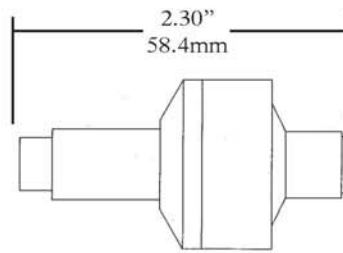
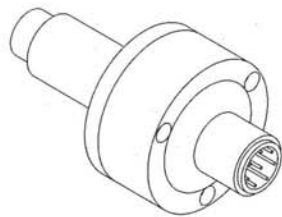


**KF-25 (HPM 2002s-06)**

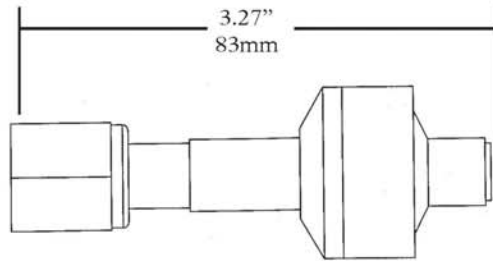
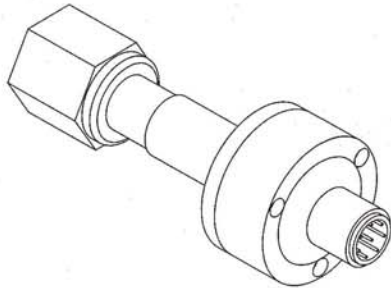
**Tube Outline Drawings** (all dimensions shown are approximate)



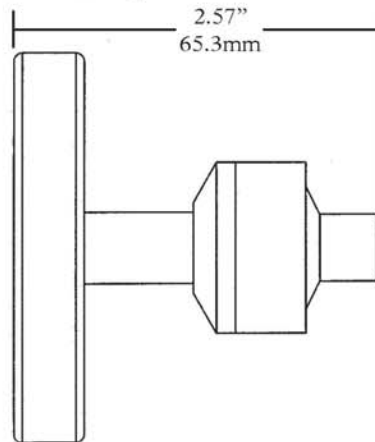
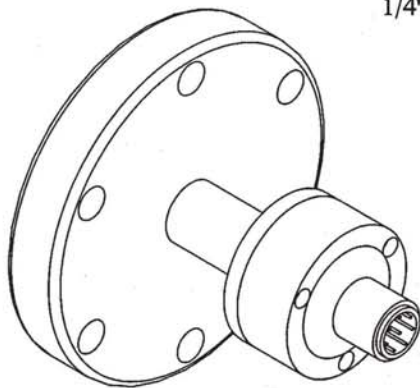
**1/8" NPT (HPM 2002s-01)**



**1/2" O.D. Smooth Tube (HPM 2002s-07)**



**1/4" VCR (HPM 2002s-02)**



**2-3/4" Conflat™ (HPM 2002s-04)**

**Tube Outline Drawings (all dimensions shown are approximate)**

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