PCB PIEZOTRONICS
AN AMPHENOL COMPANY

Model 116A05

High temperature (+800 F/427 C) pressure sensor, 100 psi, 7 pC/psi

Installation and Operating Manual

For assistance with the operation of this product,
contact the PCB Piezotronics, Inc.

Toll-free: 716-684-0001
24-hour SensorLine: 716-684-0001
Fax: 716-684-0987
E-mail: info@pcb.com
Web: www.pcb.com

Total Customer Satisfaction
PCB PIEZOTRONICS

1.0 INTRODUCTION

Charge mode pressure sensors offer high performance for precise pressure measurements over a wide range of near-static and dynamic pressures. The sensors use piezoelectric properties to convert an applied pressure into an analogous electrical charge.

The internal design of a sensor incorporates a sensing element that provides high sensitivity over a wide range of pressures. As pressure is applied to the diaphragm of the sensor, a charge is generated in the crystals. The high-impedance electrostatic charge is then conditioned externally by either a laboratory-style charge amplifier or in-line charge converter prior to being sent to a readout or recording device.

Charge mode sensors are ideally suited for applications where wide dynamic range is needed. Such applications include compressors, engines, blast, ballistic, pneumatic, hydraulic, and fluid pressures. Enclosed is a Specification Sheet that lists the complete performance characteristics of the sensor purchased.

2.0 Series 176 High Temperature Sensor

The Series 176 High temperature sensor is a special- purpose high temperature charge mode pressure sensor designed specifically to measure pressures in severe environments. The unit is most frequently used in engines, hydraulic and pneumatic devices, compressors and turbines. Ideal for sound pressure measurements, microphones and small pressure agitations.

This sensor measures transient or repetitive phenomena relative to the initial or average pressure level, over a wide amplitude range. This sensor contains extremely rigid compression-mode crystals with an integral acceleration compensating crystal to reduce vibration sensitivity and partially suppress internal resonance effects.

Manual Number: 30737
Revision: B
ECR Number: 56543

3.0 Installation

3.1 Overview

When choosing an installation method, the advantages and disadvantages of each method must be carefully weighed. Characteristics like location, ruggedness, amplitude range, accessibility, temperature and portability may be greatly affected by the installation configuration and technique. Often, the most important and overlooked consideration is the affect the mounting technique has on the frequency of the pressure being measured by the sensor.

Two basic mounting techniques are recommended for pressure sensors: the recess mount and the flush mount. The technique used is determined by the specifics of the individual application. See the Installation Drawing in this manual for additional details on the individual sensor series.

3.2 Recess Mount

A recess mount protects the sensor diaphragm from the effect of high flash temperature and particle impingement. This method is often selected because it can prolong sensor life and increase data integrity by reducing thermal effects. See Figure 3.1.

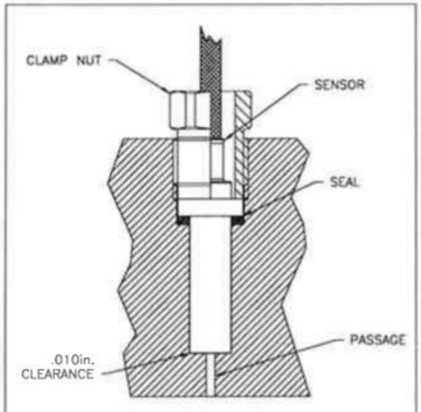


Figure 3.1 Recess Mount

When using a recess mount, note that the length of the passage may limit the frequency range of the measurement. The effect the passage has is similar to that of an under-damped second order system, with the resonant frequency determined by passage length. The passage length thus limits pressure pulse rise time and may also cause passage ringing.

The function is described by the following equation:

$$F_r = \frac{V}{4L}$$

Where: F_r = resonant frequency passage (Hz)
V = velocity of sound in air (feet/second)
L = length of column (feet)

For air at room temperature, the equation becomes:

$$F_r = \frac{3300}{L}$$

Where: L = passage length (inches)

The natural frequency and approximately fastest pressure step rise time for various length passages are shown in the following chart, using a medium of air at 77°F (25°C).

Selected Values for 77°F (25°C)

Passage length (inches)	Passage resonance (kHz)	Approx, fastest pulse rise time (microseconds)
.050	66	5
.100	33	10
.200	16.5	20
.50	6.6	50
1.0	3.3	100

Measured resonant frequencies may differ slightly from the chart values due to variations in the velocity of sound in the air from changes in temperature and pressure of the air in the passage.

To ensure diaphragm integrity, maintain .006 inches (.153 mm) of clearance ahead of the diaphragm as shown in Figure 3.1.

3.3 Flush Mount

In a flush mount installation, there is no reduced area passage from the sensor diaphragm to the test chamber. Instead, the sensor diaphragm is mounted flush with, or slightly recessed from, the inside surface of the test chamber. See Figure 3.2.

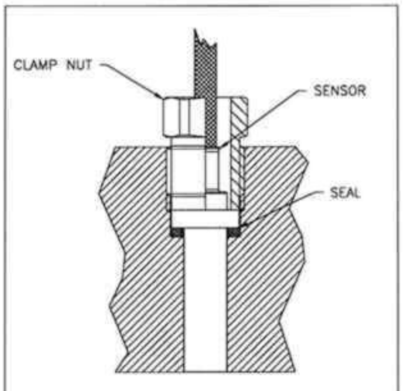


Figure 3.2 Flush Mount

If thermal transients or diaphragm impingement are concerns, use the flush mount technique only when space or frequency response considerations preclude the use of the recess mount installation.

In severe or pyrotechnic environments, sensor life may be seriously curtailed when using this mounting method.

3.4 Cabling

Care and attention to cable attachment is essential, as the reliability and accuracy of your system is no better than that of the output cable. First, check that you have ordered the correct cable type. As with sensors, no cable can satisfy all applications. Special low-noise cabling should be used with high-impedance, charge output devices.

Plug the connector on the cable into the mating connector on the sensor. Then, holding the sensor stationary, secure the connector in place by tightening down the attached cable sleeve.

Route the cable to a charge amplifier or in-line charge converter, making certain to strain relieve the sensor/cable connection and minimize motion by clamping the cable at regular intervals. Common sense must be used to avoid physical damage and minimize electrical noise. Avoid routing cables near high voltage wires. Do not route cables along floors or walkways where they may be stepped on or become contaminated. Shielded cable should have the shield grounded at one end only.

To dissipate any charge that may have accumulated in the cable, short the pins to ground prior to attachment to the charge amplifier or charge converter.

4.0 CALIBRATION

These sensors may be calibrated using static hydraulic techniques, such as dead-weight testers, or by comparison with a reference gage.

When calibrating with a laboratory-style charge amplifier, set the charge amplifier to LONG, for the time constant setting, and allow the sensor to stabilize before applying pressure. If slow drift is apparent, apply the pressure to the desired level, and immediately take a reading. Release the pressure and take another reading at zero pressure to obtain the difference between the readings at the desired present level and zero pressure. If the drift is too fast to take a reading, clean the cable connections according to the procedures out-lined in Section 7.0, Maintenance.

NOTE: Do not attempt to use a charge amplifier which, in the long time constant position, has less than a 5 000-second time constant for quasi-static calibration of charge sensors. Any drift may cause error.

A factory-supplied, NIST-traceable calibration graph is provided with each sensor, certifying its charge sensitivity in pC/psi, or when used with an in-line amplifier, in mV/psi.

5.0 Normal Operation

The high impedance signal generated by a charge output sensor is usually conditioned with a laboratory-style charge amplifier. The charge amplifier converts the high-impedance charge signal generated by the sensor into a low-impedance voltage signal. This signal may then be transmitted to a readout or recording device for analysis. See Figure 5.1 for a drawing of a typical system connection.

NOTE: When using charge-amplified systems, the noise floor of the system is dependent on the input capacitance to the charge amplifier. To minimize noise, keep the cable length between the pressure sensor and the charge amplifier to a minimum. Cable length does not affect the system sensitivity.

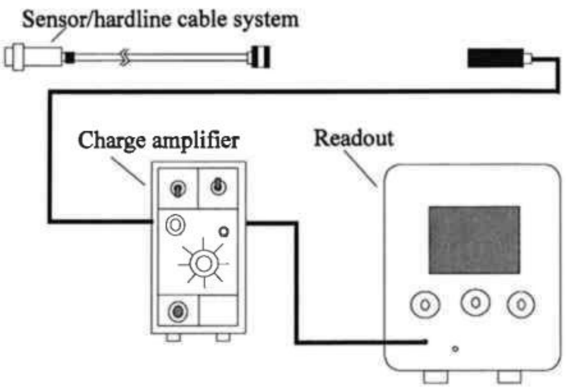


Figure 5.1 Typical System Connection

Before connecting the low-noise cable from the pressure sensor to the charge amplifier, be certain to ground the charge amplifier. This ensures that any excessive accumulated static charges across the sensor/cable combination are harmlessly discharged. If this precaution is not observed, the input FET of certain amplifiers may be destroyed. Press the ground button of the charge amplifier and adjust electrical zero if necessary.

Once system components are connected, wait a few minutes for the system to thermally stabilize. Place the switch in the OPR (operate) position and proceed with the measurement. Refer to the charge amplifier operating manual for further operating details.

For fixed sensitivity in-line charge amplifiers, the system sensitivity (mV/psi) is determined as the product of the charge amplifier sensitivity (mV/pC) and the sensor sensitivity (pC/psi).

6.0 HIGH-TEMPERATURE OPERATION

6.1 Introduction

When subjected to elevated temperature, all piezoelectric sensors/hardline cable systems exhibit decreased insulation resistance, due in part to the piezoelectric element, but due mostly to the hardline cable necessary to withstand the high temperatures. This situation can cause serious voltage offset problems in direct-coupled charge amplifiers. To solve this problem, the user must AC couple (capacitor) the charge amplifier to the sensor/cable system. See Section 6.3, Solution to Reduced Resistance, for complete details, or use different amplifiers.

6.2 Reduced Resistance at Charge Amplifier Input

Figure 6.1 illustrates a simplified schematic of a typical direct-coupled charge amplifier where:

Rf = Feedback resistor (ohms)
R; = Input leakage resistance (ohms)
Eo = Steady-state output voltage (volts)
e, = Offset voltage: FET leakage (volts)
Cf = Feedback capacitor (farads)

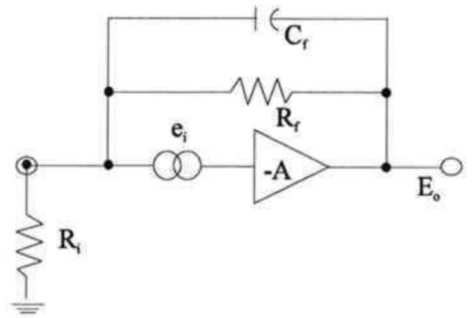


Figure 6.1 Typical Charge Amplifier Schematic

The feedback capacitor Cf comes into play only in the dynamic situation and its influence does not affect the steady-state situation. The voltage e, is a DC offset voltage, usually very tiny (microvolts), that exists at the input gate of the MOSFET circuit. This minute leakage current exists in all real devices.

As demonstrated in Equation 1, the steady-state (DC) output voltage Eo is:

Equation 1

$$E_o = e_i\left(1+\frac{R_f}{R_i}\right)$$

This equation shows that if the input (leakage) resistance at the charge amplifier is extremely high (approaching infinity), the output DC voltage approaches ei, usually a very tiny voltage. However, as Rj decreases, the term

$$1+\frac{Rr}{Ri}$$

increases, such that the output voltage can, with large ratios of Rf / R,, become large enough to result in a large Eo, perhaps large enough to be outside the normal output voltage range of the charge amplifier.

Because of the feedback capacitor Cf, this output voltage change usually does not occur rapidly but rather, it manifests itself as a slow drift in the output voltage level. If R, is low enough with respect to Rf, the voltage drift may continue until saturation of the charge amplifier occurs.

6.3 Solution to Reduced Resistance

Since the drift or offset problem is caused by a static or steady-state imbalance at the input of the charge amplifier, the solution involves blocking this steady-state effect while allowing the desired dynamic phenomena to pass. This may be accomplished by installing a series capacitor at the input of the charge amplifier, between the offending sensor (or low-impedance hardline) and the input.

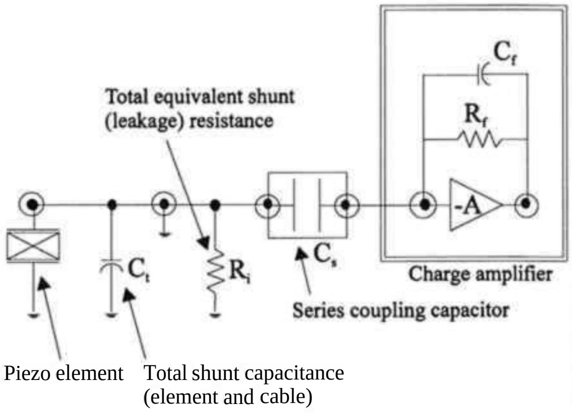


Figure 6.2 Piezoelectric System Block Diagram

Figure 6.2 illustrates a block diagram of the piezoelectric system where:

Ct = Shunt capacitor
Cs = Series blocking capacitor

With the series blocking capacitor Cs in place as shown, the dynamic charge (Q) generated by the sensor element is distributed across the two capacitors, Ct and Cs, in proportion to the size (capacitance) of each. If Cs, for example, is equal to 100 times Ct, 99% of the charge appears at the input of the charge amplifier, while 1% is across the shunt capacitor Ct. This results in a I% decrease in apparent sensitivity of the system.

This therefore demonstrates the importance of selecting the series blocking capacitor at least two orders of magnitude higher than the total shunt capacitance Ct across the input of the charge amplifier.

It is also important that this capacitor be of high quality, with a leakage resistance of greater that 1012 ohms, to avoid the DC offset discussed previously in 6.1, Introduction.

6.4 Low-Frequency Response Limitations

In a normal charge amplifier, the low-frequency response is set by the RC time constant, as established by the product of Cf and Rf. The system acts like a high-pass first order RC filter with a -3 dB frequency established by the relationship:

Equation 2

$$f_o = \frac{.16}{R_f C_f}$$

where:

f0 = -3 dB Frequency (Hz)
Rf = Feedback resistor (ohms)
Ct = Feedback capacitor (farads)

However, after the addition of the series blocking capacitor Cs, the system becomes the equivalent of two high-pass filters in series, one as previously mentioned and one comprised of series capacitor Cs and total equivalent shunt resistance R;. This new cutoff frequency is:

Equation 3

$$f_o = \frac{.16}{R_i C_s}$$

To avoid compromise of the low-frequency response established by the charge amplifier parameters and illustrated by Equation 2, the product of RCS should be several orders of magnitude higher than RfCf.

The approximate final system discharge time constant becomes:

Equation 4a

$$TC = \frac{1}{R^{\wedge}+RfCf} \qquad \text{seconds}$$

If the input coupling time constant (RC,) is very much greater than the discharge time constant of the charge amplifier (RfCf), Equation 4a then becomes:

Equation 4b

$$\frac{1}{RA} \Rightarrow 0 \text{ Seconds}$$

Equation 5

$$TC = RfCf$$

With the product RCS chosen to be much greater than RfCf , the system discharge time constant is simply RfCf (seconds). The feedback parameters of the charge amplifier establish the low frequency characteristics of the system, unaffected by the degraded input resistance parameters of the test sensor and/or cable.

6.5 Other Precautions

Always remember to keep the OPR-GND switch on the charge amplifier in the GND position while connecting or disconnecting sensors, cable, or capacitor to the input connector. Stray or accumulated electrostatic charges may build to the point that they may saturate or even damage the input circuitry of the charge amplifier.

Operate the charge amplifier in the SHORT time constant while the sensor is subject to elevated or changing temperatures.

If it is not necessary to procure data during the transition from room temperature to operating temperature, place the OPR-GND switch in the GND position to keep spurious, thermally generated charges grounded.

It is prudent to momentarily switch to the GND position even during the measurement period to ensure that excess charges do not accumulate at the input of the charge amplifier.

7.0 MAINTENANCE

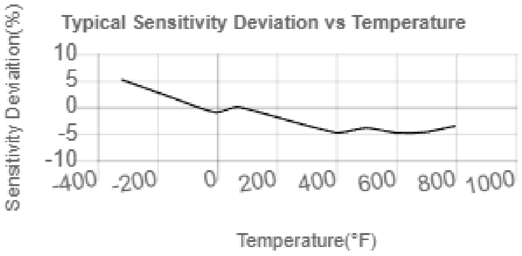
The only maintenance required on the pressure sensor is to keep the connector clean. If it is operating in a dirty environment, protect the cable connections with heat-shrink tubing or similar material.

In the event that the electrical connection of the pressure sensor becomes contaminated with dirt or moisture, the insulation resistance degrades. This may cause a reduction of sensitivity or excessive drifting when connected to the charge amplifier. If this happens, brush off the connector with no-residue solvent or other approved cleaning solutions. To restore insulation, bake the sensor in a vacuum oven at 250°F for about four hours. If the condition persists even after cleaning and/or baking, please contact a PCB applications engineer for further assistance. The sensor is hermetically sealed; it must therefore be returned to the factory if the aforementioned measures fail to restore performance.

Model Number		
116A05	**CHARGE OUTPUT PRESSURE SENSOR**	Revision: NR ECN #: 55557

Performance	**ENGLISH**	**SI**	
Sensitivity(+/- 15 %)	7 pC/psi	101.5 pC/bar	
Measurement Range	100 psi	6.9 bar	
Maximum Pressure(Total)	4,000 psi	275.8 bar	
Resonant Frequency	≥ 100 kHz	≥ 100 kHz	
Transverse Resonance	> 15 kHz	> 15 kHz	
Frequency Response(± 5.0 %)	20,000 Hz	20,000 Hz	[1]
Non-Linearity	≤ 1 % FS	≤ 1 % FS	[2]
Environmental			
Maximum Shock(Axially)	2,000 g pk	19,620 m/s^2 pk	[3]
Acceleration Sensitivity	0.01 psi/g	0.007 $kPa/(m/s^2)$	[4]
Acceleration Sensitivity	0.004 psi/g	0.0028 $kPa/(m/s^2)$	[5]
Temperature Range(Operating)	-320 to 800 °F	-196 to 427 °C	
Temperature Response	See Graph	See Graph	[5]
Maximum Flash Temperature	3,000 °F	1,650 °C	
Electrical			
Output Polarity(Positive Pressure)	Negative	Negative	
Capacitance	27 pF	27 pF	[5]
Case Isolation(800°F/430°C)	≥ 50 kohm	≥ 50 kohm	
Insulation Resistance(Room Temp)	≥ 10^{12} Ohm	≥ 10^{12} Ohm	
Case Isolation(Room Temp)	≥ 10^{12} Ohm	≥ 10^{12} Ohm	
Insulation Resistance(800°F/430°C)	≥ 50 kohm	≥ 50 kohm	
Physical			
Sensing Element	UHT-12™	UHT-12™	
Sensing Geometry	Compression	Compression	
Housing Material	Nickel Alloy	Nickel Alloy	
Sealing	Welded Hermetic	Welded Hermetic	
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack	
Weight	0.61 oz	17.2 gm	[5]

CE UKCA [6]



All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.

OPTIONAL VERSIONS

Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.

NOTES:

[1]Upper frequency response is calculated from Resonant Frequency.
[2]Zero-based, least-squares line method.
[3]Half-sine pulse duration, 1 msec
[4]Maximum.
[5]Typical.
[6]See PCB Declaration of Conformance PS158 for details.

SUPPLIED ACCESSORIES:

Model 060A25 Clamp Nut (1)
Model 40890-04 Silver Plate, SS, Seal (3)
Model PCS-1 Calibration of dynamic pressure sensors up to 100% range

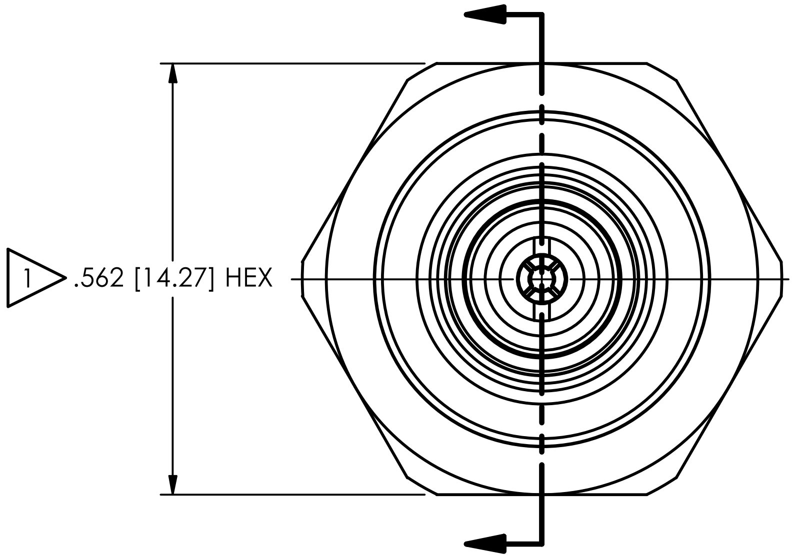
Entered: ND	Engineer: AK	Sales: RWM	Approved: RPF	Spec Number:
Date: 04/24/2025	Date: 04/24/2025	Date: 04/24/2025	Date: 04/24/2025	78288

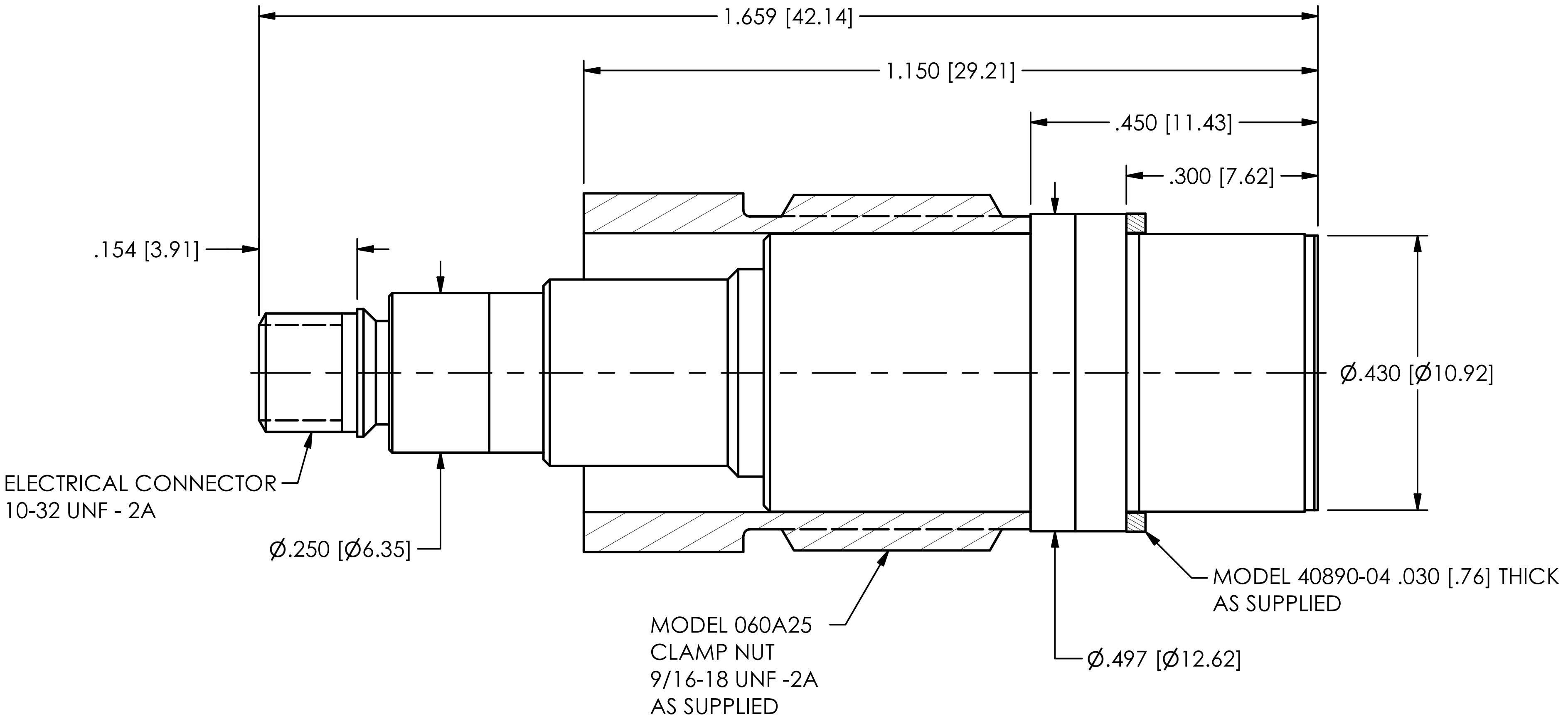
PCB PIEZOTRONICS
AN AMPHENOL COMPANY

Phone: 716-684-0001
Fax: 716-684-0987
E-Mail: info@pcb.com

3425 Walden Avenue, Depew, NY 14043

REVISIONS		
REV	DESCRIPTION	DIN
NR	RELEASED TO DRAFTING	55557

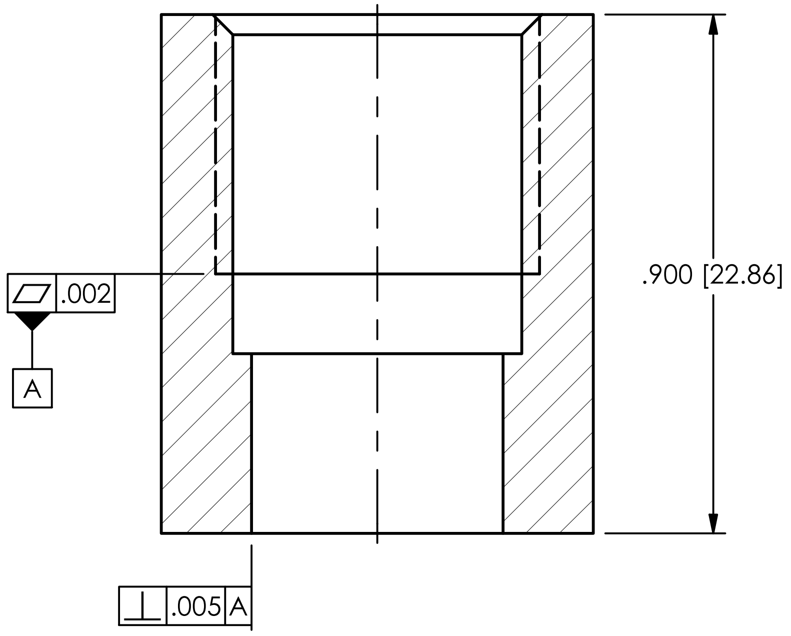




1 MOUNTING HOLE PREPARATION:

Ø.437 ±.001 [11.10 ±.03] THRU

9/16-18 UNF - 2B ↧.450 [11.43]



1 RECOMMENDED MOUNTING TORQUE: 5.0 - 6.0 FT-LBS [7 - 8 Nm]

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	
DIMENSIONS IN INCHES DECIMALS XX ±.01 XXX ±.005 ANGLES ± 2 DEGREES	DIMENSIONS IN MILLIMETERS [IN BRACKETS] DECIMALS X ± 0.3 XX ± 0.13 ANGLES ± 2 DEGREES
CABLE TOLERANCES IN ENGLISH 1"≤ LENGTH < 1' = +1"/ - 0 1'≤ LENGTH < 5' = +2"/ - 0 5'≤ LENGTH < 100' = +6"/ - 0 100'≤ LENGTH = +1'/ - 0	CABLE TOLERANCES IN METRIC 2.54cm ≤ LENGTH < 30.5cm = +2.54cm/ - 0 30.5cm ≤ LENGTH < 1.5m = +5.1cm/ - 0 1.5m ≤ LENGTH < 30.5m = +15.2cm/ - 0 30.5m ≤ LENGTH = +30.5cm/ - 0
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13

DRAWN		CHECKED		ENGINEER	
AME	4/10/25	JDM	4/10/25	APK	4/10/25

TITLE

INSTALLATION DRAWING
MODEL 116A05
HIGH TEMPERATURE PRESSURE SENSOR

PCB PIEZOTRONICS
AN AMPHENOL COMPANY
3425 WALDEN AVE. DEPEW, NY 14043
(716) 684-0001 E-MAIL: sales@pcb.com

CODE IDENT. NO.	SIZE	DWG. NO.
52681	B	78287

SCALE: 5X
SHEET 1 OF 1