Model 165A02

OBSOLETE See 165B02 Ballistic shot shell pressure sensor, 15k psi,

Installation and Operating Manual

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

Toll-free: 800-828-8840
24-hour SensorLine: 716-684-0001
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PCB PIEZOTRONICS INC.
A PCB GROUP COMPANY

Warranty, Service, Repair, and Return Policies and Instructions

The information contained in this document supersedes all similar information that may be found elsewhere in this manual.

Total Customer Satisfaction – PCB Piezotronics guarantees Total Customer Satisfaction. If, at any time, for any reason, you are not completely satisfied with any PCB product, PCB will repair, replace, or exchange it at no charge. You may also choose to have your purchase price refunded in lieu of the repair, replacement, or exchange of the product.

Service – Due to the sophisticated nature of the sensors and associated instrumentation provided by PCB Piezotronics, user servicing or repair is not recommended and, if attempted, may void the factory warranty. Routine maintenance, such as the cleaning of electrical connectors, housings, and mounting surfaces with solutions and techniques that will not harm the physical material of construction, is acceptable. Caution should be observed to insure that liquids are not permitted to migrate into devices that are not hermetically sealed. Such devices should only be wiped with a dampened cloth and never submerged or have liquids poured upon them.

Repair – In the event that equipment becomes damaged or ceases to operate, arrangements should be made to return the equipment to PCB Piezotronics for repair. User servicing or repair is not recommended and, if attempted, may void the factory warranty.

Calibration – Routine calibration of sensors and associated instrumentation is recommended as this helps build confidence in measurement accuracy and acquired data. Equipment calibration cycles are typically established by the users own quality regimen. When in doubt about a calibration cycle, a good "rule of thumb" is to recalibrate on an annual basis. It is also good practice to recalibrate after exposure to any severe temperature extreme, shock, load, or other environmental influence, or prior to any critical test.

PCB Piezotronics maintains an ISO-9001 certified metrology laboratory and offers calibration services, which are accredited by A2LA to ISO/IEC 17025, with full traceablility to N.I.S.T. In addition to the normally supplied calibration, special testing is also available, such as: sensitivity at elevated or cryogenic temperatures, phase response, extended high or low frequency response, extended range, leak testing, hydrostatic pressure testing, and others. For information on standard recalibration services or special testing, contact your local PCB Piezotronics distributor, sales representative, or factory customer service representative.

Returning Equipment – *Following these procedures will insure that your returned materials are handled in the most expedient manner.* Before returning any equipment to PCB Piezotronics, contact your local distributor, sales representative, or factory customer service representative to obtain a Return

Materials Authorization (RMA) Number. This RMA number should be clearly marked on the outside of all package(s) and on the packing list(s) accompanying the shipment. A detailed account of the nature of the problem(s) being experienced with the equipment should also be included inside the package(s) containing any returned materials.

A Purchase Order, included with the returned materials, will expedite the turn-around of serviced equipment. It is recommended to include authorization on the Purchase Order for PCB to proceed with any repairs, as long as they do not exceed 50% of the replacement cost of the returned item(s). PCB will provide a price quotation or replacement recommendation for any item whose repair costs would exceed 50% of replacement cost, or any item that is not economically feasible to repair. For routine calibration services, the Purchase Order should include authorization to proceed and return at current pricing, which can be obtained from a factory customer service representative.

Warranty – All equipment and repair services provided by PCB Piezotronics, Inc. are covered by a limited warranty against defective material and workmanship for a period of one year from date of original purchase. Contact PCB for a complete statement of our warranty. Expendable items, such as batteries and mounting hardware, are not covered by warranty. Mechanical damage to equipment due to improper use is not covered by warranty. Electronic circuitry failure caused by the introduction of unregulated or improper excitation power or electrostatic discharge is not covered by warranty.

Contact Information – International customers should direct all inquiries to their local distributor or sales office. A complete list of distributors and offices can be found at www.pcb.com. Customers within the United States may contact their local sales representative or a factory customer service representative. A complete list of sales representatives can be found at www.pcb.com. Toll-free telephone numbers for a factory customer service representative, in the division responsible for this product, can be found on the title page at the front of this manual. Our ship to address and general contact numbers are:

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DOCUMENT NUMBER: 21354
DOCUMENT REVISION: B
ECN: 17900

1.0 INTRODUCTION

The Model 165A02 is a general purpose, charge mode ballistics transducer with heliarc-welded diaphragm and a rugged quartz element of proven reliability. The transducer's welded diaphragm provides better transient thermal characteristics, important for ballistics applications. The rugged piezoelectric element utilizes synthetic quartz crystals to convert instantaneous pressure changes to an analogous electrostatic charge. Chamber pressure is sensed by the transducer as the round is fired.

The transducer also serves as a replacement for other diaphragm-type gauges. In addition to ballistics testing, the Model 165A02 can be used for hydraulic and pneumatic test applications.

2.0 DESCRIPTION

Figure 2.1 shows the external configuration of the Model 165A02. The unit is housed in a lightweight stainless steel case and has a stainless steel diaphragm. It comfortably tolerates ambient temperatures ranging from -400 to +400 °F (-240 to +204 °C).

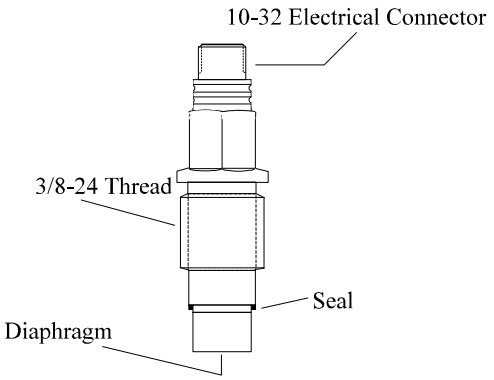

Figure 2.1 Model 165A02 External Configuration

The 3/8-24 thread and flush diaphragm design are conventional, providing direct interchangeability with existing machined diaphragm-type piezoelectric transducers. The short, rigid quartz element and stiff diaphragm give the unit a 250 kHz natural frequency and good linearity, even below 1 000 psi.

3.0 INSTALLATION

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 high-frequency operating range of the pressure 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.

A torque wrench should be used to ensure specified mounting torque when installing the unit. Refer to the Installation Drawing, located in the Appendix, for the recommended torque value.

It is wise to replace the seal each time the transducer is installed. One is supplied with the sensor; replacements are available as regular stock items.

3.1 Mounting in Existing Recessed Ports

The Model 165A02 mounts directly in existing ports machined for PCB Models 118A, 119A, 108A, 109A, and others.

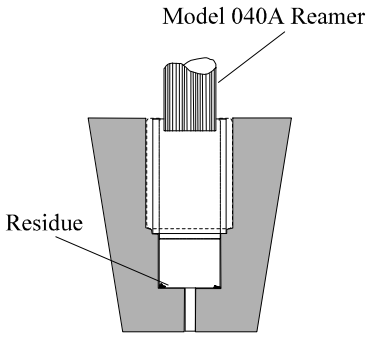

Figure 3.1 Residue Removal

Before installing the transducer in previously used mounting ports, clean out the residue remaining from previous tests as shown in Figure 3.1. This is accomplished by hand-reaming the ¼-inch diameter hole, using a PCB Model 040A Flat-Bottom Reamer or its equivalent. Refer also to the Tooling Sheet, located in the Appendix, which discusses in greater detail the Model 040A Flat Bottom Reamer and the Model 041A Pilot Reamer Bushing.

It is important to note that the seal surface may require remachining to get it sufficiently clean following prolonged use. If this procedure is necessary, do not forge too deeply the 1/4-inch (6.35 mm) diameter hole. Doing so could remove the shoulder, causing the transducer to bottom out when it is installed.

If waveform distortion occurs during prolonged testing, remove the transducer and clean out the residue as shown on the Tooling Sheet.

3.2 Preparing New Mounting Ports

Refer to the Installation Drawing provided in the back of this manual for instructions on mounting hole preparation. For best results, do not deviate from the outlined steps.

Use good machining practice in preparing the mounting port. Pay particular attention to the seal surface (.323 inches / 8.2 mm in diameter), keeping it free from tool chatter marks.

NOTE: It is important that this surface be perfectly smooth and free from nicks or other discontinuities that could cause leaks at high pressures.

3.3 Recess Mount

The recess mount technique 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 error. See Figure 3.2.

The recommended range of passage diameters is .090 to .125 inches (2.286 to 3.175 mm) in diameter.

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

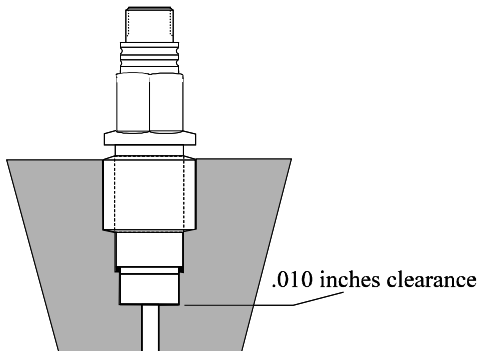

Figure 3.2 Recess Mount

The function is described by the following equation:

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

Where: Fr = 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.
If possible, keep passage lengths below 0.10 inches (.254 mm) for best results in most ballistic applications, especially at the casemouth and when measuring port pressures.

3.4 Flush Mount

In the 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 3.3.

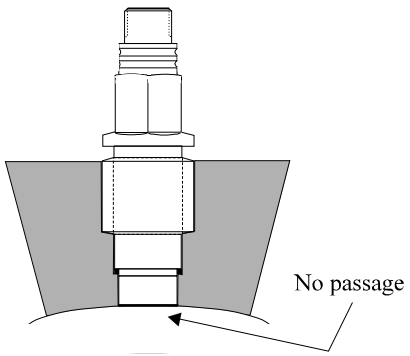

Figure 3.3 Flush Mount

If thermal transients or diaphragm impingement are concerns, use the flush mount technique only when space or rise time 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.

3.5 Flash Thermal Protection

Several additional steps may be taken to provide protection from flash thermal effects. The sensor diaphragm may be thermally insulated at the factory, using a thin (.010 inches / .254 mm) coating of ablative silicone rubber (G.E. type 560). Before the insulation is applied, the surface of the diaphragm is treated with SS4004 primer.

If more protection is required, the recess mount may be filled with DC-4 silicone grease or its equivalent. In place of the silicone rubber, one or more layers of black vinyl electrical tape on the diaphragm may provide sufficient insulation.

3.6 Cable Installation

Use only low-noise treated coaxial cable (PCB Model 003A or the equivalent) to connect the transducer to the charge amplifier, in-line voltage amplifier, or other high input impedance readout instrument. For further details on such cabling, refer to the Standard Cables Sheet, located in the Appendix of this manual.

Protect the ultra high impedance connection against moisture contamination with shrink tubing or other suitable method. Figures 5.1 and 5.2 illustrate typical circuit connections.

It is advisable to support transducer cables by tying them to rigid structures to prevent excessive motion that can generate noise and materially shorten cable life. Allow adequate strain relief.

4.0 CALIBRATION

This transducer can be calibrated using either static hydraulic techniques, such as by a dead weight tester, or by comparison with a standard dial gauge.

Set the charge amplifier for a long time constant, and allow the transducer to thermally stabilize before attempting to calibrate it.

NOTE: Do not attempt to use a charge amplifier that has less than a 5 000 second time constant when in the long position.

Several charge amplifiers are specially designed for use with ceramic accelerometers for higher frequency measurements. In general, these types are unsuitable for calibration of quartz pressure transducers by quasi-static means.

A factory charge calibration is supplied with each transducer. Factory recalibration is available for a nominal fee.

5.0 OPERATION

Most test setups include the Model 165A02 operating into an electrostatic charge amplifier, such as the PCB Model 462A. See Figure 5.1.

NOTE: Keep the input cable to the charge amplifier as short as is practical. Electrical noise at the output of any charge amplifier is directly related to input cable length (capacitance).

Press the ground button of the charge amplifier and adjust electrical zero if necessary. Range the amplifier to give the necessary full-scale voltage. For normal, drift-free operation, switch the charge amplifier time constant selector to MEDIUM or SHORT during use.

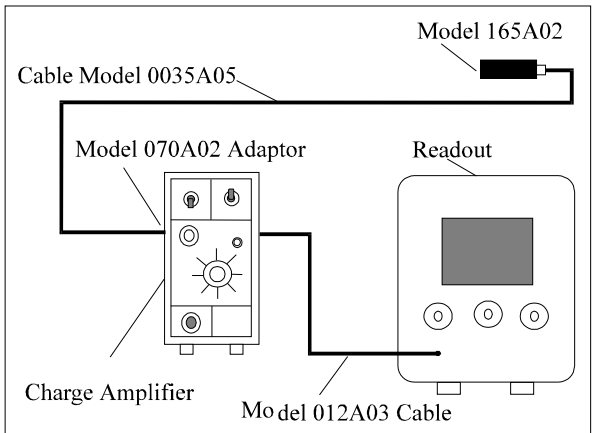

Figure 5.1 Typical Circuit Connection
Lab-Type Charge Amplifier

5.1 Polarity

Since most charge amplifiers are inverting amplifiers, the Model 165A02 is designed to produce a negative-going charge for increasing pressure at the diaphragm. Special positive-output versions are available for use with non-inverting ICP® source follower amplifiers (e.g., Models 401A and 402A). See Figure 5.2. Specify the "P" option to order the positive polarity model.

6.0 MAINTENANCE

The only maintenance required on the Model 165A02 is the periodic cleaning of the connector to restore insulation resistance.

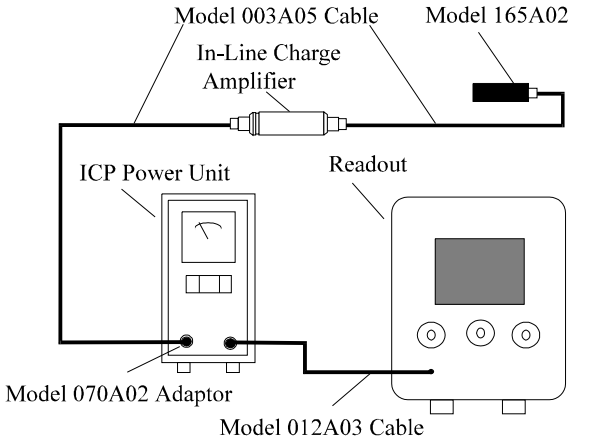

Figure 5.2 Typical Circuit Connection
In-Line Voltage or Charge Amplifier

During use in damp environments or after a period of storage, the insulation resistance of the transducer may degrade (10^{12} ohms is normal). To restore insulation resistance, wipe the connector end with a clean cloth or paper towel dipped in Freon TF® or an equivalent solvent. Bake the transducer in a 250 °F (121 °C) oven for several hours. If available, a vacuum oven expedites the process.

Model Number	CHARGE OUTPUT PRESSURE SENSOR	Revision: L
165A02		ECN #: 28464

Performance	ENGLISH	SI	
Sensitivity(± 15 %)	0.2 pC/psi	0.029 pC/kPa	[2]
Measurement Range	15 kpsi	103,400 kPa	
Maximum Pressure(static)	70 kpsi	482,700 kPa	
Resolution	10 mpsi	.069 kPa	[3]
Resonant Frequency	≥ 175 kHz	≥ 175 kHz	
Rise Time(Reflected)	≤ 2.5 µ sec	≤ 2.5 µ sec	
Non-Linearity	≤ 2 % FS	≤ 2 % FS	[4]
Environmental			
Acceleration Sensitivity	≤ .03 psi/g	≤ .021 kPa/(m/s²)	
Temperature Range(Operating)	-50 to +325 °F	-46 to +163 °C	
Temperature Coefficient of Sensitivity	≤ 0.06 %/°F	≤ 0.108 %/°C	
Maximum Flash Temperature	3000 °F	1649 °C	
Maximum Shock	20,000 g pk	196,140 m/s² pk	
Electrical			
Output Polarity(Positive Pressure)	Negative	Negative	
Capacitance	4-6 pF	4-6 pF	[1]
Insulation Resistance(at room temp)	≥ 10^{12} ohm	≥ 10^{12} ohm	
Physical			
Sensing Element	Quartz	Quartz	
Housing Material	C-300	C-300	
Diaphragm	17-4 Stainless Steel	17-4 Stainless Steel	
Sealing	Epoxy	Epoxy	
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack	
Weight	0.52 oz	14.6 gm	

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.

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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.

M - Metric Mount

P - Positive Output Polarity

W - Water Resistant Cable

NOTES:
[1] Typical.
[2] Quasi-static sensitivity within 2% of dynamic sensitivity.
[3] Resolution dependent on range setting and cable length used in charge system.
[4] Zero-based, least-squares, straight line method.

SUPPLIED ACCESSORIES:
Model 065A06 Seal ring 0.318" OD x 0.250" ID x 0.010" thk 316L SS material
Model 065A19 Spacer set, 0.250" ID

Entered: BLS	Engineer: WJL	Sales: RWH	Approved: APB	Spec Number:
Date: 3.26.08	Date: 3.21.08	Date: 3.21.08	Date: 3.26.08	5659

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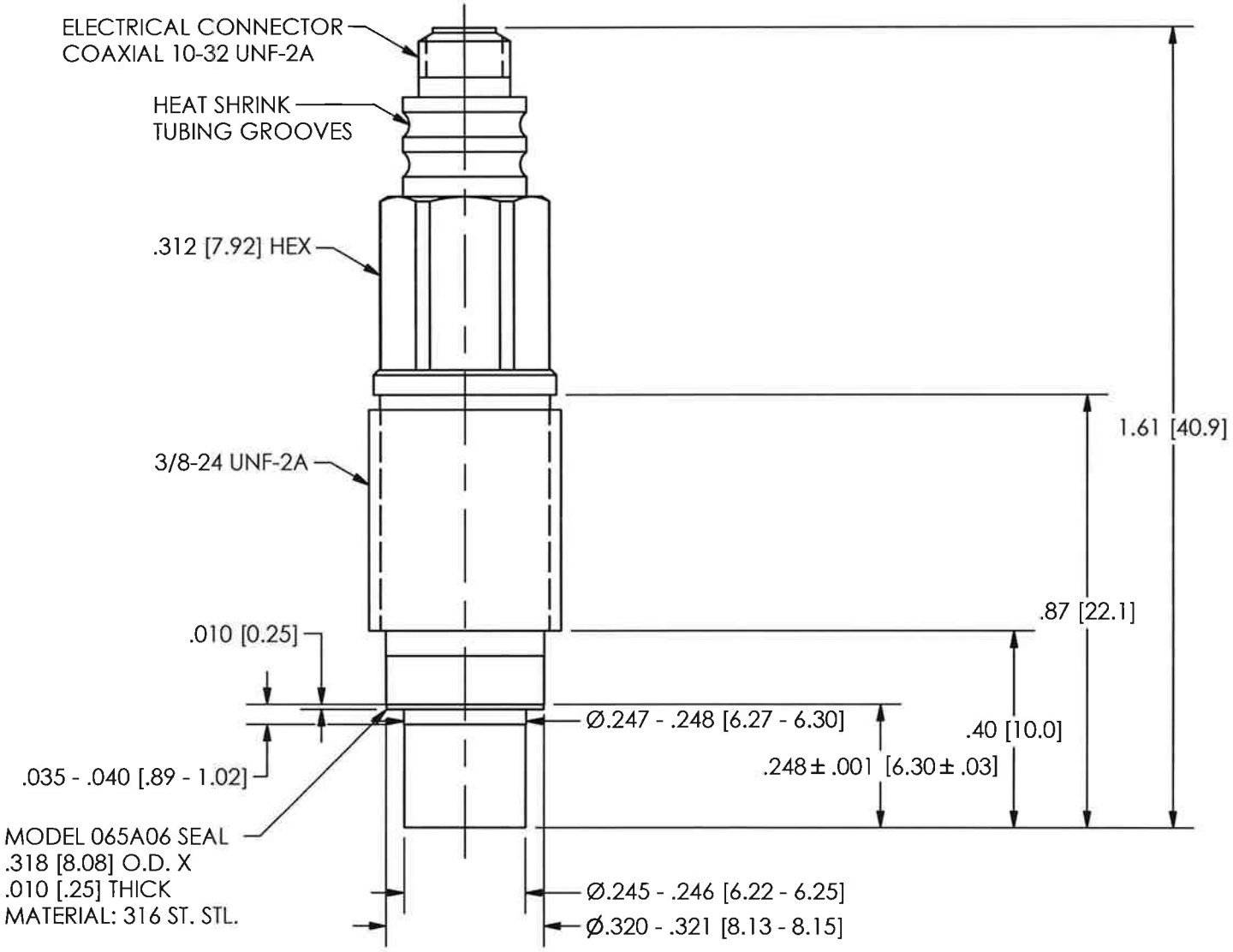
E-Mail: pressure@pcb.com

5228

REVISIONS		
REV	DESCRIPTION	ECO
A	REVISED PER ECN	13610
B	ADDED 165B02 TO TITLE BLOCK	31340



1.) SEE SHEET 2 OF 2 FOR MOUNTING HOLE PREPARATION DIMENSIONS.

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DRAWN	CHECKED	ENGINEER
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	MDF 9/16/09	FCB 9/16/09	NJL 9/16/09
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13	TITLE: INSTALLATION DRAWING MODEL 165A02 & 165B02 SERIES PRESSURE SENSOR		

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(716) 684-0001 E-MAIL: sales@pcb.com

CODE IDENT. NO. 52681	DWG. NO. 5228
SCALE: 3 X	SHEET 1 OF 2

REVISIONS		
REV	DESCRIPTION	ECO
	- SEE SHEET ONE -	

5228

MOUNTING HOLE PREPARATION

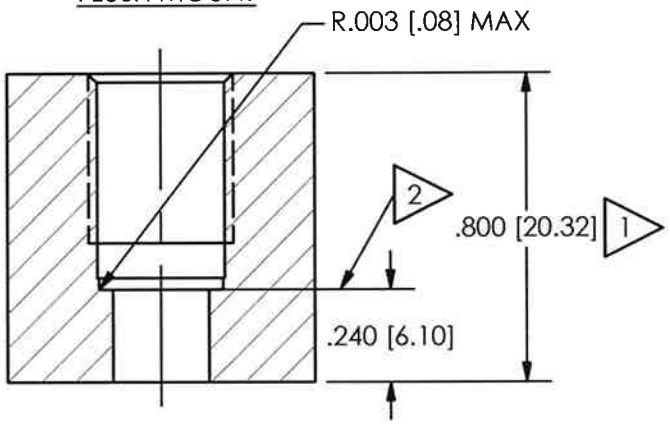
Ø.2500 $^{+.0010}_{-.0000}$ [6.350 $^{+.025}_{-.000}$] THRU 1 3

⌴ Ø.323 [8.20] (↧.560 [14.22]) 3

⌴ Ø.332 [8.43] (↧.530 [13.46]) 3

3/8-24 UNF-2B ↧.470 [11.94] PERF THD. 4

FLUSH MOUNT



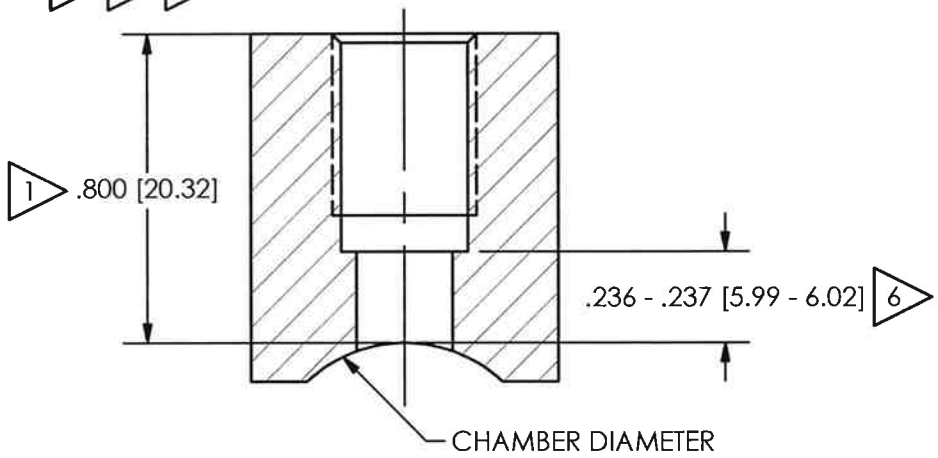
MOUNTING HOLE PREPARATION

Ø.2500 $^{+.0010}_{-.0000}$ [6.350 $^{+.025}_{-.000}$] THRU ONE WALL 1 3 5

⌴ Ø.332 [8.43] TO DEPTH SHOWN

3/8-24 UNF-2B ↧.470 [11.94] PERF THD.

SHOTSHELL FLUSH MOUNTING



7.) RECOMMENDED MOUNTING TORQUE ON .312 [7.92] HEX, 20-24 FOOT POUNDS [27-33 NEWTON METERS].

6 HOLD THIS DIMENSION TO OBTAIN FLUSH MOUNT.

5 ℄ OF Ø.2500 [6.350] HOLE MUST INTERSECT ℄ OF CHAMBER BORE WITHIN .001 [.03] TIR.

4 CAUTION: DO NOT TOUCH SEAL SURFACE WITH TAP WHEN TAPPING HOLE.

3 THESE DIAMETERS MUST BE CONCENTRIC TO WITHIN .001 [.03] TIR.

2 SEAL SURFACE MUST BE FLAT AND FREE OF TOOL MARKS WITH A MIN 63 [1.6] ✓ FINISH.

1 DIMENSIONS SHOWN ARE FOR .800 [20.32] THICK WALL. ⌴ FOR THICKER WALLS.

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DRAWN	CHECKED	ENGINEER	
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]	MDF 9/16/09	EOB 9/16/09	NJL	9/16/09
DECIMALS XX ±.01 XXX ±.005	DECIMALS X ±0.3 XX ±0.13	TITLE: INSTALLATION DRAWING MODEL 165A02 & 165B02 SERIES PRESSURE TRANSDUCER			
ANGLES ± 2 DEGREES	ANGLES ± 2 DEGREES				
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13				

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CODE IDENT. NO. 52681	DWG. NO. 5228
SCALE: 2 X	SHEET 2 OF 2