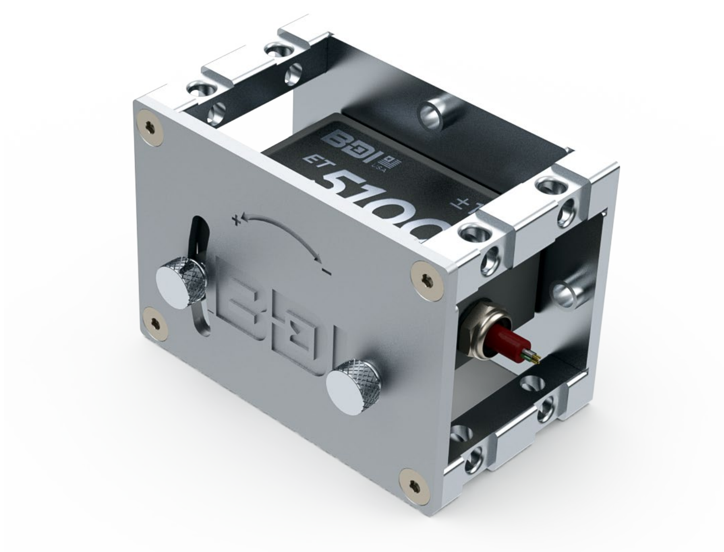
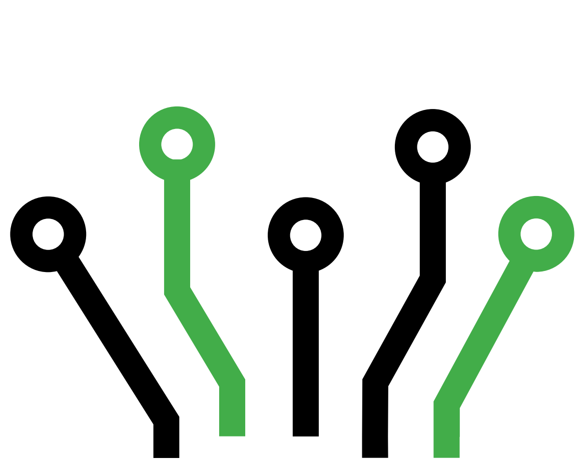
RAW DATA. REFINED RESULTS.

OPERATIONS MANUAL



SENSORS

T500 – ELECTROLYTIC TILTMETER



Document Revision History

Version	Date	Changes
1.0	2/28/2012	Initial release document
2.0	6/7/2012	▪ Updated to match the styles and formatting of previous operation manuals ▪ Setting time graphs added
2.1	4/2/2013	▪ Updated to reflect the recent CE compliance approval. ▪ Power ratings updated
3.0	01/21/2019	▪ Updated to include new corrosion protection ▪ New template and styles were applied

WARRANTY INFORMATION

BDI warrants its products to be free from defects in materials and workmanship under normal use and service for thirty-six (36) months from date of shipment. This warranty shall be void if any products have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. Batteries have no warranty.

All equipment manufactured by BDI is intended for use by a qualified professional only. Under this warranty BDI's obligation is limited to repairing or replacing (at BDI's option) of defective products. In no event shall BDI be liable for punitive, exemplary, special, indirect, incidental, or consequential damages and the customer shall assume all costs of removing, reinstalling, and shipping of defective products. EXCEPT AS STATED HEREIN, BDI MAKES NO WARRANTIES, EXPRESSED OR IMPLIED, AND SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY.

Before returning any product, BDI technical support must be contacted at +1-303-494-3230 or by visiting BDITEST.COM/contact and submitting a request. A technician will help determine the nature of the problem and if it cannot be resolved, authorization will be given to return the item. A return merchandise authorization (RMA) will be sent to the customer to be filled out and shipped back with the equipment. BDI will not accept shipment of any product without prior authorization as provided herein.

Ship all equipment to:

BDI
ATTN: TECHNICAL SUPPORT
740 S PIERCE AVE UNIT 15
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1. INTRODUCTION

1.1 ABOUT THE T500 ELECTROLYTIC TILTMETER

The single-axis T500 tiltmeter has been designed for use with our Structural Testing Systems (STS), Structural Monitoring Systems (SMS), and is compatible with most other standard data acquisition systems (DAQs). If handled with care, they should provide years of trouble-free service.

BDI has evaluated several different types of tiltmeters on the market and has determined that while many have adequate accuracy, etc., their use and installation is generally cumbersome for field applications. Based on over 30 years of field testing experience, we have designed a unit that can be mounted on all four orthogonal surfaces and zeroed without the need for hand tools, significantly reducing installation time.

Note that due to the nature of the internal electrolytic fluid technology, the T500 tiltmeters have a relative slow response time and are therefore not suited for dynamic testing. However, in cases where a live load can be applied relatively slowly, (such as during a bridge test where the vehicle can be instructed to cross at very low speed) the response should be suitable for structural analysis comparisons when recorded along with other sensors.

1.2 ABOUT THIS MANUAL

This is a comprehensive document that explains the functions and features of the T600. BDI manufactures two types of data acquisition systems, which will be referenced throughout the manual.

1. **The Structural Testing System (STS):** Rugged, wireless, battery powered DAQ that includes an intelligent (Intelliducer) connector design, which makes the system extremely easy to deploy on a variety of field projects.
2. **The Structural Monitoring System (SMS):** Modular system with 4- or 16-channel nodes that can be used in laboratories or on permanent large-scale monitoring projects.

Also, the following highlighted message blocks will periodically appear and contain important information that the user should be aware.

STOP: This symbol and corresponding message represents information regarding the device that if not followed could lead to damaging the device! Pay close attention to this message.

WARNING: This symbol and corresponding message represents vital information and is critical for the device operation and/or the operational settings/configuration.

INFORMATION: This symbol and corresponding message represents general information and/or tips on successfully operating/configuring the device.

2. T500 Overview

2.1 Technical Specifications

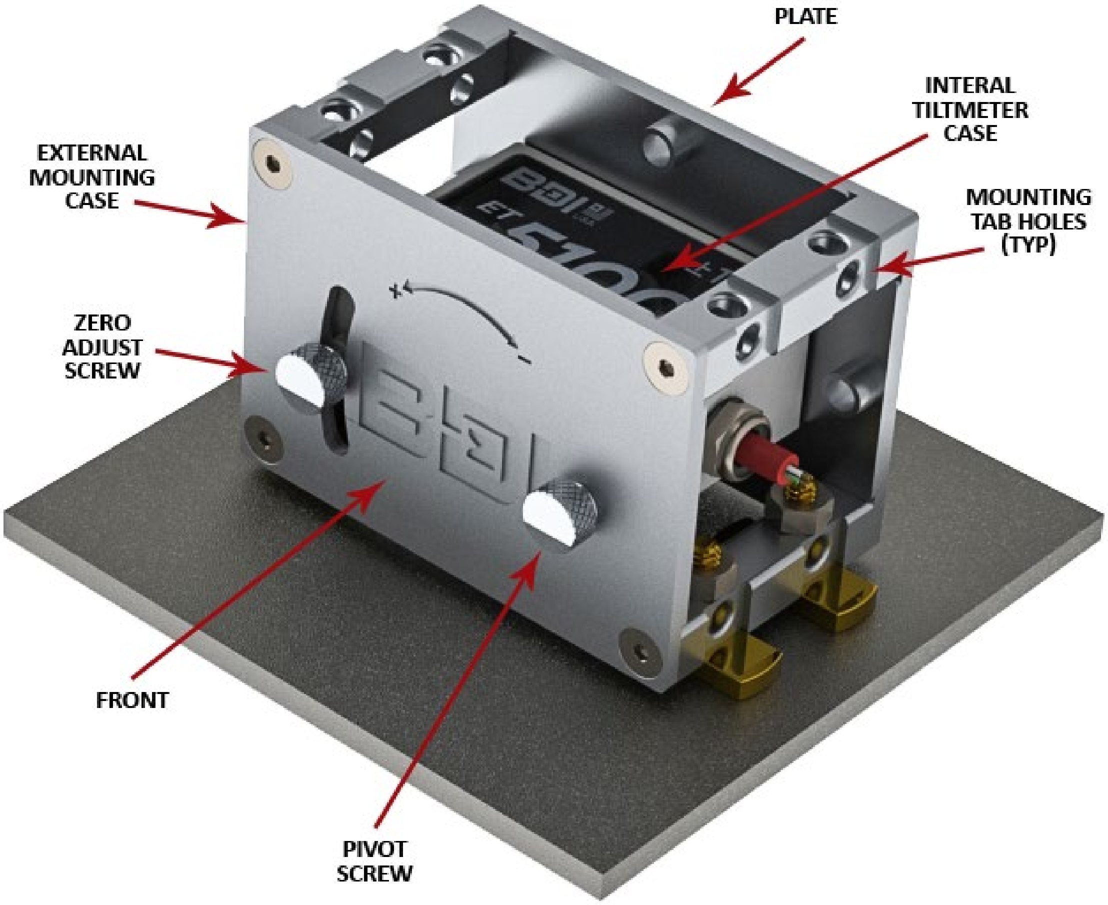


Figure 1: T500 Overview

Table 1: T500 Specifications

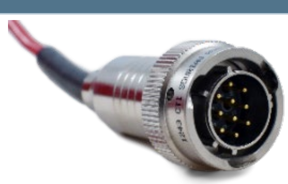
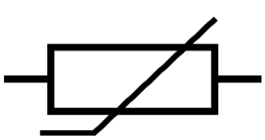
MODEL	T500-005	T500-030	T500-100	T500-600
LINEAR RANGE (ARC DEGREES)	±0.5	±3	±10	±60
TOTAL RANGE (ARC DEGREES)	±1	±6	±15	±80
OUTPUT (mV/ARC SECOND)	1	0.4	-	-
OUTPUT (mV/ARC DEGREE)	-	-	420	160
RESOLUTION (ARC DEGREES)	< 0.0001	< 0.0003	< 0.0005	< 0.001
NULL REPEATABILITY (ARC DEGREES)	< 0.0008	< 0.0008	< 0.001	< 0.02
SYMMETRY @ 1/2 LINEAR SCALE (%)	< 2	< 2	< 2	< 2
ACCURACY @ 1/2 LINEAR SCALE (%FS)	-	< 2	< 2	< 0.8
ACCURACY @ FULL SCALE (%FS)	-	< 8	< 5	< 3

NULL IMPEDANCE (KOHMS) +/-20%	1	12	40	8
NULL STABILITY, 12 HRS @ 25 DEG. C (ARC DEG'S, TYP.)	< 0.005	< 0.005	< 0.001	< 0.005
SETTLEMENT TIME (SECONDS)	~1.1	~1.2	~0.75	~1.0
EXCITATION VOLTAGE	+5 to +15 Vdc			
POWER RATING **MAX:** **TYPICAL:** **INTELLIDUCER[1]:**	 75 mW 2.5 mW @ +5.0 Vdc 13 mW @ +5.0 Vdc			
INPUT IMPEDANCE	5 MΩ			
OUTPUT	±2 Vdc			
OPERATING TEMPERATURE	-13 °F to 158 °F (-25 °C to 70 °C)			
STORAGE TEMPERATURE	-40 °F to 176 °F (-40 °C to 80 °C)			
TEMP. COEFFICIENT OF SCALE (%/ °C, TYP.)	0.6	0.6	0.1	0.1
CABLE	Custom lead cable length made to order: IC-02-187 [22 AWG, 2 shielded pair, drain wire, red PVC jacket] IC-02-250 [22 AWG, 2 shielded pair, drain wire, blue PVC jacket] IC-03-250 [24 AWG, 3 shielded pair, drain wire, black PVC jacket]			
HOUSING	Machined 6061-Aluminum			
CORROSION PROTECTION	Hard Anodized Clear (MIL-A-8625 Type III)			
WEATHER PROOFING	Designed to exceed IP67			
DIMENSIONS	4.25 x 2.6 x 3 in (108 x 66 x 76 mm)			
WEIGHT	1.2 lb (544 g)			
MOUNTING	Through holes for ¼ in (M6) bolts or anchors on five sides Reusable mounting tabs (gluing/welding)			

[1] Intelliducer connector required with STS Intelliducer data acquisition nodes.

2.2 OPTIONS AND ACCESSORIES

Table 2: T500 Options and Accessories

OPTIONS AND ACCESSORIES	
	**Intelliducer Connector** – Required for use with STS data acquisition nodes, cable is connected and potted for a weatherproof seal
	**Integrated Thermistor** – Temperature range of -55 °C to +220 °C, ±0.5 °C accuracy

	**Reusable Mounting Tabs** – ¼-20 or M6, zinc plated steel mounting tab
	**Protective Covers** – Insulated aluminum protective covers

3. Operation

The T500 tiltmeters are restricted to testing applications in which the live load can be applied relatively slowly such as on a lift structure which operates slowly, or a bridge where the vehicle can be instructed to cross at a low speed. If faster rotation responses must be captured, contact BDI for alternative tiltmeter models that allow higher frequency measurements to be recorded.

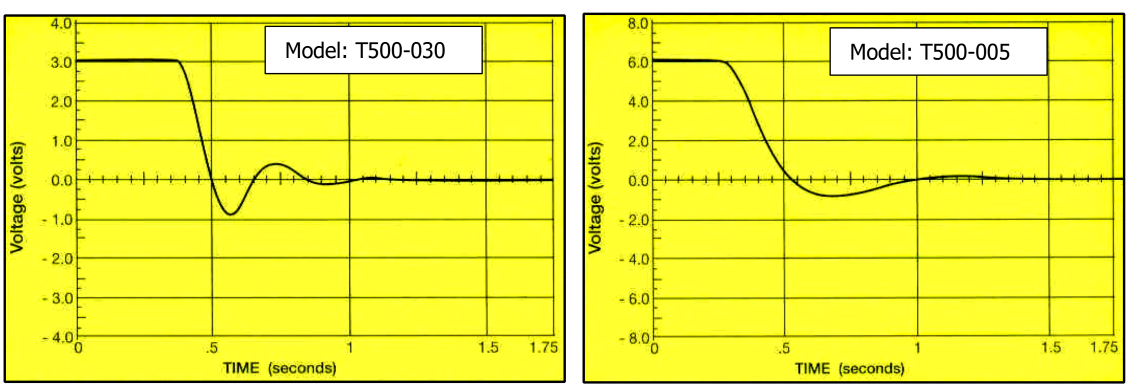
WARNING: The T500 tiltmeters are not suitable for recording dynamic structural responses.

3.1 Theory of Operation

When attached to a structural element subjected to rotations, the T500 tiltmeters measure the slight changes in angle perpendicular to gravity from their initial position with an enclosed liquid bubble system similar to a carpenter's level. This technology inherently has a brief settlement or lag time to allow the internal sensor output to stabilize after the applied rotation. Please refer to Table 4 for settlement time values and Figure 2 for a sample graphical output.

Table 3: Tiltmeter Settlement Times

T500 Tiltmeter Settlement Times				
Range (Degrees)	±0.5°	±3°	±10°	±60°
Settlement time (seconds)	~1.1	~1.2	~0.75	~1.0



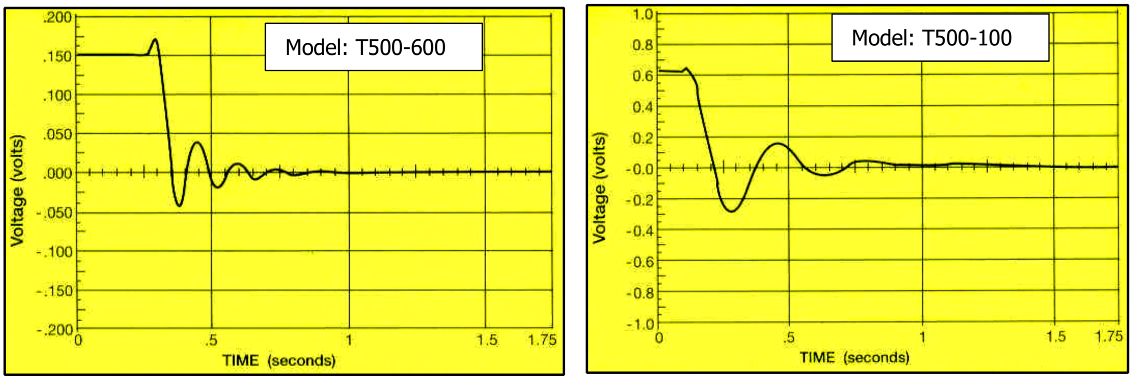


Figure 2: Graphical View of Settlement Time

3.2 Temperature Sensitivity

For rotation measurements recorded in a relatively short period of time (such as during a diagnostic load testing) temperature variations should be minimal, and the sensor output should not be significantly impacted.

However, for longer-term monitoring applications where the sensor may encounter extremely cold conditions (down to -13˚F or -25°C), the output of the sensor will be adversely affected. Temperatures below -65˚F (-54°C) may result in damage to the sensor.

3.3 Connecting the T500 to Data Acquisition Systems

This section outlines how to connect and test T500 tiltmeters for most standard data acquisition systems that are designed to handle either differential or single-ended outputs.

3.3.1 Electrical Connections

When using the T500 tiltmeter with our STS Intelliducer data acquisition systems, they will be equipped with a pre-wired Intelliducer plug and calibration factor and no additional configuration is necessary.

When using the T500 tiltmeter with any data acquisition system that does not have the pre-wired Intelliducer connector, the user must verify that the system can supply an excitation voltage of between +5 Vdc to +15 Vdc and supply the required current (0.5mA @ +5 Vdc, 0.9mA @ +15 Vdc).

X

STOP: Improper connections can damage internal components which are not repairable and will void any warrantee.

The T500 tiltmeter contains an on-board internal voltage regulator so any voltage in this range will be sufficient and will not affect the calibration factor (i.e. the sensor output is independent of the input voltage). Using the input/output signals specified in Table 5, the unit can be configured for either single (signal referenced to ground) or differential (signal referenced between two dedicated terminals), also shown in Table 5. Throughout this document, it is presumed that the differential output configuration is used.

Table 4: Electrical Connections

Tiltmeter Signal	Wire Color	Intelliducer Pin	Single-Ended Connection	Differential Connection
+ Excitation (+5 to +15 Vdc)	Red	A	Excitation Positive Input	Excitation Positive Input
+ Signal	Green	C	Sensor Positive Input	Sensor Positive Input

+2.5V reference	White	J	Not connected	Sensor Negative Input
- Excitation (Ground)	Black	K	Excitation Negative Input (Ground)	Excitation Negative Input (Ground)
Shield Wire	Bare	K	Shield, or Excitation Negative Input (Ground)	Shield, or Excitation Negative Input (Ground)

3.3.2 Single-Ended Output Connections

Table 5: Single Ended Characteristics

Single Ended Output Characteristics	
Output Range	+1 V to +4 V
Output at 0.0° (center of range)	+2.5 V
Output Poles	Measurement made between +Signal and -Excitation (Ground)
Voltage Multiplier for GGF	$\boldsymbol{Signal_{Out}}$
Comment	+2.5 V reference not used, prevent from shorting.

3.3.3 Differential Output Connections

Because common mode signals (V_{common}) and common offset drift (V_{offset}) are cancelled out with the differential configuration, this method is preferred.

$$Signal_{diff} = \left(+Signal + V_{commen} + V_{offset}\right) - (+2.5V_{reference} + V_{commen} + V_{offset})$$
$$Signal_{diff} = +Signal - 2.5V_{reference} + (V_{commen} - V_{commen} + V_{offset} - V_{offset})$$

Table 6: Differential Ended Characteristics

Differential Output Characteristics	
Output Range	-1.5 Vdc to +1.5 Vdc
Output at 0.0° (center of range)	0.0 Vdc
Output Poles	Measurement between +Signal and +2.5 Vdc reference
Voltage Multiplier for GGF	$\boldsymbol{Signal_{diff} = +Signal - 2.5V_{reference}}$
Comment	Calibration factor same as for Single Ended Output

3.3.4 Applying Calibration Factors

If an STS/SMS DAQ is being used, a calibration factor will be provided by BDI and can be added the system's calibration file as defined in the supplied software. The output data will be in the units designated by the calibration sheet supplied with every unit.

For use with other DAQs, each T500 tiltmeter is supplied with a Calibration Certificate that provides the following information, as an example:

$$\boldsymbol{GGF = 0.3307\ Degrees/V_{out}}$$

where:

GGF = General Gage Factor

0.3307 = Example GGF value for a ±0.5° tiltmeter in Arc Degrees
V_{out} = Signal Output Voltage (Volts DC)

To convert the output signal to the rotation angle:

$$Rotation = GGF \times Signal_{out}$$

where:

Rotation = Measurement in Arc Degrees
GGF = General Gage Factor
$Signal_{out}$ = Signal Output Voltage from the T500 (Volts DC)

If it is suspected that the T500 tiltmeter unit is out of specification, please contact BDI for evaluation and further information on re-calibrations as outlined in the Warranty section of this manual.

3.4 Verifying T500 Output

Once the tiltmeter is connected either the STS/SMS or third-party DAQ system, it is important to check that it is working properly by rotating it through its full range and ensuring that the output is corresponding to the motion and range in which the sensor is being subjected. The following simple tests should be routinely conducted, especially if the tiltmeter has been dropped or otherwise mishandled.

INFORMATION: It is highly recommended that each tiltmeter be tested in the laboratory prior to every field mobilization.

3.4.1 Resolution/Electronic Noise Test

Set the unit on a flat, non-moving surface and loosen both thumbscrews until they are "snug", but not tight. Adjust the left thumbscrew to be centered between the bottom and top of the arc. Without touching the unit, run a short test (approximately 15-20 seconds), store the data at approximately 30 Hz or higher, and evaluate in a spreadsheet or other graphing program to verify that the response is stable and at the resolution limit of the recording equipment being utilized.

If significant electronic noise is present, double-check the hookup and evaluate if there are any possible grounding or errant voltages. For example, if the unit is sitting on an ungrounded metal surface, electronic noise can be induced into the very sensitive sensor, therefore, make sure the test specimen is grounded at the same potential as the DAQ unit. Figure 3 illustrates resolution level of a ±3.0° tiltmeter using a 24-bit STS data acquisition system. Note that the system is achieving a resolution out to ton thousandth of a degree.

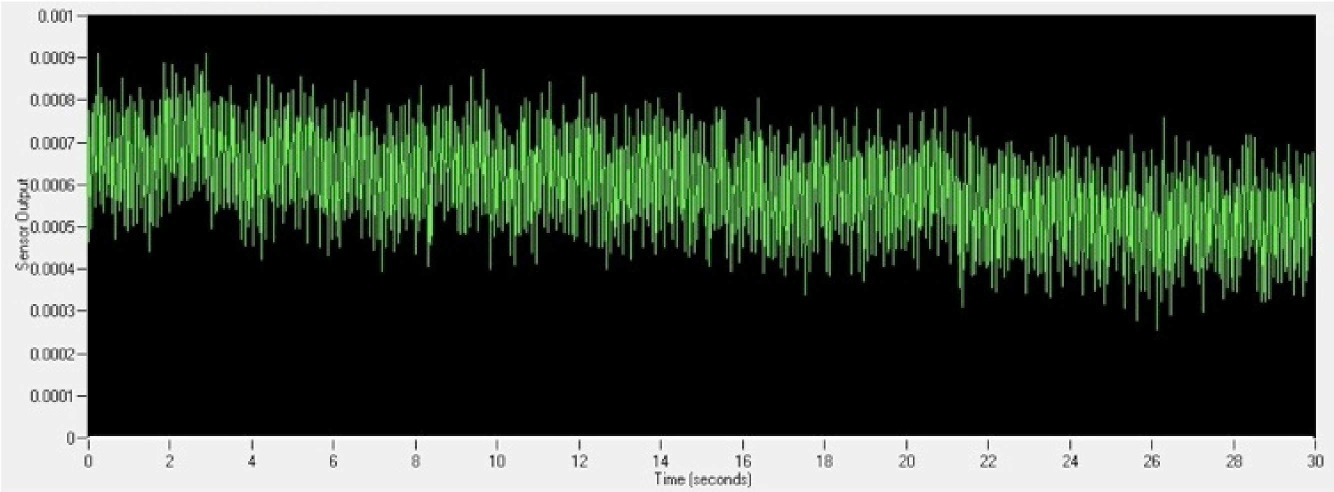


Figure 3: Noise Level from a 3.0° Tiltmeter Using a 24-Bit Data Acquisition System

3.4.2 Output Response Test

Set the STS/SMS DAQ or a third-party DAQ system in a "real time" output display mode. Loosen both thumbscrews to "snug" (but not tight), and, beginning with the left thumbscrew in mid-position of its arc, rotate the thumbscrew through its arc in the negative (up) direction and verify that the output being displayed on the PC is a negative angle. Then, rotate back to the center of the range, and perform the same operation in the positive (down) direction, verifying a positive output.

Depending on the angle range of tiltmeter used, the output should display its full range before hitting the maximum output range. Tighten both thumbscrews and put the STS/SMS DAQ or a third-party DAQ system in "collection" mode at a sample frequency equal to or higher than 30 Hz. With the unit sitting on a table, apply a smooth positive rotation to the whole unit followed by a smooth negative rotation. The output for the entire range should be a positive curve followed by a negative curve and should not appear jagged or otherwise incorrect. Once the T500 tiltmeter has passed the preliminary steps outlined above, it should be ready for field use.

3.5 Initial Zeroing of Tiltmeter After Installation

Once installation is complete according to Section 3, the (need outline centering and expanding range in either direction) should be manually zeroed to provide the most possible range in both directions after installation and before testing to ensure that the entire range can be utilized. Manual zeroing requires the sensor to be plugged in and the STS or DAQ software to be running. Using the "real time" output display in the software, adjust the tiltmeter using the thumbscrew until the output reads at or near zero. Be sure to tighten both thumbscrews before proceeding with tests.

3.5.1 Settling Time

Due to the nature of the electrolytic fluid technology used in T500 tiltmeters, there is a natural settling time in the range of approximately 0.3 to 1.2 seconds (refer to Section 2.1 for exact settling times for each sensor), making them unsuitable for capturing high-speed dynamic responses. However, since rotations are usually measured along with several other sensor types such as strains and deflections during any given field test, it is recommended that the live load be applied as slow as possible to address the settling time issue.

3.5.2 Field Preparation

We always suggest running a full test in the laboratory prior to shipping it out for field use. This will provide adequate time to address any possible issues rather than under stressful conditions on the jobsite.

4. Installation

There are several alternative mounting methods that can be used depending on the orientation, location, material being mounted to (steel, concrete, timber), and the length of test (hours, weeks, months, years). Due to the large number of variables associated with adhesive use (thermal cycles, UV exposure, vibration, impact, moisture, corrosion of base steel, etc.) adhesive is recommended for temporary testing and monitoring applications only. Please contact BDI for further mounting alternatives.

4.1 Orientation

T500 tiltmeters are designed for uniaxial measurements only, meaning they measure rotation along one axis primary. Since the sensor is gravity-based, it must be oriented with the serial plate facing up for each of the four possible positions.

The T500 tiltmeters can be installed on many structure types and in all types of applications, so it is impossible to outline all of the details for each installation. However, with practice and experience, the user can select from a combination of the mounting techniques that BDI has developed over the years.

The T500 tiltmeter has been designed with four mounting options as shown in Figure 4.

1. Back Mount
2. Bottom Mount
3. End Mount
4. Top Mount

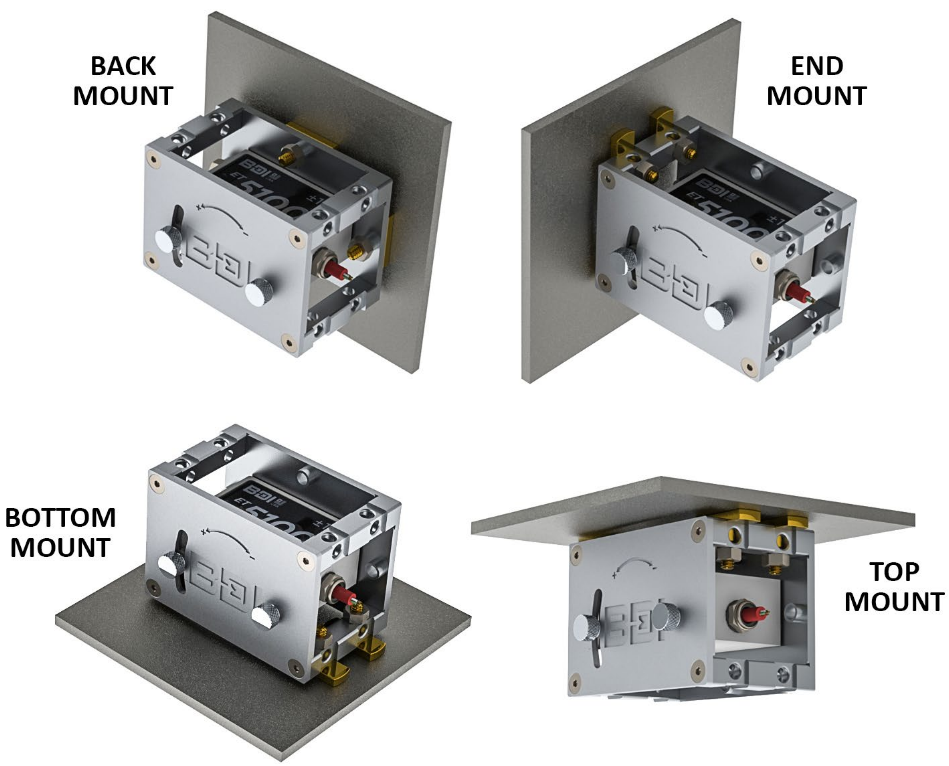


Figure 4: Mounting Positions for T500 Tiltmeter

Once it has been determined which orientation the sensor is to be used, the surface will need to be marked accordingly. Figure 5 provides the center of the mounting tab locations as measured from the centerlines for the various configurations.

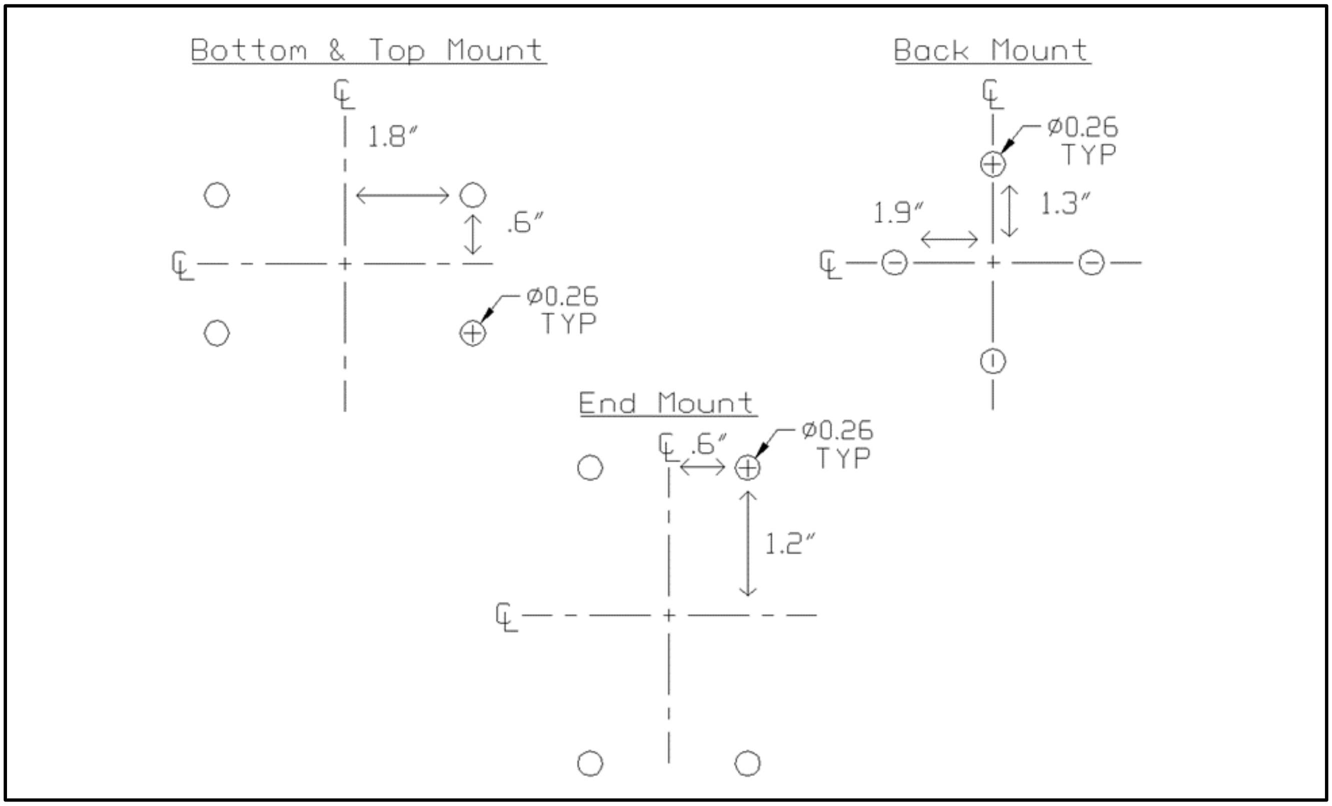


Figure 5: Mounting Hole Spacing for Various Installation Positions

WARNING: It is imperative that the black and silver serial plate shown below to **ALWAYS BE FACING UP**.

Figure 6: T500 Label – MUST Face Up

4.2 Installation on Steel Members

In most situations, the most efficient and least invasive method of mounting the T500 tiltmeter for short term applications is using the tab/glue system, as shown below for an example flat steel plate.

INFORMATION: BDI manufactures both Imperial (1/4-20) and metric (M6) tabs. To easily distinguish them from each other, BDI has scribed all metric items as seen in Figure 6.

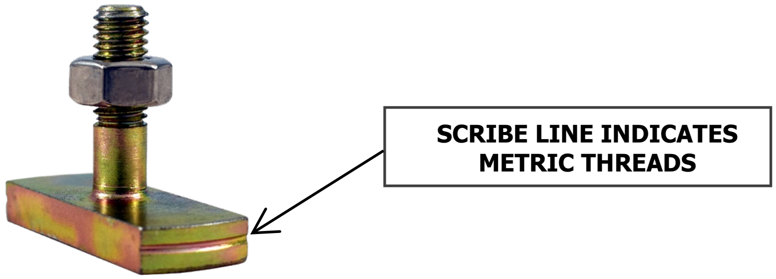


Figure 7: Identifying Metric vs. Imperial Tabs

1. Place 4 tabs in mounting holes (in this case, the four bottom holes as shown in Figure 8) and tighten the 1/4-20 (or M6) nuts to approximately 40 in-lbs (4.5 Nm). Note that the Top, Bottom, and End Mountings have machined slots to hold the tabs. The back mount does not have machined slots so a vise grip (or similar tool) will be needed to hold the tab in place while tightening.

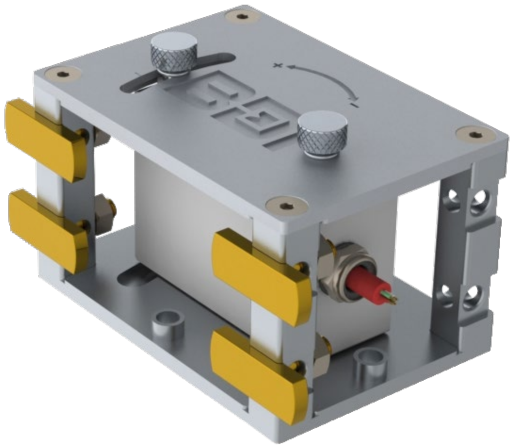


Figure 8: Mounting Tabs Attached for Bottom Mounting

2. Locate the centerline of the gaging area in both the longitudinal and transverse directions. First, locate the midpoint and draw two centerlines as shown in Figure 9. The longitudinal centerline should be approximately 8 in (203 mm) long and the transverse centerline should be approximately 6 in (152 mm) long. This will allow the marks to be seen while the tiltmeter is being installed.

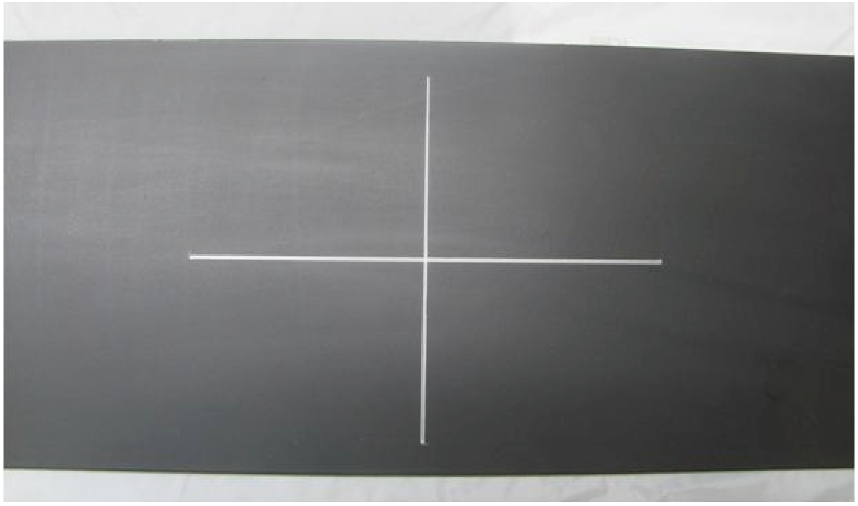


Figure 9: Marking Structural Member for Tiltmeter Installation

3. To complete the locating sequence, make two marks at approximately 1.8 in (46 mm) on either side of the transverse centerline and two marks at 0.6 in (15 mm) above and below the longitudinal centerline as shown in Figure 10. An alternate way of marking these locations is to hold the tiltmeter in place over the two centerline marks and making small marks where the tabs will be installed, then use a T-square to complete tab marking.

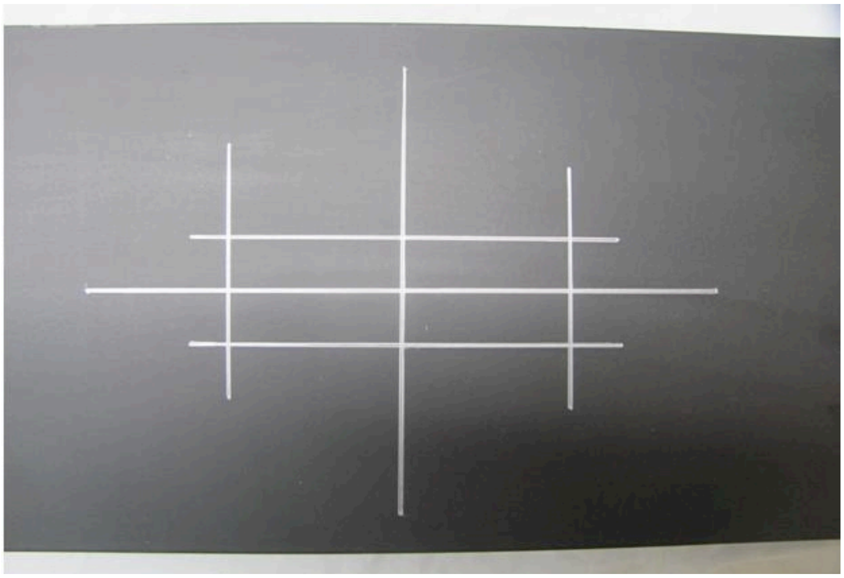


Figure 10: Tiltmeter Location Marked for 4 Tabs

4. Remove paint or scale from the areas shown in Figure 11 using a power grinder until a clean metal surface is obtained.

REMEMBER: Always wear adequate personal protective equipment such as goggles, earplugs, and facemasks while grinding. Also, due to generated sparks, insure that there are not flammable liquids or other materials nearby that can be ignited.

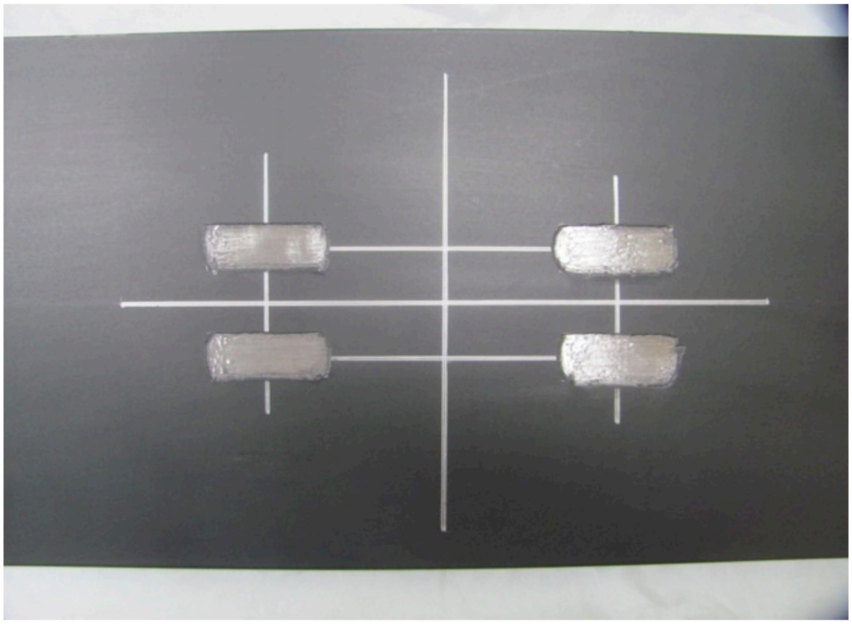


Figure 11: Steel Member Prepared for Adhesive

5. Next, very lightly grind the bottom of the tabs that have already been mounted to the sensor to remove any oxidation and/or other contaminants. Before mounting, set the sensor in the location it is to be attached, and ensure that all four tabs seat uniformly on the member and that the unit does not "rock" as this is important for achieving a good bond.
6. Apply a thin line of adhesive to the bottom of each tab (see "Information" below) about ¼ in (6.4mm) wide. Mount the sensor in the marked location, and then pull it away. This action will apply adhesive to the structural member at each of the four-tab locations.
7. Spray the four adhesive spots on the structural member with "light shots" of the adhesive accelerator (Loctite Tak Pak 7452, Part # 18637 in 0.7 oz aerosol spray container).
8. Very quickly, mount sensor in its proper location and apply a light force to the top of the tabs for approximately 15-20 seconds.

If the above steps are followed, it should be possible to mount each sensor in approximately five minutes. A mounted tiltmeter is shown in Figure 12.

INFORMATION: Loctite 410 is suggested to be used for short installations, such as a load test.

Loctite H4500 suggested for applications where Loctite 410 is not adequate, such as longer duration load tests, high force application, or temporary monitoring applications.

To find the closest Loctite Distributor please call 1 (800) 243-4874 or visit www.loctite.com

Figure 12: Tiltmeter Installed on Structural Member

Once testing is completed, the tiltmeter will need to be carefully removed from the structural member. Due to the geometry of the Tiltmeter, an end wrench will need to be used to remove the nuts from the tabs. Unthread the nuts and **carefully** remove the Tiltmeter from the tabs. Note that due to the tight tolerances of the mounting holes, the Tiltmeter may have to be 'rocked' or 'jiggled' slightly if one or more of the tabs has been bent slightly until it is clear of the tabs.

Often, the above approach will make removing the tabs very difficult from steel members due to the strength of the adhesive. Therefore, BDI has developed a Tab Removal Tool (TRT) to help reduce the possibility of damaging BDI sensors and tabs (see Figure 13). Each TRT has a hex head machined into the bottom face for tightening and/or loosening the designated nut size, and the small hole in the face of the hex head has been threaded to capture the threaded stud.

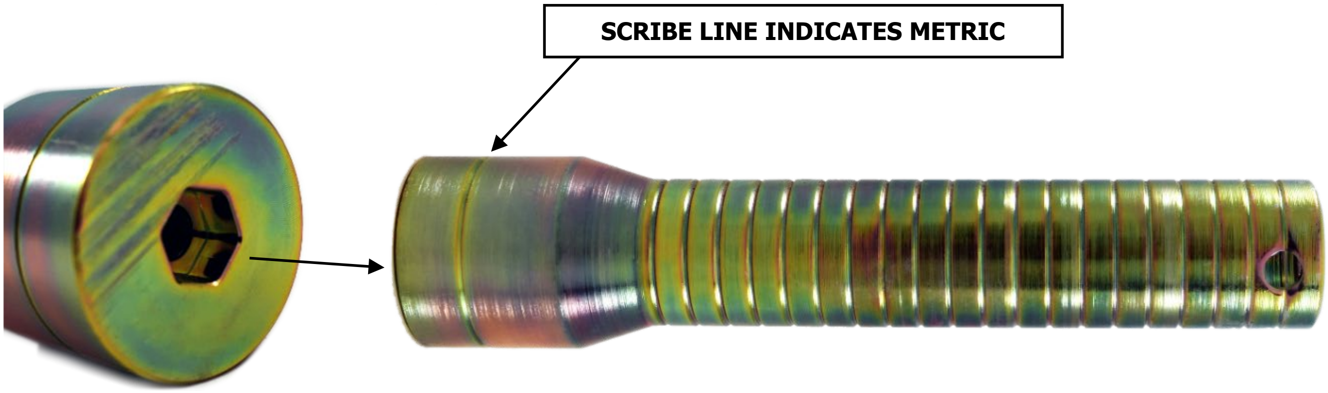


Figure 13: Tab Removal Tool (TRT)

The following instructions describe the method used to remove a sensor that has been mounted to a steel surface. If a TRT is not available, a pair of vise grips can be used although there is a greater chance of damaging the tabs using a vise grip.

1. The T500 tiltmeters will require a 7/16 or M10 end wrench to loosen and remove the nuts on the end of the Tabs. Once all the nuts are removed, slide the T500 tiltmeter off of the mounting tabs.
2. Thread the TRT on to the tab until the face is flush with the foot of the tab as seen below. If a gap remains between the TRT and the tab foot, there is a high likelihood that the stud will be bent in the next step. Also, do not over tighten the tab into the TRT or it will be hard to remove the tab from the TRT. After a few tries this process will become a simple procedure.

Figure 14: Tab Removal Tool with Tab Screwed On

3. In the direction of "thin" axis of the tab as shown in Figure 15, give the TRT a quick tug or tap and the tab should pop off the member surface. Depending on how well the tab is fixed, particularly on a steel surface, more force may be required. In this case, simply hit the handle of the tool with a small rubber mallet. Note that holes in the top of the tool have been supplied so that a lanyard can be added if necessary.

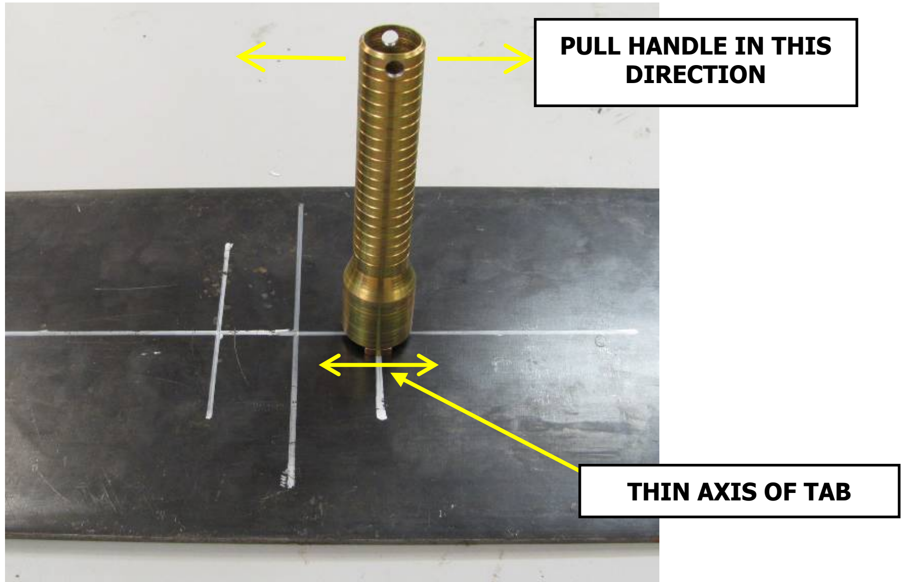


Figure 15: Removing Tab with TRT

4. Unthread the tab from the TRT and continue with the other sensors. If the tab remained with the sensor during removal, use vice grips to hold the foot of the tab while loosening the nut. Sometimes, tabs may be damaged during the removal process, especially if a TRT is not available. For example, threads can be slightly deformed, requiring either disposal or the use of a 1/4-20 (or metric M6) die to allow smooth operation.
5. The tabs can be re-used by soaking them in acetone for 30-40 minutes to remove the hardened adhesive. Be sure to cover the container since the acetone will evaporate quickly and is very flammable!

STOP: Acetone is extremely flammable! Use only in properly ventilated areas and avoid any possible ignition sources.

4.3 Installation on Concrete Members

4.3.1 Concrete

In general, the basic tab and glue technique described above is suitable for most applications, however, if any of the following parameters exist, BDI recommends using mechanical anchors rather than glue:

- If concrete is moist or wet
- If the sensor must remain in place for more than a day or two
- If the structure being instrumented is subjected to significant vibrations (e.g. traffic)
- If the instrumented areas are directly over automobile or train traffic where if the sensor came loose, it could create a hazard
- If the instrumented area is difficult to re-access during the testing period in case sensor comes loose

If it is judged that the tab and glue system is insufficient, some extra steps should be followed when using this method for concrete members. The primary concern when mounting sensors on either reinforced or pre-stressed concrete is that the surface must be clean, dry, and dust-free in order for the glue to adhere. Therefore, it is highly recommended that compressed air (either in cans or from a compressor) be used to remove the dust after grinding has been completed. Follow the above steps as outlined for steel, except just prior to applying the glue to the tabs, use the compressed air to clean any surface dust away from the mounting point.

4.3.2 Concrete Mounting Studs

If it is judged that the conditions warrant more secure mounting system, then threaded mounting studs can be used. These will require a hole to be accurately drilled in the concrete with a hammer drill as described below.

1. Locate the gaging point on the structure and mark out the hole spacing as described in Section 4.1 . Using a concrete drill, drill a hole using a 3/8 in concrete drill bit approximately 1.0 in deep. If mounting to pre-stressed concrete, ensure to avoid drilling into the pre-stressing tendons.
2. Drop in the 1/4-20 x 1-1/2 in Power Fasteners Power-Stud or similar and lightly tap in with a hammer to set.
3. Slide the sensor over the stud.
4. While holding the sensor in place, screw a nut on the stud and tighten with an open-end wrench.

4.4 Installation on Timber Members

If the T500 tiltmeter is to be mounted to a timber member or other relatively soft materials, use a 1-1/2 in self-tapping screw and a power screwdriver. If the wood has any sort of glue laminated section or it has been chemically treated, it is recommended that a pilot hole be drilled.

5. Maintenance & Recalibration

5.1 Maintenance

INFORMATION: It is highly recommended that each T500 tiltmeter be tested in the laboratory prior to each field mobilization.

+ **Recalibration:** It is recommended that the T500 tiltmeters be recalibrated at least every two years.
+ **Maintenance:** The T500 tiltmeter has been designed to minimize the amount of maintenance required to remain operational. The units are completely sealed internally, and the only available replacement component is splicing a new section of instrumentation cable. At least 12 in (300mm) of cable exiting the tiltmeter body is required for this procedure.
+ **Cleaning:** The mounting holes should periodically be inspected and cleared of any debris and adhesive. To remove adhesive from the mounting holes, use the tip of a shop rag or cotton swab wetted with acetone. Wipe the adhesive until it dissolves. Afterwards, a shop rag with mild soapy water can be used to remove other debris.

STOP: Acetone is extremely flammable! Use only in properly ventilated areas and avoid any possible ignition sources.

+ **Mounting Tabs:** Mounting Tabs have been designed to be reusable by simply dissolving the adhesive with acetone. Acetone can be re-used multiple times, but if it becomes too saturated with adhesive it will start leaving a thin layer of adhesive in the threads of the mounting tabs. Also, sometimes when the mounting tabs are removed from a structure the top threads can be chipped. If it becomes hard to thread nuts onto the mounting tab stud, run a 1/4-20 (or M6) die down the threads to remove the chips and adhesive from the threaded stud.

5.1.1 Repair & Replacement

If a T500 tiltmeter is damaged beyond repair, BDI will provide the original customer an option to purchase a replacement unit at a discounted price. Please contact BDI to obtain authorization for return of the unit as instructed in the Warranty Information section of this manual.

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