metrozet

A Kinematics Division

MBB-1

Miniature Broadband Seismometer

User's Manual

Revision 1.02

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DO NOT USE THE ELECTRICAL CABLE FOR LIFTING OR HANDLING OF THE SENSOR!

MBB-1
Miniature Broadband Seismometer
with Cable

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DO NOT USE THE ELECTRICAL CABLE FOR LIFTING OR HANDLING OF THE SENSOR!

No User-Serviced Parts

The MBB-1 is a self-contained triaxial seismometer. There is no reason to open or modify the sensor. There are no manual adjustments to make to, nor are there any user-serviced parts within the sensor. Opening and/or modifying the sensor is unnecessary, and doing so will void the instrument's warranty.

Electrical Safety Notice

As with all electrical instruments, potentially lethal potentials can be present on all metal surfaces, including conductors within any cables. Proper grounding of these elements is important to minimize these risks. The user of this product is responsible for its installation and operation in a safe manner, and in accordance with all local requirements for electrical safety.

Disclaimer

In no event shall Metrozet, LLC or Kinemetrics, Inc. be liable for any special, incidental, indirect, or consequential damages of any kind, or any damages whatsoever, including, without limitation, those resulting from loss of use, or data, whether or not advised of the possibility of damage, and on any theory of liability, arising out of or in connection with the use or performance of the information presented or products described in this manual.

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Introduction and Instrument Description

MBB-1 is a triaxial broadband seismic sensor that provides a velocity-sensitive passband from 40 seconds to approximately 150 Hz.

The sensor is packaged in a stainless steel housing, to allow reliable operation in a shallow borehole or posthole. It operates over a nominal tilt range of ±2.5 degrees, allowing simple deployment in environments typically considered "non-ideal" for broadband sensors.

The sensor ships with standard cabling designed for direct connection to a Quanterra Q330-series, or Kinemetrics Rock-series, digitizers. These connections support both period-shortening (setup mode; 1 second corner period), and remote calibration functions. The sensor is designed to receive operating power directly from the digitizer by using the standard cable.

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Electrical Connections

MBB-1 Sensor

The MBB-1 sensor uses an oceanographic grade connector (Glenair 802-013-07Z19-19PA receptacle). The connections to the sensor are as follows:

Pin	Name	Description	Input/Output
1	Z_VELOCITY+	Z Output differential pair	Output
2	Z_VELOCITY-	Z Output differential pair	Output
3	N_VELOCITY+	N Output differential pair	Output
4	N_VELOCITY-	N Output differential pair	Output
5	E_VELOCITY+	E Output differential pair	Output
6	E_VELOCITY-	E Output differential pair	Output
7	ANALOG_GND	Common-mode ground for differential output signals; reference for Enable lines and for CAL input	Input/Output
8	Z_MPOS	Z Mass Position	Output
9	N_MPOS	N Mass Position; proxy for sensor tilt along N-axis Approximate scale factor of 4V per degree of tilt	Output
10	E_MPOS	E Mass Position; proxy for sensor tilt along N-axis Approximate scale factor of 4V per degree of tilt	Output
11	CAL_EN	Enable line for calibration mode; connects CAL input to sensors; 3-10V input range	Input
12	PER_SW_EN	Enable line for 1 second “setup” mode; 3-10V input range	Input
13	CAL_INPUT	Single-ended CAL stimulus input; ANALOG_GND reference; approximate +/-10V maximum	Input
14	CASE_GND	Connection to sensor CASE	Input/Output
15	INPUT_POWER_PLUS	Input power plus; 9-36V range; galvanically-isolated from analog sensor electronics; reverse-polarity and overvoltage protected	Input/Output
16	INPUT_POWER_RETURN	POWER_RETURN line	Input/Output
17	NC	Unused pin	N/A
18	NC	Unused pin	N/A
19	NC	Unused pin	N/A

Table 1: MBB-1 connector pinout description. The connector is Glenair 802-013-07Z19-19PA.

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MBB-1 Cabling

The MBB-1 is available with two versions of cabling. Both cables provide an oceanographic-grade mating plug for connection to the sensor. Both are fabricated from a thin, flexible, polyurethane-jacketed cable.

DO NOT USE THE CABLE FOR LIFTING OR MOVING THE SENSOR!!!

The standard cable is 10 meter length, with an outbound termination (16-shell, 26 pin Souriau plug) designed for direct connection to Quanterra and Kinemetrics digitizers. This connection supports control of period switching and calibration, as well as direct power input from the digitizer. An alternative cable is 40 meters long, with a pigtailed (bare) outbound end.

A. 10 meter long, dual-terminated cable

Glenair Plug Socket #	**Connection**	**Description**	**Souriau Plug Pin #**
1	Z_VELOCITY+	Z Output differential pair	A
2	Z_VELOCITY-	Z Output differential pair	B
3	N_VELOCITY+	N Output differential pair	D
4	N_VELOCITY-	N Output differential pair	E
5	E_VELOCITY+	E Output differential pair	G
6	E_VELOCITY-	E Output differential pair	H
7	ANALOG_GND	Common-mode ground for differential output signals; reference for Enable lines and for CAL input	N
8	Z_MPOS	Z Mass Position	K
9	N_MPOS	N Mass Position; proxy for sensor tilt along N-axis Approximate scale factor of 4V per degree of tilt	L
10	E_MPOS	E Mass Position; proxy for sensor tilt along N-axis Approximate scale factor of 4V per degree of tilt	M
11	CAL_EN	Enable line for calibration mode; connects CAL input to sensors; 3-10V input range	P
12	PER_SW_EN	Enable line for 1 second “setup” mode; 3-10V input range	T
13	CAL_INPUT	Single-ended CAL stimulus input; ANALOG_GND reference; approximate +/-10V maximum	V
14	CASE_GND	Connection to sensor CASE; 1M series R	a
15	INPUT_POWER_PLUS	Input power plus; 9-36V range; galvanically-isolated from analog sensor electronics; reverse-polarity and overvoltage protected	b
16	INPUT_POWER_RETURN	POWER_RETURN line	c

Table 2. Connections supported in standard, 10 meter cable.

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B. Pigtailed, 40 meter cable

Glenair Plug Socket #	Connection	Description	Wire Grouping/ Insulation Color
1	Z_VELOCITY+	Z Output differential pair	Pair 1/Wire 1 Black
2	Z_VELOCITY-	Z Output differential pair	Pair 1/Wire 2 Black/White Stripe
3	N_VELOCITY+	N Output differential pair	Pair 2/Wire 1 Brown
4	N_VELOCITY-	N Output differential pair	Pair 2/Wire 2 Brown/White Stripe
5	E_VELOCITY+	E Output differential pair	Pair 3/Wire 1 Red
6	E_VELOCITY-	E Output differential pair	Pair 3/Wire 2 Red/White Stripe
7	ANALOG_GND	Common-mode ground for differential output signals; reference for Enable lines and for CAL input	Single Wire 1 Violet
8	Z_MPOS	Z Mass Position	Single Wire 2 Violet/White Stripe
9	N_MPOS	N Mass Position	Single Wire 3 Blue
10	E_MPOS	E Mass Position	Single Wire 4 Blue/White Stripe
11	CAL_EN	Enable line for calibration mode	Single Wire 5 Yellow
12	PER_SW_EN	Enable line for 1 second “setup” mode; 3-10V input range	Single Wire 6 Yellow/White Stripe
13	CAL_INPUT	Single-ended CAL stimulus input	Single Wire 7 Green
14	CASE_GND	Connection to sensor CASE; 1M series R	Single Wire 8 Green/White Stripe
15	INPUT_POWER_PLUS	Input power plus	Pair 4/Wire 1 Orange
16	INPUT_POWER_RETURN	POWER_RETURN	Pair 4/Wire 2 Orange/White Stripe

Table 3. Connections and wire details for 40 meter long, pigtailed cable.

The cabling is supplied with neoprene boots over the molded connectors. In addition, the sensor receptacle (on the top cap) is shipped with a dust cap. As this is a “downhole” sensor, the cap and the boot on the sensor end of the cable are meant to be removable. They are not intended to be placed downhole! It is recommended that you store these protective elements in a clean, dry place, and to re-install them (after cleaning the sensor and cable plug), prior to storage or shipment.

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System Grounding

There is a dedicated CASE_GND wire in the cable. It makes a direct connection (with 1Mohm series resistance) to the digitizer CASE_GND) within the dual-terminated, 10 meter cable. Users of the pigtailed cable have additional flexibility in connecting this GND to their specific system ground nodes.

Mounting Feet

The MBB-1 ships with stainless stall "half-ball" feet mounted in the bottom of the package. These are typically sufficient for most deployments. For precision-leveled deployments, on uneven or sloping surfaces, a set of leveling feet and locking nuts are included that can be installed in place of the half-ball feet.

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Sensor Operation

Cable Connection

Apply a very small amount of silicone grease to the inside of the mating plug on the cable. The grease should be applied to the outside of the inner (keyed) insert sensor connector. The O-ring is on the inner wall of the receptacle, outside of the pins. **Take care not to bend or damage the pins when applying the silicone grease.**

Connect the cable to the sensor, ensuring that all surfaces are clean, and free of dirt or grit. Attach the cable by lining up the keys on the plug with the keyways on the sensor receptacle and engaging the brass nut. The round bump on the cable overmold should point to the W direction, toward the bubble level. Work the connector gently to insert it as the nut is tightened. Tighten sufficiently to engage the red seal at the base of the sensor connector. We recommend a torque limit of about 20 in-lbs. **DO NOT OVERTIGHTEN!**

DO NOT USE THE ELECTRICAL CABLE FOR LIFTING!!!

Startup and Settling

The sensor will start immediately after connection to a valid power source. In the case of the dual-terminated cable, the sensor will be powered whenever it is connected to the digitizer.

At startup, the sensor automatically enters a 1 second (setup) mode, for approximately 1 minute. After this, it automatically switches back to its standard measurement mode (40 seconds). During other large, impulsive events (such as moving the sensor under power), it is recommended to place the sensor in 1 second mode temporarily, by asserting the PER_SW_EN line for approximately 20-30 seconds. This accelerates settling of the electronic subsystems within the sensor. Following this manual settling operation, the PER_SW_EN line should be de-asserted to restore the sensor to 40-second mode.

In principle, the 1 second mode enable signal is a digital line provided by the digitizer. For example, the MBB-1 cabling is designed so that this is provided by on Pin T, controlled by so-called GENEN-3 of the Q330 digitizers. Therefore, this switching in the field is fairly simple within the Willard setup and configuration program. Other digitizers may have different control lines.

The settling time for a sensor in 40 second mode (PER_SW_EN NOT asserted) depends upon sensor tilt. For a leveled sensor, it may take 1-2 minutes. For sensor elements at or near the extreme tilt limits (±2.5 degrees), the sensor may require as long as 5 minutes to settle.

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Full-Scale Tilt Range

The sensor will operate over a nominal tilt range of ±2.5V. The exact operational tilt range will be slightly skewed by offsets (mass position offsets) within the sensor elements. Typical skew is at or below 0.2 degrees, meaning that horizontal sensors (the two axes significantly affected by tilt) will operate reliably over a range that is at least ±2.3 degrees.

The mass position outputs of the E and N sensors serve as a proxy for *in situ* tilt. They have an approximate scale factor of 4 V/degree of tilt.

Calibration

The sensor supports an acceleration-equivalent calibration stimulus. That is, the sensor electronics generates a DC-coupled current, proportional to CAL input voltage.

The input impedance of the CAL signal conditioning circuitry is approximately 5.8M. The maximum input level is ±10V.

Use of an acceleration-equivalent stimulus means that the output of the sensor, within its passband (40 seconds to 150 Hz), to a “white” (constant amplitude with frequency) input stimulus, is frequency-dependent. The output level varies as 1/f. For example, the output is 1000X larger at 0.1 Hz than it is at 100 Hz. In view of this, CAL stimulus levels must be tailored to avoid electronic clipping/saturation within the sensor. As a general rule, limiting input voltages at frequencies at or above the low frequency corner (0.025 Hz) to about 0.01V peak, is advised. At high frequency (i.e., at or around the sensor's upper corner frequency of 150 Hz), the stimulus amplitude can approach the maximum peak value of 10V. Metrozet can suggest various stimulus types and amplitudes that will reliably excite the sensor below saturation, but with reasonable signal-to-noise ratio. Please contact us at support@metrozet.com for details.

Deployment Hardware Interfaces

Figure 1 shows a bolt pattern on the sensor top cap that is designed to allow attachment of various deployment hardware. There are bolt holes (Qty. 4 of 10-32UNF) and alignment pin holes (Qty. 2 of 0.127” diameter). At a minimum, the user should use the bolt holes for attachment of a lifting rope, when deployments are deeper than arm's length (where the sensor body can be held). **DO NOT USE THE ELECTRICAL CABLE FOR LIFTING!!!**

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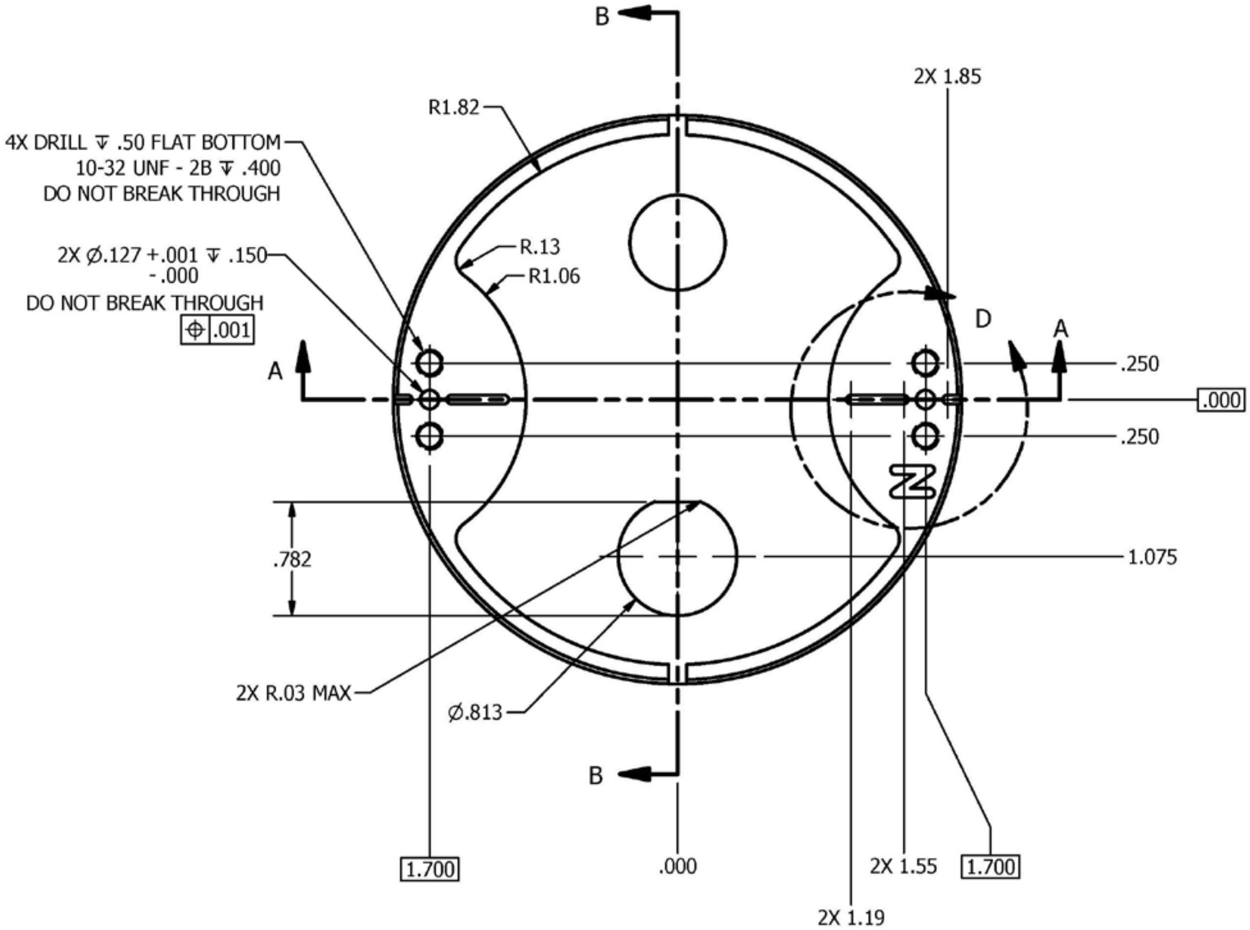

Figure 1. Details of attachment points on MBB-1 top cap. Qty. 4 of 10-32 UNF holes are available for attachment. The pair of 0.127" holes can be used for precise azimuth alignment of tooling that is attached to the sensor top cap.

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Sensor Response

The MBB-1 frequency response can be described well by a simple set of conjugate pole pairs:

P1 = -0.111+/-0.111j (radians/second)
P2 = -480+/-600j (radians/second)
P3 = -750+/-1125j (radians/second)

The frequency response is defined as:

$$\mathbf{TF}\,(s) \quad = \quad \frac{\mathbf{G\,[s][s]|P2|^2\,|P3|^2}}{\mathbf{(s - P1)(s - P1^*)(s - P2)(s - P2^*)(s - P3)(s - P3^*)}}$$

where G is the scalar responsivity (Volts-sec/m):

G ~ 750 V-sec/m

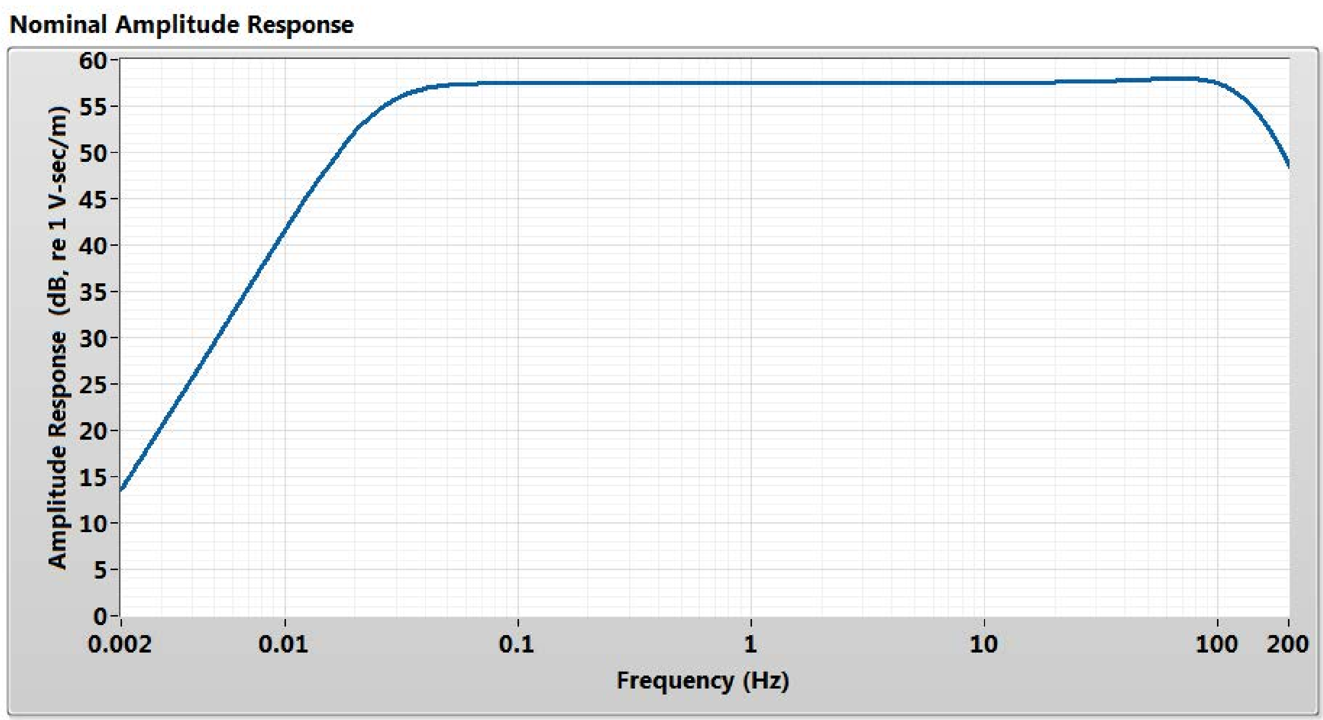

Figure 2. Amplitude of Transfer Function (Nominal)

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Getting support

For any questions, problems, or further needs regarding the MBB-1Triaxial Seismometer, please contact Metrozet at **support@metrozet.com** or Kinemetrics at **support@kmi.com**.

Posthole installation suggestions

The shown posthole inner diameter is 8 inch and the PVC pipe I.D. is 6 inch. However, the installation will be successful even with smaller diameter, ~7 inch I.D. posthole and ~5 inch I.D. PVC pipe. Of course, the deeper the posthole, the more reduction in the surface noise will be.

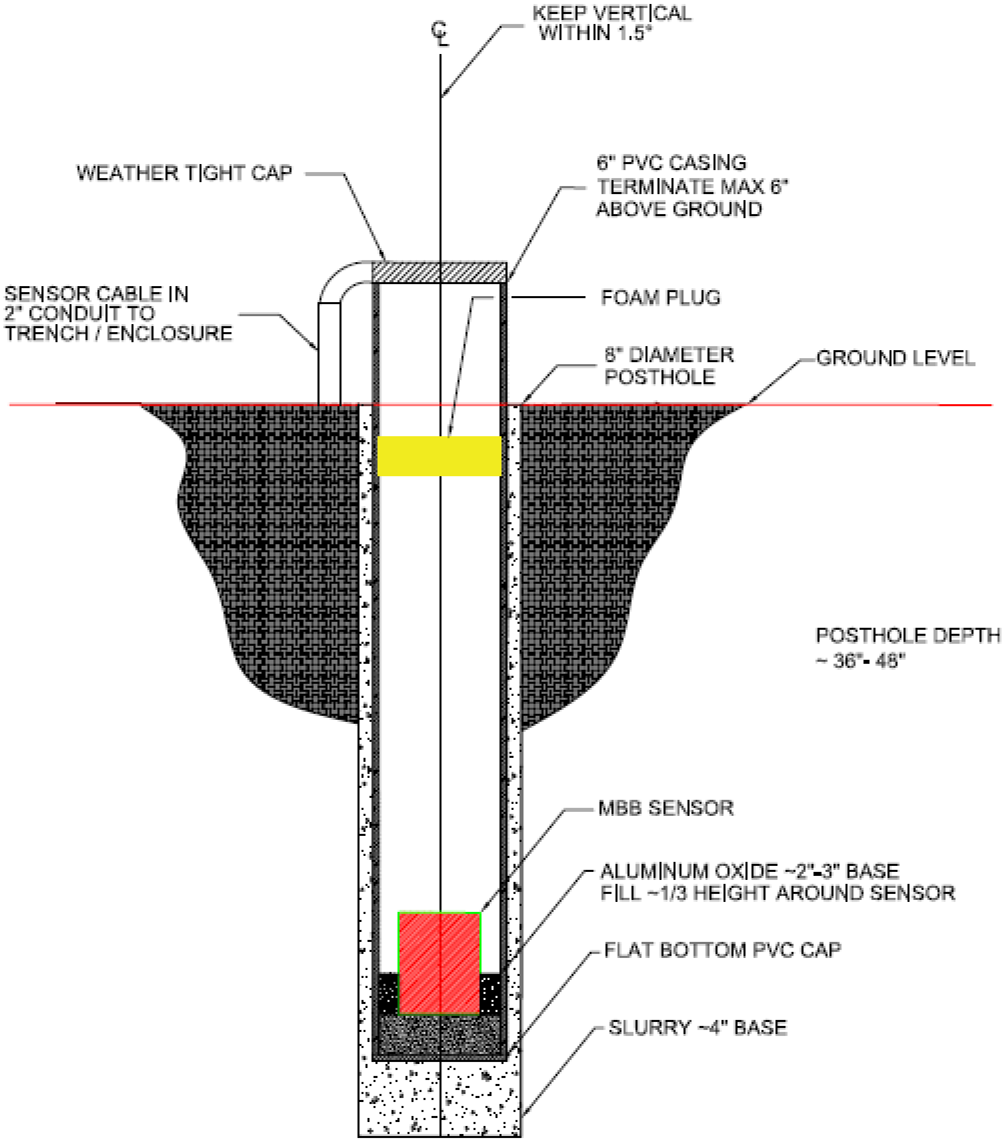

Figure 3. Vertical section showing the recommended borehole installation details.

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Posthole installation accessories

The following items are not necessary for surface/vaults installations, but are mandatory for a successful posthole/borehole installation:

1. **Posthole Kit,** to include: block, clamp, plate, lifting bracket, rope and screws. This option is for safe sensor lowering into the borehole and safe pulling it out of the borehole. Please see Figure 4.

2. **Orientation pole**. This option is mainly for sensor orientation and requires the Posthole Kit above. Please see Figure 5**.**

3. **Extension pole, 5 ft (1.5 m) section**. This option is to extend the loading pole to up to 20 sections (totaling 100 ft or 30 m). Please see Figure 5**.**

4. **Aluminum Oxide media, 10 lbs (4.5 kg)**. This option is to assure mechanical coupling between the sensor and the borehole (or pipe/casing, if present). This quantity is sufficient to compact 2 inches of media at the bottom of the borehole, surround the sensor, and cover it several inches if installation is done in a 6 inch inner diameter borehole (or larger borehole and a 6 inch inner diameter casing).

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Metrozet MBB-1 Specifications

Specification	**Value**
Axes Orientation	E(X), N(Y), UP(Z)
Sensor Format	Non-Galperin: Two (2) horizontal sensors, one (1) vertical sensor
Scale Factor	Velocity Output: 750V-sec/m differential, ±2% Boom Position Output: Approximate 23 V-sec^2/m For E and N sensors, this is approximately 4 V/degree of tilt
Full-Scale Range	Output Voltage: ±20V Peak Velocity: ±13 mm/sec H Sensor Tilt: ±2.5 degrees, nominal
Response Passband	40 seconds (±2%) to 150 Hz (±5%), -3 dB response points
Period Switching	Relay-enabled 1 second mode for rapid settling
Axis Alignment	Within 0.8 degrees
Output Impedance	100 ohms, differential, on Velocity signal outputs
CAL Stimulus Input	DC-coupled; approximate 5.8M input impedance; ±10V range; acceleration-equivalent; relay-isolated
Self Noise	Below NLNM from 17 seconds to 5 Hz
Size	3.90” Diameter x 4.70” Tall (9.9 cm x 11.9 cm)
Weight	~ 6 lbs (2.7 kg)
Package	Passivated 316 Stainless Steel housing and top cap; Mounting hole pattern on top cap for attachment of lifting/orientation aids; three threaded holes on bottom for feet
Electrical Connector	Glenair 802-013-07Z19-19PA receptacle; oceanographic grade
Operating Temperature Range	-40ºC to +60ºC
Power	9-36V Input, galvanically-isolated; 360 mW typical, at level orientation

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Drawings of Posthole Installation Accessories

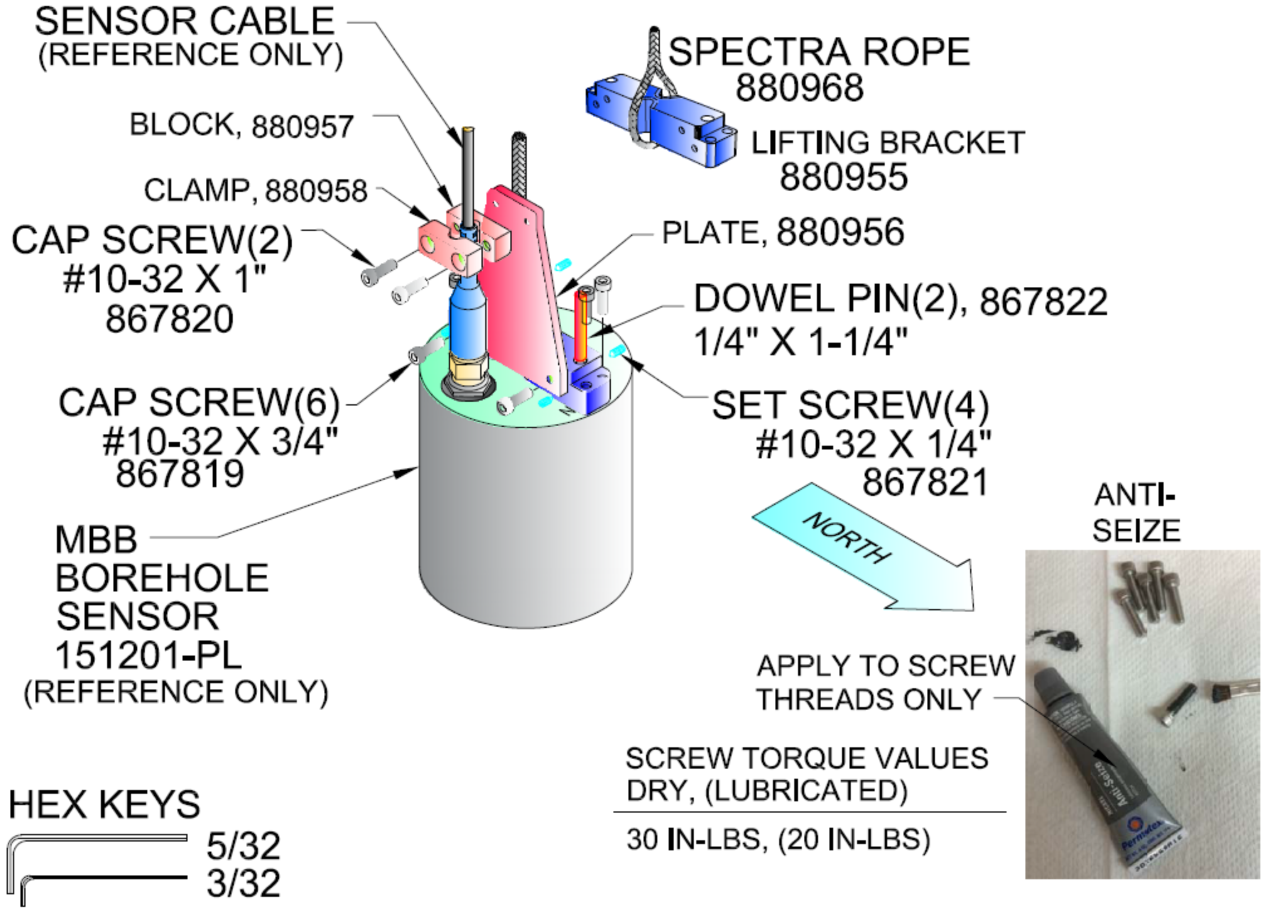

Figure 4. Posthole Kit

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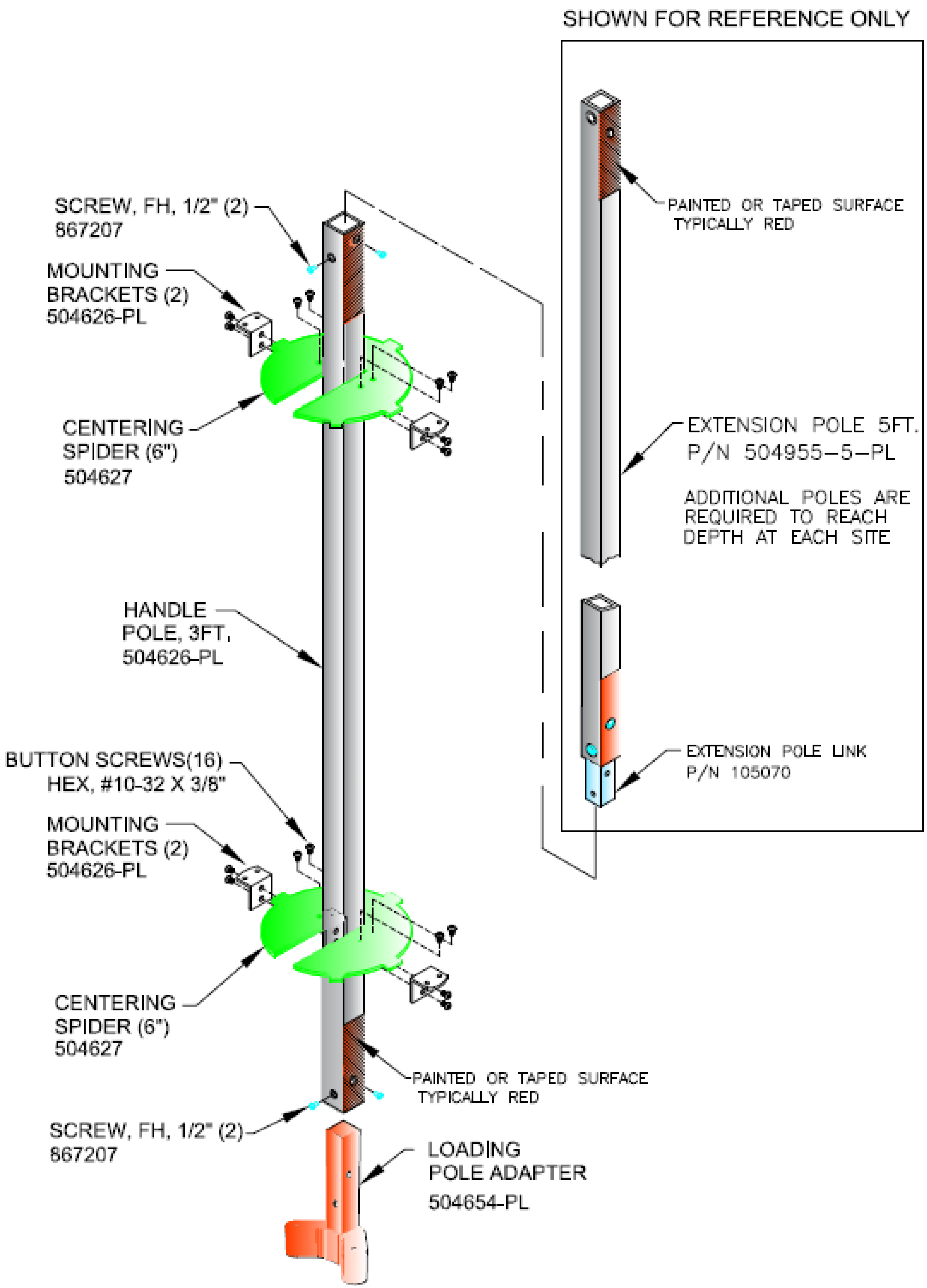

Figure 5. Orientation pole and extension pole