Horizontal Digitilt Inclinometer Probe

50302999

This equipment should be installed, maintained, and operated by technically qualified personnel. Any errors or omissions in data, or the interpretation of data, are not the responsibility of Slope Indicator Company. The information herein is subject to change without notification.

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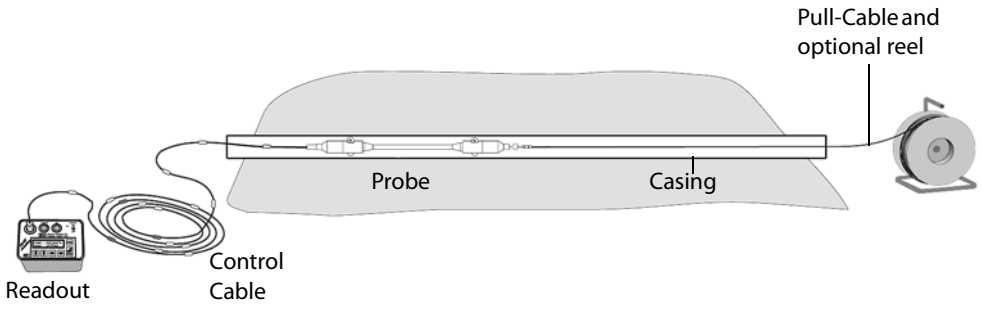
Introduction

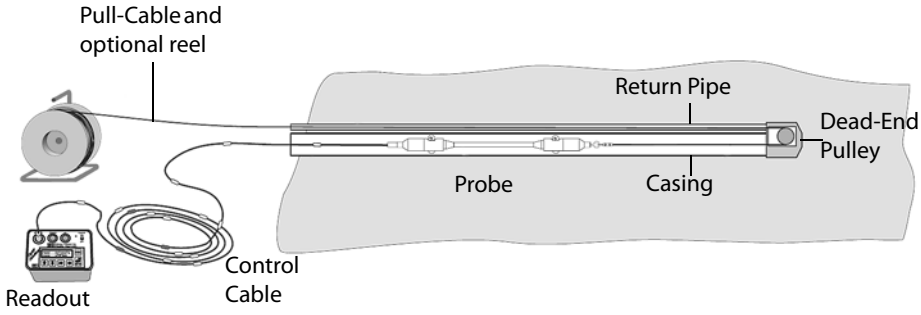
About Horizontal Inclinometers

85mm (3.34") Inclinometer casing is installed in a horizontal trench or borehole with one set of grooves aligned to vertical. When the far-end of the casing is not accessible, a dead-end pulley and cable-return pipe are installed along with the casing.

The probe, control cable, pull-cable, and readout unit are used to survey the casing. The initial survey establishes the profile of the casing, and subsequent surveys will reveal changes in the profile if ground movement occurs.



Open-End Installation

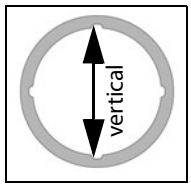


Closed-End (dead-end) Installation

Components

Casing

s**Casing:** 85mm (3.34")OD casing is required. One set of grooves must be vertical. Telescoping sections are not recommended.

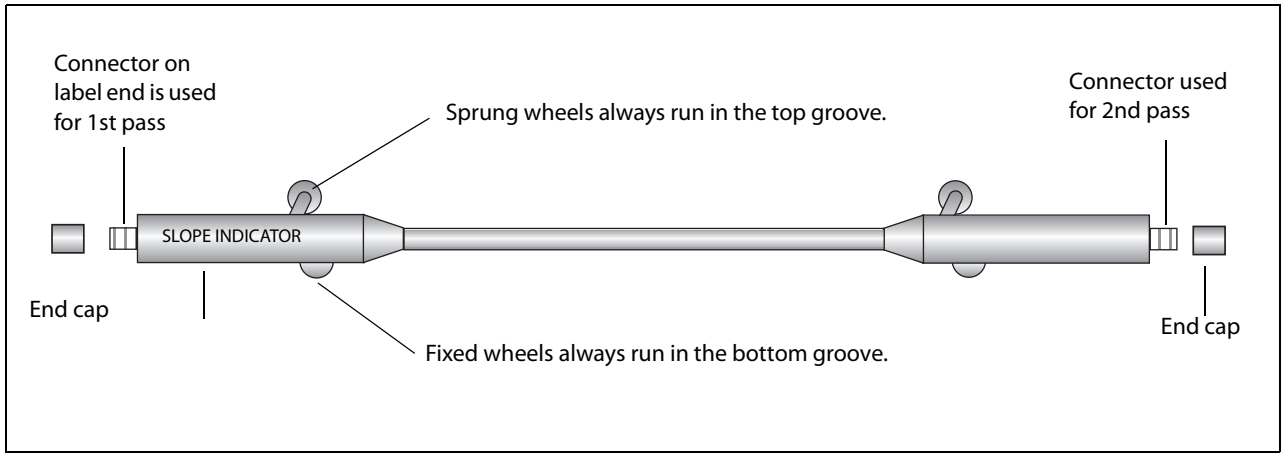


Probe

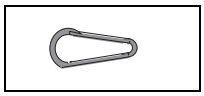
Fixed Wheels: The fixed wheels (as opposed to the sprung wheels) of the probe are kept in the bottom groove of the casing during both passes of the survey.

Two Cable Connectors: The probe has a connector for the control cable at each end. The cable is connected to one end on the first pass and to the opposite end on the second pass.

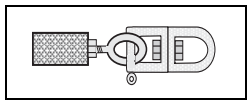
Label: The label end of the probe is oriented to the near-end of the installation during the first pass through the casing.



Pull-Cable and Control Cable



Pull Cable: The pull-cable is 1/8" stranded, stainless steel cable. It is used to pull the probe to the far-end of the casing. A carabiner is permanently attached to the pull-cable. Leave the pull cable and carabiner in the casing when you leave the site.



Pull-Cable Connector: The pull-cable connector screws onto the end of the probe. The carabiner snaps onto the connector to attach the pull-cable to the probe. Take the pull-cable connector with you when you leave the site.

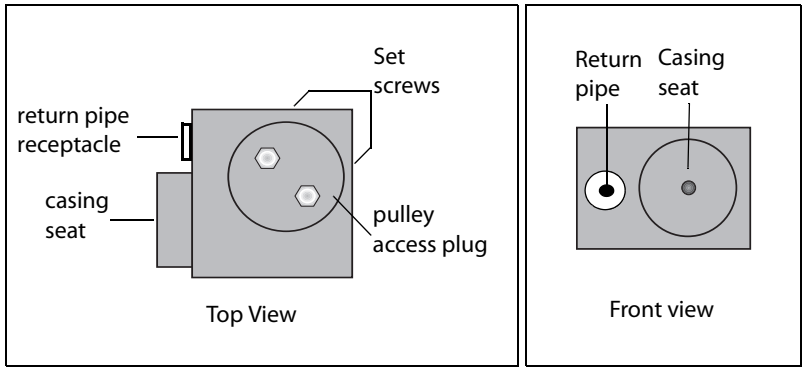
Control Cable The control cable is used to control the depth of the inclinometer probe and conduct power to the probe. Metric control cables are graduated at 0.5 meter intervals and English control cables are graduated at 2-foot intervals.

Readout

The Digitilt DataMate is used to read the horizontal inclinometer probe. See product manual for Digitilt DataMate for complete operating instructions.

Installation Accessories

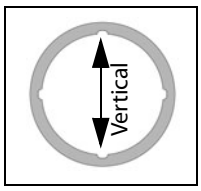
Dead End Pulley: When the far end of the casing is not accessible, a dead-end pulley and cable return pipe are installed in the trench.



Installation of Casing

Overview

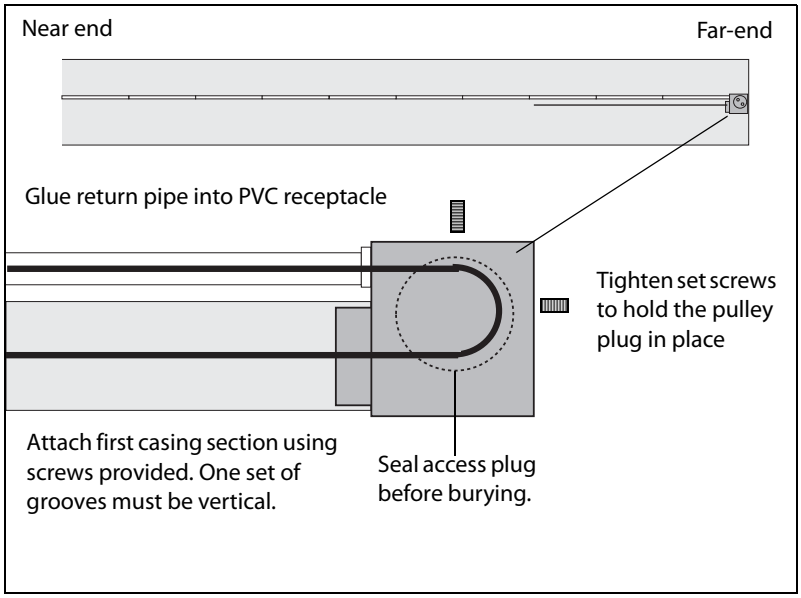
Install 85mm (3.34") casing in trench. One set of grooves must be vertical. A dead-end pulley is used if one end of the installation is inaccessible. Telescoping sections are not recommended.



Casing Installation

1. Start with compacted fill. Excavate a trench approximately, 0.5m wide x 0.6m deep (1.5 ft. X. 2.0 ft.), with a small (5%) gradient for drainage. Place a 150mm (6") layer of sand in the bottom of the trench.

2. If you are not using a dead-end pulley, skip to step 3. Assemble return pipe, starting at near-end. Pull stainless steel cable through pipe as sections are assembled. Place pulley at far-end of trench with pulley access plug on top. When return pipe installation has reached the pulley, push pull-cable through the PVC receptacle and out through casing seat.Glue PVC pipe into receptacle.



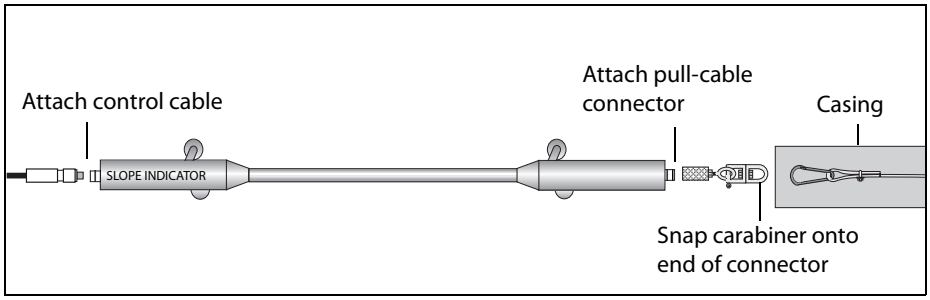
3. Assemble casing, starting at the far-end. Orient casing so one set of grooves is vertical. Pull stainless steel cable through as you add casing sections. If you are using a dead-end pulley, attach the first section of casing using the screws provided.

4. When casing is assembled, plug ends to keep dirt and debris out of casing. Cover the casing with sand and compact evenly.

5. Remove plugs. Attach carabiner to pull-cable, at near-end, with the u-clamp.

6. Test the installed casing: Attach control cable and pull-cable to probe. Pull the probe through the casing, from near-end to far-end, and back to ensure the grooves are aligned.

7. Plug ends again and backfill remainder of trench with select fill.



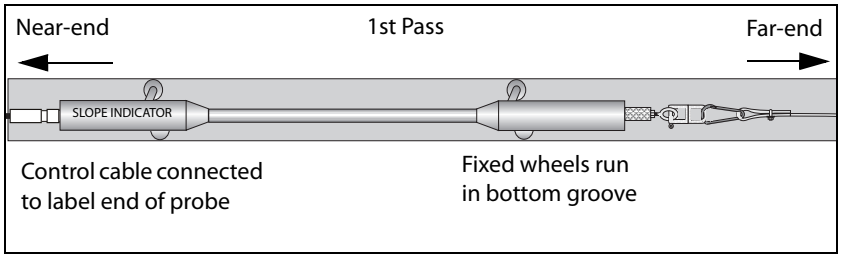
Taking Readings

Overview

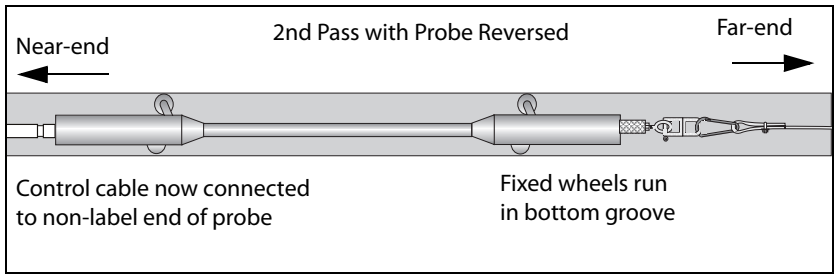
In a standard horizontal inclinometer survey, the probe is drawn through the casing twice, with each pass beginning at the far-end of the casing.

The pull-cable is used to pull the probe to the far end to start the pass. The control cable is used to position the probe as it is drawn toward the near end of the casing.

First Pass: The control cable is connected to the 'label' end of the probe.



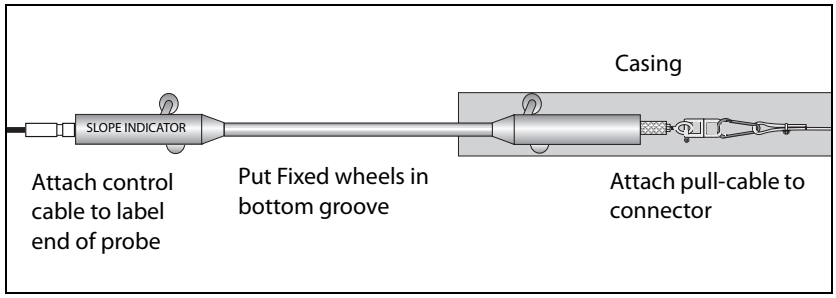
Second Pass: At the end of the first pass, the probe is reversed end for end and control cable and pull cable are reconnected. The probe is then reinserted in the casing, fixed wheels still in the bottom groove.



Setting up

You should have the inclinometer probe, the indicator, and the control cable. It may be useful to bring a large tub to hold the control cable and a rag to wipe the cable and probe after readings have been taken.

1. When you arrive at the site, lay out a plastic sheet or tarp to set the equipment on.
2. Unlock and remove any protective caps from the casing.
3. Remove protective caps from probe and control cable.
4. Attach the control cable to the label end of the probe. Align the connector key on the control cable with the keyway in the probe. Then insert the connector and tighten the nut to secure the connection. Do not over-tighten the nut, since this will flatten the O-ring and reduce its effectiveness.
5. Attach pull-cable connector to opposite end. Snap carabiner onto swivel connector of eyebolt cap to attach pull cable.



Inserting the Probe for the 1st Pass

Pull Probe to Far-End

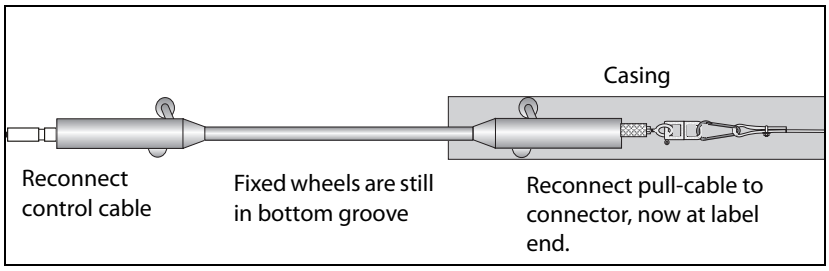
1. Turn on the indicator. This energizes the accelerometer, making it less susceptible to shock.
2. Insert the probe into the casing with the fixed wheels in the bottom groove. Pull-cable end should be oriented to the far-end.
3. Use the pull-cable to position the probe at the far-end.
4. Allow the probe to adjust to the temperature inside the casing. Five or ten minutes is usually sufficient.

Readings for First Pass

1. Position the probe for first reading. Use the control cable to draw the probe to the first depth marker. Align marker with the reference. This will be the starting depth for the installation. Program the Digitilt DataMate per instructions.
2. Wait for the numbers on the readout to stabilize. Press the handswitch to record the A axis reading. If you are using a manual indicator, write down the A-axis reading. The horizontal probe is uniaxial so you can ignore the B axis.
3. Draw the probe to the next depth marker while holding the pull cable in tension, to avoid over-pull. Wait for a stable reading, and then record it. Repeat this process until the probe is at the near-end of the casing.

Readings for Second Pass

1. Remove the probe. Disconnect control cable and pull-cable connector. Reverse the probe, keeping the fixed wheels pointed down.
2. Reconnect the control cable and pull-cable. Reinsert probe into casing. Use pull cable to reposition probe at the far-end.



Reverse Probe for2nd Pass

3. Draw control cable to position the probe at starting depth. Repeat survey, taking readings for the second pass.
4. Remove the probe. Disconnect the control cable and pull-cable. At this point, you may want to validate the data set and make any corrections necessary.

Leaving the Site

Wipe off the probe and cable. Remove pull-cable connector and pack in probe case. Replace end-caps on cable and probe, and return the probe to its protective case. Replace the indicator's protective plugs. Coil the cable. Replace and lock any protective caps.

At the Office

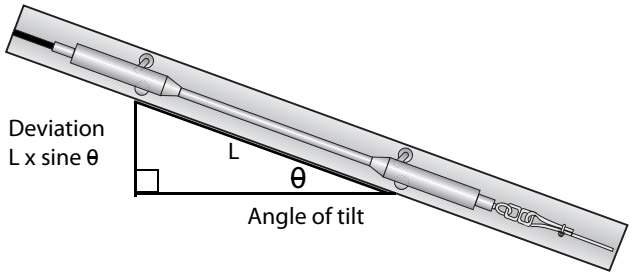
Wipe off the indicator and recharge its batteries. Transfer the data set to a PC. Oil the probe wheels. If the storage place is dry, remove protective caps from probe, indicator, and control cable to allow all connectors to dry.

Data Reduction

Inclinometer Measurements

The horizontal inclinometer measures tilt in the plane of its wheels. Data reduction converts the tilt measurement to a linear measure in inches or mm.

The basic principle involves the sine function, an angle, and the hypotenuse of a right triangle. We are interested in the length of the side opposite the angle.



Deviation

In the drawing above, the measurement interval is the hypotenuse of a right triangle. The measurement interval is typically 0.5 m with metric-unit probe or 2 feet with English-unit probe.

The side opposite the angle of tilt is deviation. It is calculated by multiplying the sine of the angle of deflection by the measurement interval. This calculation translates the angular measurement into a vertical distance (and is the first step to calculating settlement or heave).

Displacements

Changes in deviation are called displacements, since the change indicates that the casing has moved away from its original position. When displacements are summed and plotted, the result is a high resolution representation of movement.

Reducing Data Manually

Normally, computer software is used to reduce inclinometer data. Here, we show how to reduce the data manually.

Displayed Readings

Slope Indicator's readouts display "reading units" rather than angles or deviation. Reading units are defined below:

$$\text{Displayed Readings}_{\text{English}} = \sin\theta \times 20{,}000$$

$$\text{Displayed Readings}_{\text{Metric}} = \sin\theta \times 25{,}000$$

Combining Readings

The standard two-pass survey provides two readings for each interval. This two-pass system has several advantages. First, it eliminates the sensor offset, which can change from survey to survey. Second, it provides a means of detecting error through checksums and other routines. Third, it tends to smooth the effect of random errors. During data reduction, the two readings are combined and averaged. For example:

$$\text{A0 Reading} = 359$$

$$\text{A180 Reading} = -339$$

$$\text{Averaged Reading} = \frac{359 - (-339)}{2}$$

$$= 349$$

Calculating Deviation

To calculate deviation, we average the A0 and A180 readings, divide by the instrument constant, and multiply by the measurement interval. In the example below, we show an English-unit calculation:

$$\text{Lateral Deviation} = \text{Measurement Interval} \times \sin\theta$$

$$= 24 \text{ inches} \times \frac{359 - (-339)}{2 \times 20,000}$$

$$= 0.4188 \text{ inches}$$

Divide reading unit by instrument constant to obtain sine of angle.

Combine the A0 & A180 readings and divide by 2 to average them.

Calculating Displacement

Displacement, the change in vertical deviation, indicates movement of the casing. To calculate displacement, we find the change in (combined) reading units, divide by the instrument constant, and multiplied by the length of the measurement interval.

$$\text{Combined Reading}_{\text{initial}} = 698$$

$$\text{Combined Reading}_{\text{current}} = 700$$

$$\text{Displacement} = \text{Measurement Interval} \times \Delta \sin\theta$$

$$= 24 \text{ inches} \times \frac{700 - 698}{2 \times 20,000}$$

Calculate the change in combined readings (current-initial) and divide by 2 to average them

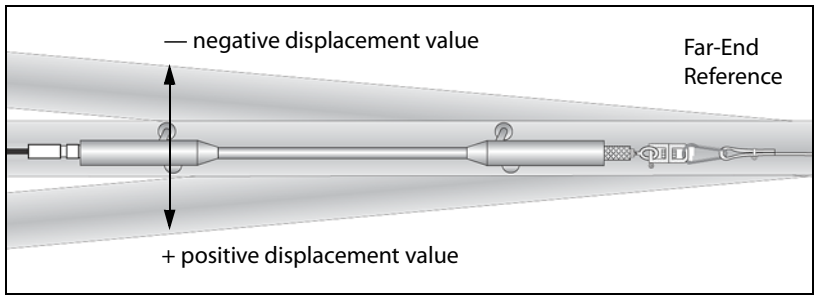
$$= 0.0012 \text{ inches}$$

Direction of Movement for Horizontal Inclinometers

Displacements can be referenced to either end of the casing. The reference affects the meaning of negative or positive displacements, as illustrated below.

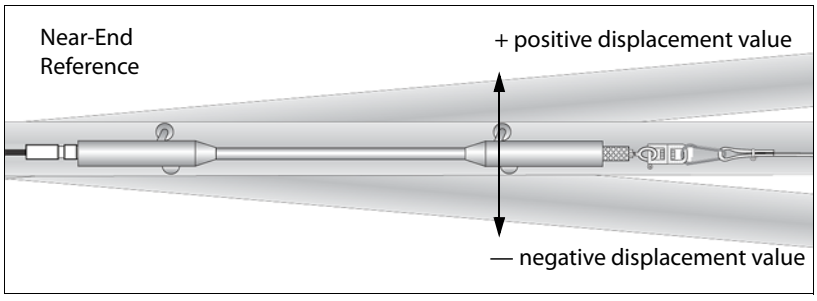
Far-End Reference

When the far end of the casing is used as the reference, negative displacements indicate upward movement and positive displacements indicate downward movement.



Near-End Reference

When the near end of the casing is used as the reference, negative displacements indicate downward movement and positive displacements indicate upward movements.



Maintenance

Casing

During Installation: It is important to keep the inside of the casing as clean as possible. Soil material causes wear on the grooves and wheels.

Probe

Cleaning the Probe: When you finish a survey, wipe moisture off the probe and replace the protective cap. If necessary, rinse the probe in clean water or wash it with a mild laboratory grade detergent when you return to the office.

Drying the Probe: When you return to the office, remove protective caps from the control cable, probe, and readout unit. Allow connectors to air-dry thoroughly for a number of hours. Afterwards, replace the caps.

Storing the Probe: The probe, control cable, and readout unit should be stored in a dry place. For extended storage, keep the probe in a vertical position.

Lubricating the Wheels: Lubricate the wheels regularly. Spray a small amount of lubricant or place a drop of oil on both sides of the wheel bearings. Check that the wheels turn smoothly.

Caring for O-Rings: Periodically clean and lubricate the O-ring on the connector end of the inclinometer probe. Use O-ring lubricant.

Cleaning the Connectors: Try to keep connectors clean. If it is necessary to clean, them, use a cotton swab slightly moistened with alcohol. Be careful to use only a small amount of alcohol. Do not clean connectors with spray lubricants or electrical contact cleaners. Solvents in these products will attack the neoprene inside the connector.

Control Cable

Cleaning the Cable: If necessary, rinse the cable in clean water or wash the cable in a laboratory-grade detergent, such as Liquinox.® Do not use solvents to clean the cable. Be sure the protective cap is in place before immersing the end of the cable in water. Do not immerse the Lemo connector.

Cleaning Connectors: If it is necessary to clean the connector, use a cotton swab moistened with a small amount of alcohol. Do not use spray lubricants or electric contact cleaners. Solvents contained in such products will attack the neoprene inserts in the connectors.

Drying Connectors: When you return to the office, remove protective caps from the control cable, probe, and readout unit. Allow connectors to air-dry well for a number of hours. Afterwards, replace the caps.

To prevent reliability problems in hot, humid climates, be sure to allow connectors to air-dry when the equipment is brought into the office or storage area. This is especially important if the office is air-conditioned, since the warm moist air trapped in the connector will condense as the connector cools. Remove the cap, allow the connector to air-dry, then replace the cap when the connector is dry and cool.

Storing the Cable: Control cable and other inclinometer components should be stored in a dry place. Be sure that you have allowed all connectors to air-dry before placing equipment in storage.

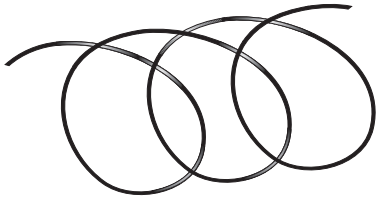
Coiling Cable

Improper coiling of any electrical cable twists conductors and can cause reliability problems. The best solution is a cable reel with a minimum hub diameter of 300 mm (12"). If a reel is not available, coil the cable as shown below.

1. Loop cable forward as shown in drawing.

2. Twist cable backwards to make a second loop as shown in drawing.

3. Continue coiling cable with alternating loops as in step 1 and 2 above.



Good Practices

Casing

- Always begin with a smooth, flat surface in the trench.
- 85 mm (3.34") casing is required. Telescoping sections are not recommended.
- Keep inside of casing clean of sand and debris during installation. Raising the open end off the dirt floor of the trench will help keep material out.
- Mark the outside edge of the open casing (at 6:00 position) with a permanent marker for the reference
- Great care must be taken to ensure that one set of internal grooves is completely vertical when installed. A carpenter's level can be placed on an alignment tool to ensure verticality before the sections are permanently joined.

Horizontal Probe

- When you connect control cable to the probe, avoid overtightening the nut, since this will flatten the O-ring and reduce its effectiveness.
- Protect the probe from shock. Transport the probe in its carrying case. Try to cushion the case.
- Protect the probe from sudden acceleration.

Control Cable

- When you connect control cable to the probe, avoid overtightening the nut, since this will flatten the O-ring and reduce its effectiveness.
- Although the control cable is rugged, it should be handled with care to prevent abrasion, cuts, or internal damage. Wipe off the cable after every use and allow connectors to air-dry. Coil cable properly to prevent twisting (see "Coiling Cable" on previous page). Check for nicks periodically. Avoid making small radius bends in the cable, especially near connectors.
- When very high precision is expected it may be useful to periodically record the date and the precise length of your control cable.

Taking Readings

- Use the same probe and control cable for each survey.
- Use a consistent reference. The goal is placement repeatability within 5 mm or 1/4 inch. Always align depth marker at same reference. If arbitrary location is used, probe positioning will be inconsistent, and data will have to be manipulated before it is useful.
- With an open-ended installation, it is best to have a technician on both ends, one handling the control cable and one keeping slight tension on the pull cable. You can use walkie-talkies to communicate during surveys.
- Always pull the probe smoothly to the reading depth. Maintain tension on the control cable and the pull cable. If you accidentally pull the probe beyond the intended depth, reposition the probe at the previous location, then pull it back to the intended depth. This technique ensures the probe will be positioned consistently.
- Wait 10 minutes for the probe to adjust to ambient temperature.
- Wait for displayed readings to stabilize. The DataMate displays 3 diamonds when readings have stabilized within two units. Note: you must always wait 10 minutes for temperature adjustment even if the DataMate displays 3 diamonds.
- Validate surveys on site using checksum statistics.