Horizontal Digitilt Inclinometer Probe

50303599

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 DGSI (Durham Geo Slope Indicator). The information herein is subject to change without notification.

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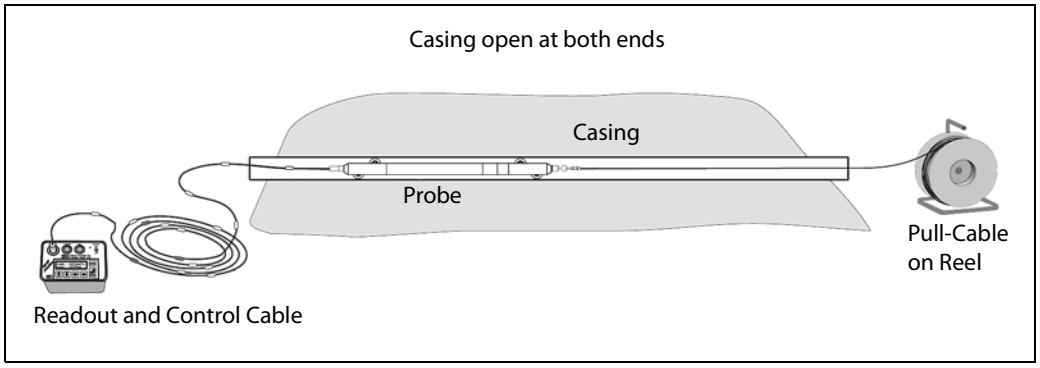
Contents

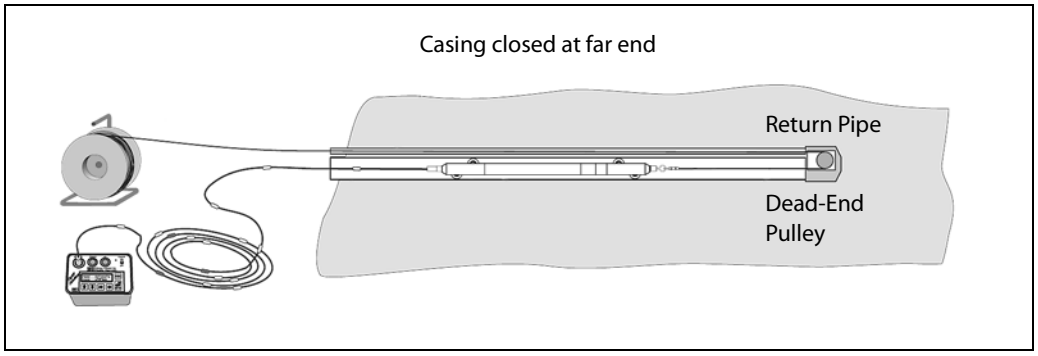
Introduction

About Horizontal Inclinometers

Inclinometer casing is installed in a horizontal trench or borehole. As shown in the drawings below, the casing can be open at both ends, or closed at the far end. When the casing is closed at the far end, a dead-end pulley and cable-return pipe are also installed.

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 has occurred.

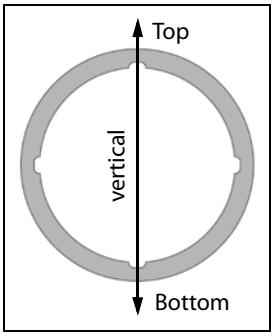




Components

Inclinometer Casing

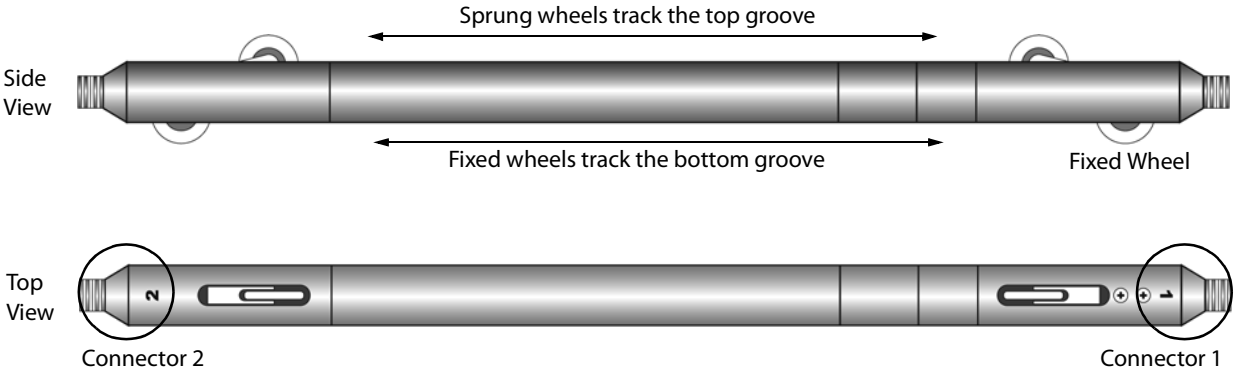
Inclinometer casing is a special-purpose pipe used for inclinometer installations. Grooves inside the casing control the orientation of the probe and provide a flat surface for tilt measurements.



Casing is installed with one pair of grooves aligned vertically, so that there is top groove and a bottom groove.

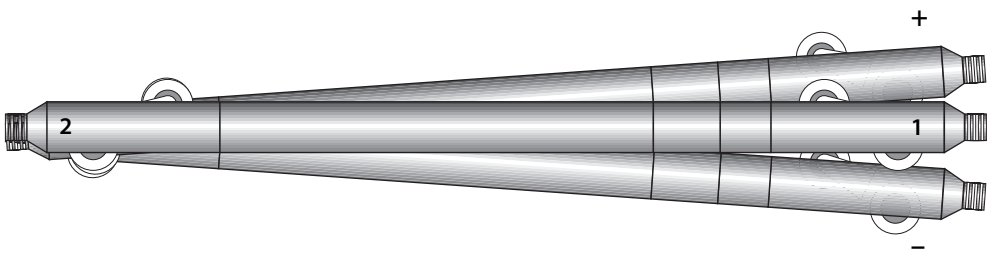
Horizontal Probe

The horizontal inclinometer probe is used to obtain tilt measurements along the length of the casing. It has wheels that track the grooves in the casing. Always orient the probe so that its sprung wheels track in the top groove and its fixed wheels track in the bottom groove.

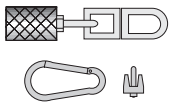


The probe has identical connectors at each end. Looking at the probe from the top, you can see that the connectors are labelled 1 and 2.

When the probe is horizontal and connector 1 is raised, the tilt reading will be a positive value. If connector 1 is lowered below horizontal, the tilt reading will be a negative value.



Pull-Cap and Carabiner



A special pull-cap is supplied with the probe. This cap is screwed onto either connector to allow attachment of the pull cable. A snap carabiner (snap clip) is also supplied with the probe. It is permanently attached to the pull cable, providing a quick way to connect and disconnect from the pull cap and probe. If you have more than one installation, you can order additional carabiners. The part number is 02750012.

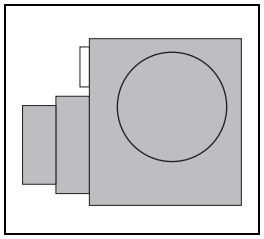
Pull Cable

A stainless steel pull cable is used at the start of every survey to pull the probe to the far end of the casing. The pull cable is stored inside the casing when you leave the site.

We recommend that you buy a reel for the pull cable. It is important that the cable is not twisted or kinked.

The pull cable should be long longer than the casing to allow easy handling and easy connection to a reel. When a dead-end pulley is used, the length of the pull cable must be doubled. It must go through the casing, around the pulley, and through the return pipe.

Dead-End Pulley



When the far end of the casing is closed, a dead-end pulley and cable return pipe are installed so that the pull cable can be operated from the near end of the casing.

The dead-end pulley is not used when both ends of the casing are open.

Control Cable

The control cable is used to control the position of the probe conduct power and signals between the probe and the readout. Metric control cables are graduated at 0.5 meter intervals and English control cables are graduated at 2-foot intervals.

Readout

The Digitilt DataMate records the inclinometer survey. Operation of the DataMate is covered in a separate manual.

Installation of Casing

Planning

Site conditions vary widely, so these instructions are general rather than specific. Read through the instructions, and then make a plan that is suitable for your site.

Casing Size

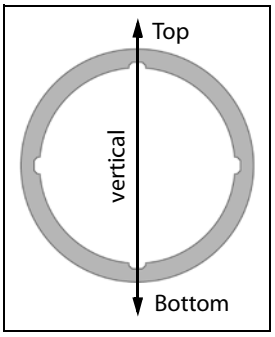
Use either 70mm or 85 mm (3.34" or 2.75") casing. The current version of the horizontal probe (50303510 or 50303500) is supplied with two sets of wheels that can be interchanged for different sizes of casing.

The retired version of the horizontal probe (50302910 or 50302900) requires 85mm (3.34") casing and cannot operate in 70mm casing.

Casing Type

- Slope Indicator's Standard casing, is the recommended casing for horizontal installations. Couplings are glued, so ABS cement is required.
- Slope Indicator's QC casing is less convenient. Couplings are harder to snap together and this makes it difficult control orientation of the grooves.
- Telescoping sections are not needed and not recommended.

Casing Orientation



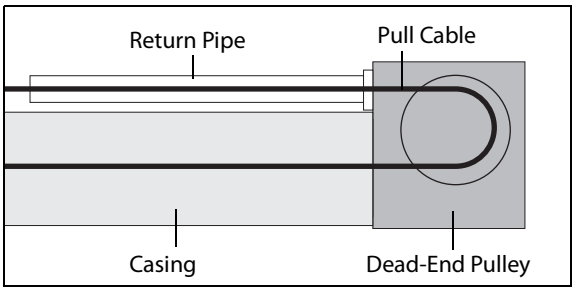
- Install the casing with one pair of grooves oriented vertically, so there is a top groove and a bottom groove. Accuracy degrades when grooves are off vertical by more than 3 degrees.
- Mark the outside of each section of casing to show where the top groove is. This lets you easily check the overall orientation of the casing during assembly and backfilling.
- Check the verticality of the top and bottom grooves each time you add a length of casing. Use a plumb bob or carpenter's level.
- Keep casing in shipping boxes and in the shade until it is used.
- Review casing assembly instructions. Try joining two sections of casing to help predict possible problems.
- Use clean rags to plug ends of casing. Tie a string onto the rags, to avoid leaving a rag inside.

Pull Cable

- Pull cable should be longer than the casing to allow easy handling and easy attachment to a reel. If a dead-end pulley is used, the cable length must be doubled.
- Put the pull cable on a reel so that it will not kink or carry sand and dirt into the casing.

Dead-End Pulley

- If the far end of the casing is closed, you must install a dead-end pulley and a return pipe.The dead-end pulley should be oriented vertically, so that the cable will stay on the pulley. That puts the return pipe above the casing, as shown in the drawing below.
- Thus it is probably easiest to assemble the casing first, working toward the pulley. When you reach the pulley, thread the pull cable through the pulley, and then assemble the return pipe, working away from the pulley.



Excavate the Trench

- Check that the fill has been compacted well before trenching.
- Site specifications may suggest a width and depth for the trench, otherwise, make the trench at least 0.5m (1.5') wide and 0.6m (2') deep. A 3% grade is useful for drainage.
- Check that the bottom of the trench free from rocks or other hard materials.
- Place a 150 mm (6 inch) layer of sand or other finely graded material on the bottom of the trench and tamp it well so that casing will be supported by a firm, flat surface.

Assemble the Casing

1. Position the reel where you will begin assembly of the casing. Thread the pull cable through each section of casing as it is added.
2. Follow casing assembly instructions, but consider that trenched installations do not require rivets or sealed couplings.
3. As you work, keep the inside of the casing as clean as possible. For example, placing cardboard under the casing to use as a

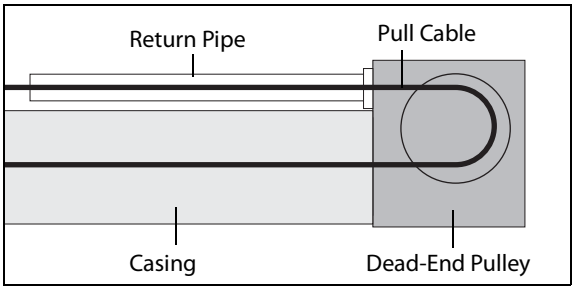
work surface when you apply glue to casing and couplings and push the two together. Also, plug the end of the casing with a rag when practical.

4. Check the orientation of the casing (the verticality of the top and bottom grooves) after adding each section of casing. For best results, use a plumb bob or carpenters level. Also, check the overall orientation of the casing by sighting along the marks you made on the outside of the casing. Keep in mind that it is very difficult - and requires many hands - to correct orientation problems later.
5. When assembly is complete, inspect couplings, and make check of the overall orientation of the grooves.
6. Install the dead-end pulley assembly, if required.

Installing a Dead-End Pulley

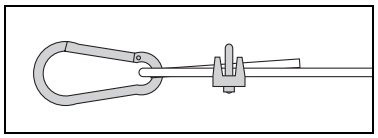
A dead-end pulley and return pipe for the pull cable must be installed when there is no access to the far end of the casing.

1. Cut off the end of the casing, so that the full thickness of the casing is available.
2. Orient the dead-end pulley so that the return pipe will be above the inclinometer casing.
3. Thread the pull cable through the dead-end pulley.
4. Join the casing to the dead-end pulley using solvent cement and the screws provided.
5. Thread the pull cable into the first section of return pipe and continue assembling the return pipe, working away from the dead-end pulley.



Backfill the Trench

1. Tuck the pull cable into the casing, and then plug the ends of the casing to prevent entry of sand and dirt.
2. Place sand or other finely graded material to the sides of the casing and then over the top of the casing to a depth of 150 mm (6 inches). Take care that you do not change the alignment of the casing as you place and tamp the sand.
3. Test that the probe can pass smoothly through the casing. Attach the supplied carabiner to the pull cable, as shown in the drawing. Then screw the pull-cap onto the probe and snap on the pull cable. Refer to reading instructions for attachment of control cable, orientation of probe, etc.



4. Plug ends again and backfill the remainder of trench with finally graded material or select fill. Compact by hand.
5. Later terminate the ends of the casing as specified by the project engineer. It is useful to place protective housings over the ends of the casing so that it cannot be vandalized.

Taking Readings

Overview

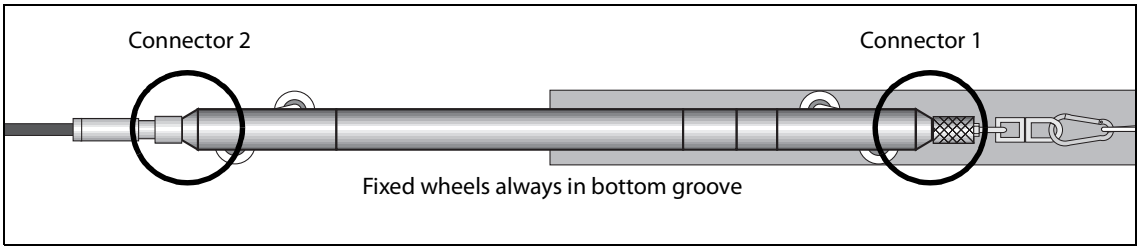
An inclinometer survey consists of readings acquired from two passes of the probe through the inclinometer casing. The two passes are known as the 0 pass and the 180 pass, because the probe is reversed for the 180 pass.

Each pass begins at the far-end of the casing. The pull-cable is used to pull the probe to the far end. The control cable is used to position the probe for each reading.

If you have a partner working at the opposite end of the casing, you may need radios or cell phones to coordinate your activities.

Taking 0 Readings

1. Remove protective caps from the ends of the probe. Screw the pull-cap onto Connector 1. The connector is labelled on the top side of the probe body. Snap the carabiner from the pull cable onto the pull-cable cap.
2. Plug the control cable into Connector 2. Gently tighten the nut. Avoid over-tightening, since this will flatten the O-ring over time and reduce its effectiveness.
3. Power on the readout, and insert the probe into the casing, placing the fixed wheels in the bottom groove of the casing.



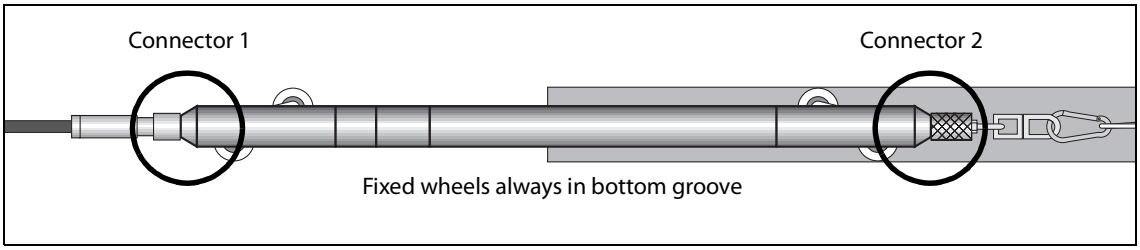
4. Pull the probe to the far end of the casing. Then use depth marks on the control cable to precisely place the probe for the starting reading.
5. Select the appropriate installation from the DataMate's list of installations, and step through the parameters until the start depth is displayed.
6. Wait for the A-axis value on the readout to stabilize, then record the reading. Ignore the B-axis reading, since there is no B-axis sensor.
7. Draw the probe to the next reading position, indexing the

depth mark against the end of the casing (or some other reference). When the reading is stable, record it.

8. Repeat the previous step, taking readings at each prompted interval until the probe is at the near-end of the casing. Then choose "Continue" on the DataMate.

Taking 180 Readings

1. Withdraw the probe and swap connectors, attaching the pull cable to Connector 2 and the control cable to Connector 1.
2. Insert the probe into the casing, oriented with fixed wheels in the bottom groove.



3. Pull the probe to the far end of the casing. Then use depth marks on the control cable to place the probe at the same starting point as in the 0 pass.
4. Wait for the reading to stabilize, then record it.
5. Draw the probe to the next reading position, indexing the depth mark just as you did in the 0 pass. When the reading is stable, record it.
6. Repeat the previous step, taking readings at each prompted interval until the probe is at the near-end of the casing. Then choose "Done" on the DataMate.
7. (Optional). Use the DataMate's validation routine to check that you have a good survey. See the DataMate manual for details.
8. Withdraw the probe. Unclip the pull cable and store it inside the casing. Lock the casing as required. Keep the pull-cable cap with the probe.

Leaving the Site

1. Wipe off the probe, remove the pull-cap and control cable, replace protective caps, and put the probe in its case.
2. Wipe off control cable, replace protective caps, and then coil the control cable carefully.

At the Office

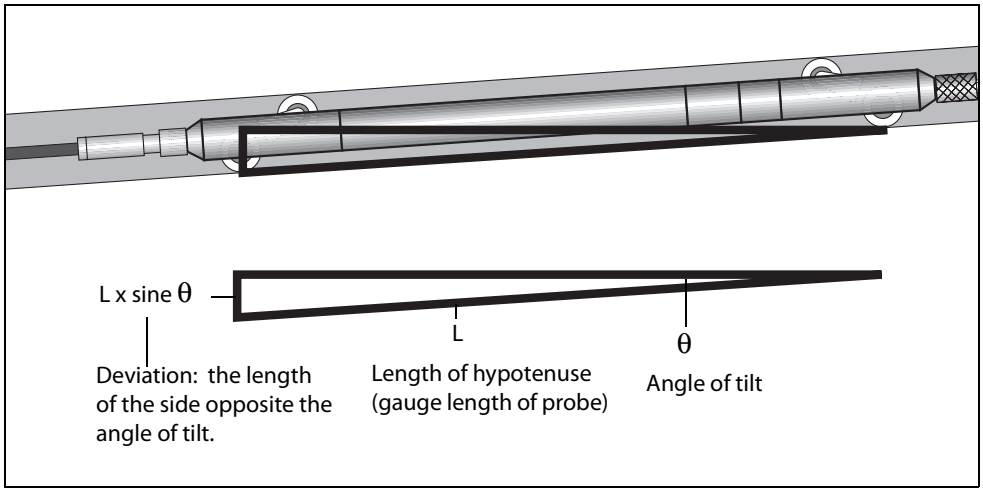
1. Transfer readings to your computer.
2. Then perform standard maintenance on the probe and read-out (for example, remove protective caps to let connectors dry, and oil the wheels). See the chapter on Maintenance for more information.

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, typically equal to the gauge of the probe, is the hypotenuse of a right triangle. This is normally 0.5 m with a metric-unit probe or 2 feet with an 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.

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:

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

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

Calculating Deviation

To calculate deviation, we algebraically subtract the A180 reading from the A0 reading, divide by 2 x instrument constant, and multiply by the measurement interval. In the example below, we show an English-unit calculation, where the A0 reading is 359 and the A180 reading is -339:

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

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

$$= 0.4188 \text{ inches}$$

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.

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

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

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

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

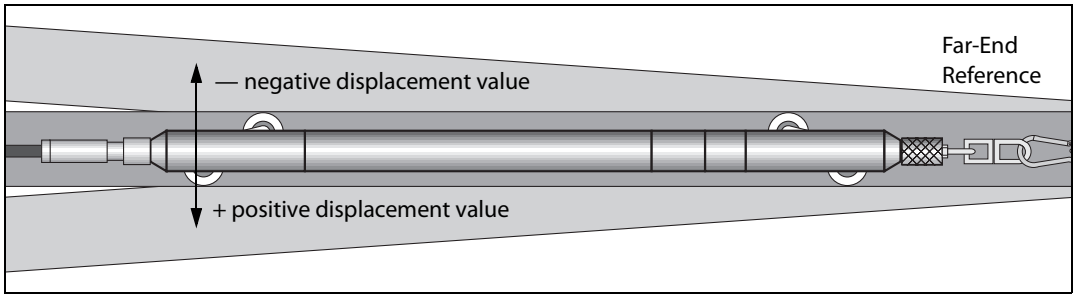
$$= 0.0012 \text{ inches}$$

Direction of Movement

Displacements can be referenced to either end of the casing.

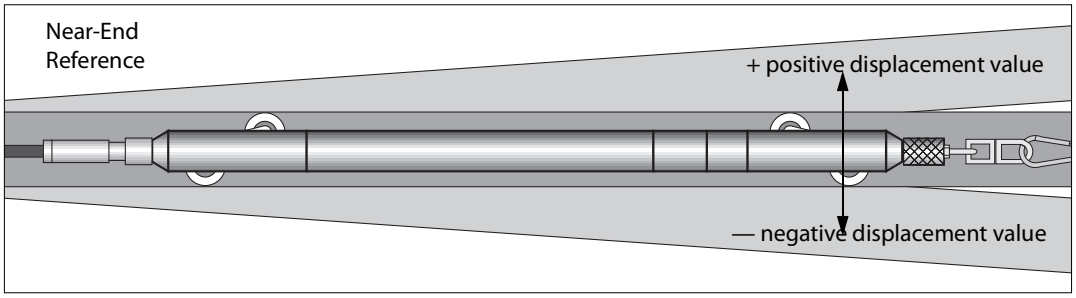
Far-End Reference

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



Near-End Reference

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



Maintenance

Casing

During Installation: It is important to keep the inside of the casing as clean as possible. Soil and sand particles can abrade grooves, wheels, and cable.

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.