The World Leader in Vibrating Wire Technology

48 Spencer Street
Lebanon, NH 03766, USA
Tel: 603•448•1562
Fax: 603•448•3216
E-mail: geokon@geokon.com
http://www.geokon.com

Installation Manual

Model 6500

Inclinometer Casing

(Rev A, 08/06/2018)

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1. INTRODUCTION

The Model 6500 Inclinometer Casing is used with the Model 6000 Inclinometer Probe. It has four grooves oriented at 90 degrees, which are designed to guide the wheels of the probe and keep them oriented in a known direction.

The casing is usually installed by grouting it inside a borehole, and as the ground moves the casing moves with it. For monitoring unstable slopes, it is essential that the casing be deep enough to pass through the zone of moving ground into the stable ground below. Similarly, where inclinometer casing is installed in slurry walls, bulkheads, piles or retaining walls the casing should probably extend below the structure into the ground below.

Casing may also be installed in fills, as the fill is placed, for instance, in earth dam embankments, embankments on soft ground, bridge abutments etc. In these cases, where the fill is also undergoing settlement, telescoping couplings will be required. In addition, the casing may be installed along with devices to measure settlement.

This manual covers three types of installation:
1. Installation in boreholes
2. Installation in fills
3. Installation in structures

The user should also be aware of the possibility that the casing may become twisted during installation. This is more likely the longer the casing. In the appendices will be found descriptions of spiral sensors and how they can be used to perform a spiral survey of the inclinometer casing grooves. The information from the spiral survey can be entered into spreadsheet software, so that directions of maximum tilt or inclination can be correctly oriented at any point along the casing. For further details on installation procedures, the reader is referred to the book “Geotechnical Instrumentation for Monitoring Field Performance.” by John Dunnicliff, published by John Wiley & Sons, NY.

2. GENERAL CONSIDERATIONS

Certain procedures are typical for all types of installations.

2.1 Tools

The following tools and accessories will be required:

- End plugs
- Casing couplings
- Blind rivets - Eight per coupling - dome head, 6 mm (1/4") head, 3 mm (1/8") diameter 13 mm (1/2") long. (Stainless steel for regular couplings, aluminum for telescoping couplings.)
- Blind Rivet Gun
- Battery powered hand drill - Geokon part # 6501-10
- #30 drill bits
- Vinyl electric tape (Scotch 88)
- Duct tape
- Caulking - Geokon part #6501-5
- Wadding
- Clamps

2.2 Preassembly

In order to save time during the actual installation it is normal to preassemble the couplings onto one end of each length of casing. The couplings are attached using four blind rivets located at 45 degrees to the casing grooves (see Figure 1). Make sure that the rivets are not near the grooves. The gap between the casing and the couplings is first caulked and then taped, first with electrical tape and then with duct tape. It is good practice to tape over the rivet heads also.

On the bottom of the lower most casing the end plug is riveted in place then caulked and taped. It is recommended that a wad of burlap or other such soft material be packed into the lowest 12 inches of casing. This will provide a cushion to protect the inclinometer probe from shock damage should it be accidentally dropped to the bottom of the casing.

In many instances, it is possible to preassemble two lengths of casings, joining them together to form a six meter (20 ft.) long section. Where there is a high wind, or precarious footing, this may not be advisable.

Where telescoping couplings are required (see Figure 1), mark on the casing where the couplings will end so that the requisite gap is created. For example if the coupling is 600 mm (23.6") long and the required gap is 300 mm (11.8"), then a mark is made 150 mm (6") from the end of each casing and the couplings are then riveted in place with their ends opposite these marks. Note that with telescoping couplings it is better to use aluminum rivets rather than stainless steel. The aluminum rivets are weaker and shear more easily.

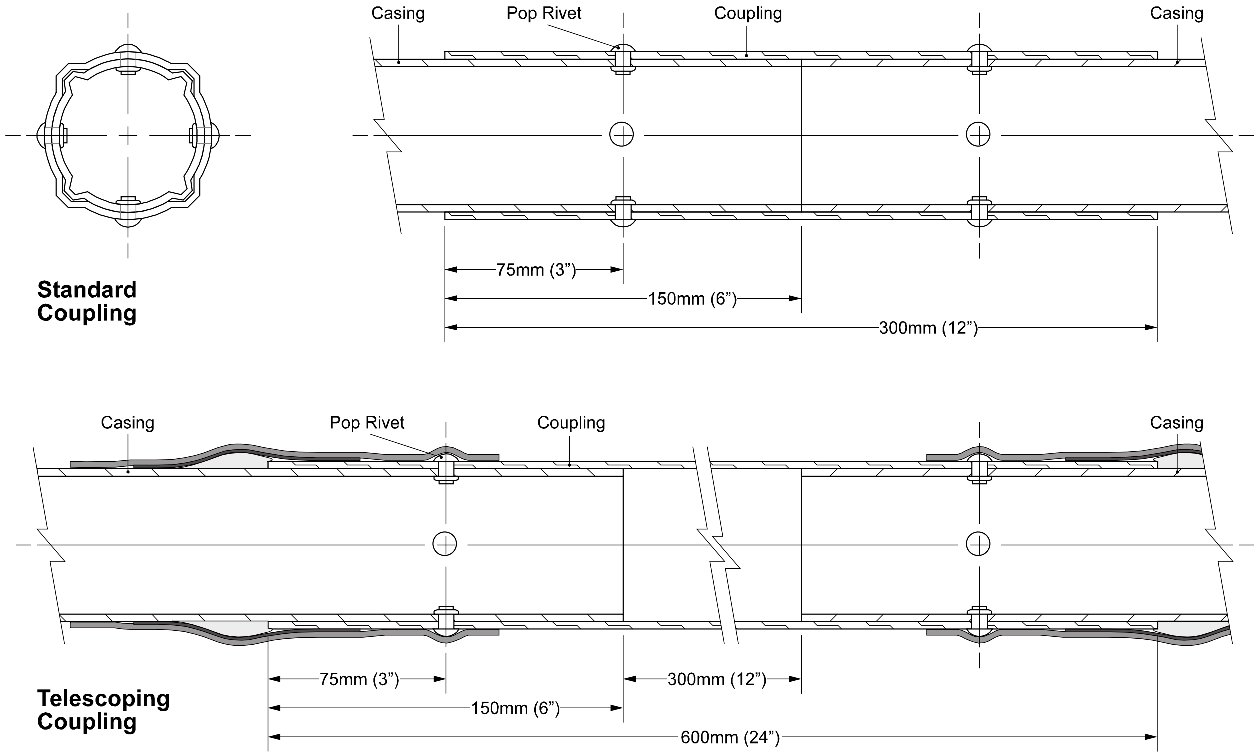

Figure 1 - Inclinometer Casing and Couplings

3. INSTALLATION IN BOREHOLES

3.1 Borehole Requirements

Boreholes may be from four to six inches in diameter or larger depending on the drill rig. Boreholes in soft ground may require the inclinometer casing to be installed inside steel casing that is then removed. Alternatively, the inclinometer casing may be installed down the center of hollow stem augers.

If the hole is to be grouted it should be large enough to accommodate the tremie grout pipe, which can be as small as 1/2″ diameter, but 3/4″ is preferable.

3.2 Grout Requirements

The best grout mix has the consistency of pancake batter and includes at least 10% to 15% by weight of bentonite to keep the grout soft. This is especially necessary where settlement is occurring. Use enough cement and water to make the grout pumpable.

3.2.1 Stage Grouting

When grouting inclinometer casings longer than 30 m, precautions must be taken to prevent the grout pressure from collapsing the casing. This is accomplished by stage grouting using more than one grout tremie pipe.

The volume of grout required to fill the annulus for the first 30 m (100 ft.) should be calculated and then an extra 10% of the volume should be added to it. This amount of grout is then pumped into the borehole through the deepest tremie pipe. *Note: It is good practice to lubricate the tremie pipe by pumping water through it before pumping any grout.*

When all the grout has been pumped then clear water is pumped slowly at a low pressure through the number two grout pipe. This will dilute and wash out the grout immediately around and above the end of the number two pipe.

Allow sufficient time for the first stage grout to set up. Then grout the next stage through the number two pipe. Proceed as above with subsequent stages.

During any grouting, the inside of the inclinometer casing must be filled with water. This will neutralize to some extent the outside grout pressure and will help in overcoming the buoyancy forces tending to push the casing out of the borehole. This force may need to be further resisted by adding weights to the top of the casing (see Appendix C).

At the end of each grouting stage, flush the inside of the casing with water to remove any grout that might have leaked in.

3.3 Installation Procedures

Beginning with the bottom section, already capped with the end plug, tape the grout tremie pipe to the outside of the casing, so that the end is close to the bottom. It is good practice to cut a few notched holes in the tremie pipe, close to the end, in case the bottom of the tremie pipe becomes plugged as the casing is lowered into the borehole.

Lower the first casing section into the borehole, until the top is at a convenient working height. Orient one of the grooves in the direction of the anticipated movement. Wedge the casing in place or hold it firmly in some way so that it cannot slip down the borehole. Connect the next section with blind rivets and caulking tape. Then lower the two sections until the third can be added. Add water to the inside of the casing to overcome any buoyancy forces that may develop. Continue in this way until all the sections have been added. Keep the groove orientation consistent and avoid twisting the casing. Feed the grout pipe into the borehole alongside the casing. If the grout pipe is to be retrieved, do not tape the pipe to the casing, except at the bottom. When the casing has reached the required depth and is sitting on the bottom of the borehole, make a final check of the orientation. Fill the casing with water or steel drill rods to hold the inclinometer casing in place. Carefully remove any steel casing, or auger steel from the borehole using a direct pull only (no twisting).

Grout the inclinometer casing in place following the directions outlined in Section 3.2. When grouting is complete remove the grout tube or cut it off at the top of the hole. Flush the inside of the casing with clean water to remove any grout that might have leaked in.

Place a top cap (locking caps are available) over the top of the casing. In areas where vandalism is prevalent, a locking cap must be required or better yet a larger stand pipe with locking cap should be grouted in place around the inclinometer casing, where it protrudes above the ground.

4. INSTALLATION IN FILLS

Inclinometer casings installed in fills must use telescoping couplings of a number and range sufficient to accommodate the anticipated magnitude of the settlement of the fill. The normal distance between couplings is 1.5 m (5 ft.) and the telescoping couplings should be set in a fully opened position. Two methods may be used; in one the casing is installed to protrude above the fill level and is protected by a mound of hard compaction fill, in the other method the casing is capped and filling and compaction continues over the top of the pipe for approximately 1.5 m (5 ft.). An excavation is made to uncover the top of the casing so that another section can be added. Then the excavation is backfilled and the fill compacted with hand tools.

Both methods are disruptive to the construction process. The second method less so, but in both cases, great care and attention is required to prevent damage to the casing.

5. INSTALLATION IN STRUCTURES

In concrete structures such as piles, slurry walls, retaining walls etc., the inclinometer casing is assembled, taped, and then tied in place to any reinforcing bars in the concrete.

APPENDIX A. SPIRAL SURVEY USING THE MECHANICAL SPIRAL SENSOR MODEL 6010-1

The Model 6010-1 Spiral Sensor is shown in Figure 2. It comprises a flat plate that is designed to fit in opposite grooves of 2.75″ (Model 6500) Inclinometer Casing. To this flat plate are attached sectional orientation rods that enable the plate to be positioned at any depth within the casing. A pointer attached to the orientation rods is positioned over a protractor scale clamped to the top of the casing and reveals instantly the orientation of the casing grooves, at the position of the flat plate, relative to the grooves at the top of the casing. This amount of spiral is noted and entered into the appropriate software program.

A 1.6 mm (0.0625") braided, plastic coated aircraft cable, attached to the flat plate can be used to lower and raise the plate and orientation rods inside the casing.

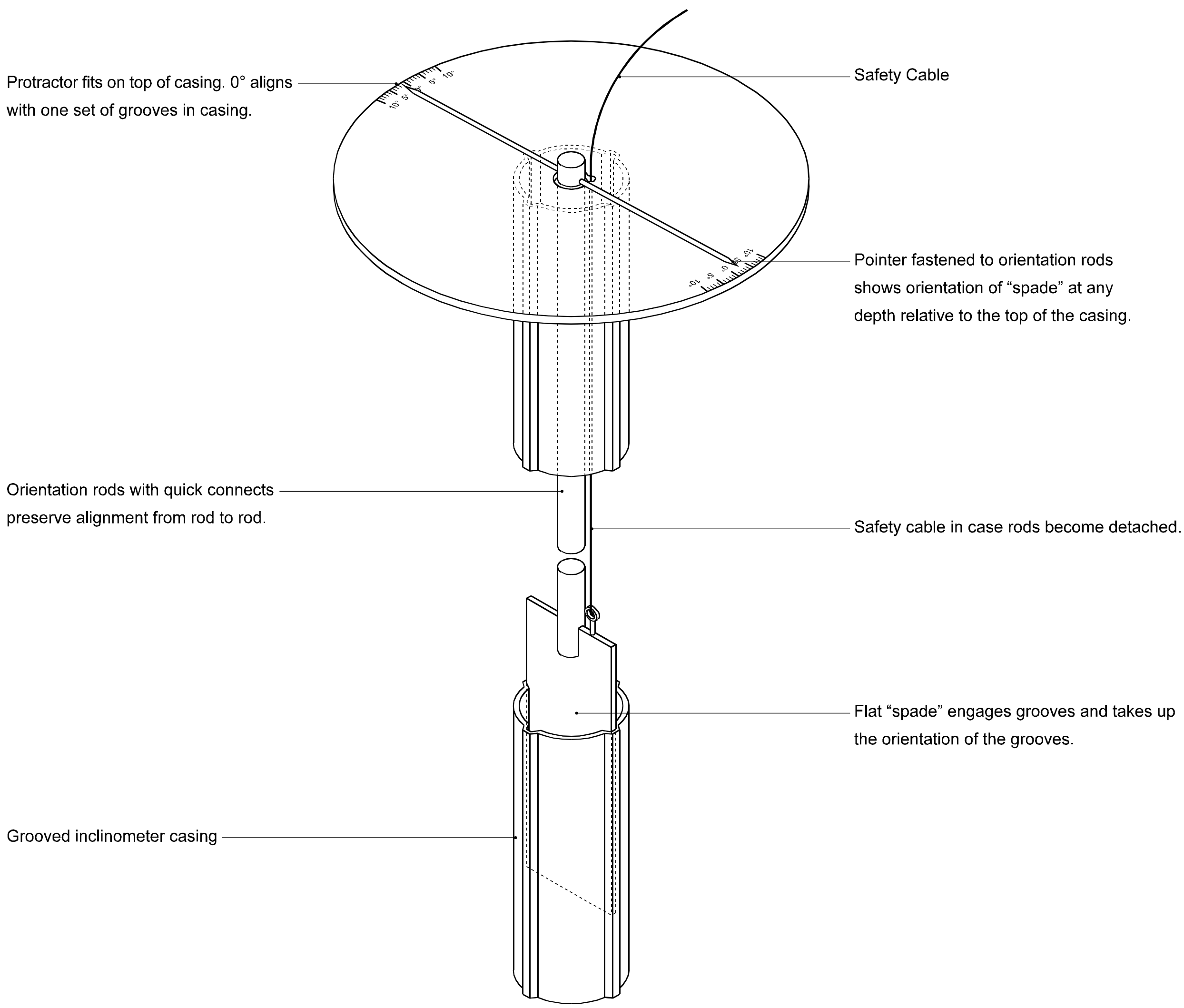

Figure 2 - Model 6010 Spiral Sensor

APPENDIX B. SPIRAL SURVEY USING THE ELECTRONIC SPIRAL INDICATOR PROBE MODEL 6005-1

B.1 Introduction

The Model 6005-1 Spiral Indicator, shown in Figure 3, is designed to be used in conjunction with the standard inclinometer cable (Model 6000-4) and with the Model GK-604D Readout.

The probe is lowered down the casing on the cable with the upper most wheel in the A+ groove and a reading is taken at measured intervals along the casing using the GK-604D Readout.

Figure 3 - Model 6005-1 Spiral Indicator Probe

B.2 Sensor Details or Borehole Requirements

The sensor contains a microprocessor controlled fluxgate compass with an accuracy of ± 0.5° over a tilt range of ±16°. *Note that this Spiral Indicator will not work in a steel cased borehole,* nor in situations where steel is present in the form of I beams, rebar, angles and channels etc. at distances of less than 305 mm (12") from the Spiral Indicator (or farther where the amount of steel is greater, or is oriented in an unfavorable direction.)

B.3 Readout Procedure

The Spiral Indicator Probe (Figure 3) connects to a GK-604-3 Analog Reel System (Figure 4) or the GK-604-4 Interface Module (Figure 5). In general, operation of the Spiral probe is similar to the standard 6100-1* probe with a few exceptions.

Figure 4 - GK-604-3 Analog Reel System

Figure 5 - GK-604-4 Interface Module

The steps below provide basic instruction on how to perform a spiral survey:

1) Connect the 6005-3 probe to the Remote Module and ensure that a Bluetooth pairing exists between the Remote Module and the FPC-2 Field PC. (See the GK-604D instruction manual for more information regarding Bluetooth pairing.)

2) Launch the GK-604D IRA.

3) Create a new probe in the Probe Library and configure it for a probe type of “Compass”. Enter “200” for “Zero Shift A” and “.1” for “Gage Factor A” parameters. Save the settings.

4) Create a new hole to represent the physical hole, shaft or well that a spiral survey is to be performed on. Select the compass probe created in item #3 as the probe to be assigned to this hole. Set the “Azimuth Angle” parameter to “0” then save settings.

5) Press the “POWER ON (BLUETOOTH)” button on the reel and ensure that the blue light is blinking.

6) From the main screen, tap the “Application” menu, then “Live Readings” (Figure 6) to display the “Live Readings” screen for compass headings (Figure 7).

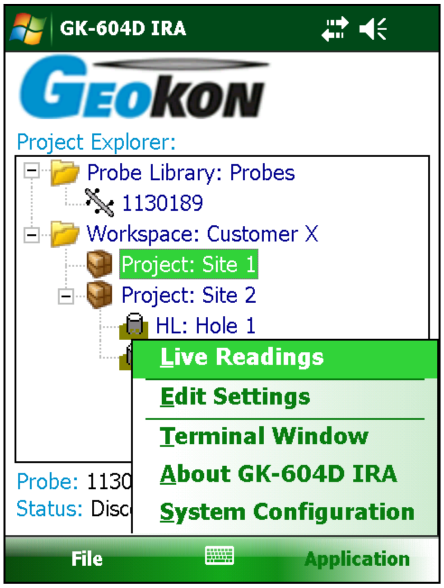

Figure 6 - Application Menu

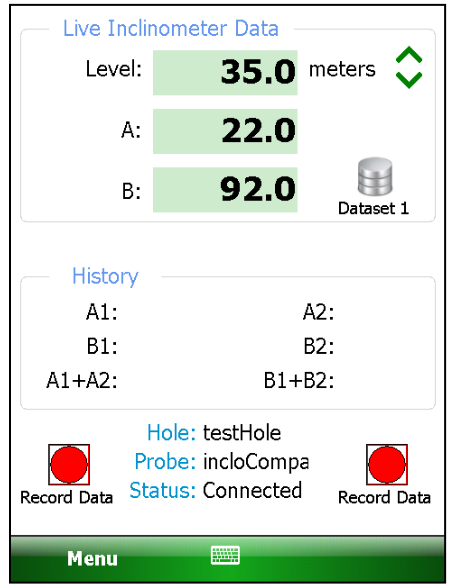

Figure 7 - Live Readings for Spiral Data

7) With the probe connected to the GK-604D, and held in an approximately vertical position, twist the probe through one full revolution. The reading on the A-axis should go from zero degrees to 360.0 degrees then back to zero. With long inclinometer cables there can be some voltage loss in the cable such that the maximum reading may be less than 360.0 degrees. If this occurs then a correction can be made using the A-axis Gage Factor option. Select this option if for example the maximum reading is only 350 degrees, then enter an A-axis gage factor equal to 1.029 (360/350). Recheck the probe output and verify that the reading varies between zero and 360 degrees.

8) Take readings at 0.5 m (two foot) intervals beginning at the bottom of the casing (or at the top if preferred). Unlike an inclinometer survey, a spiral survey only requires A+ data; a second pass is not necessary (do **not** tap Dataset after first pass).

9) When done the survey, tap "Menu->Exit Live Readings" and the screen shown in Figure 8 will be displayed. Tap "Yes" to save the compass survey data.

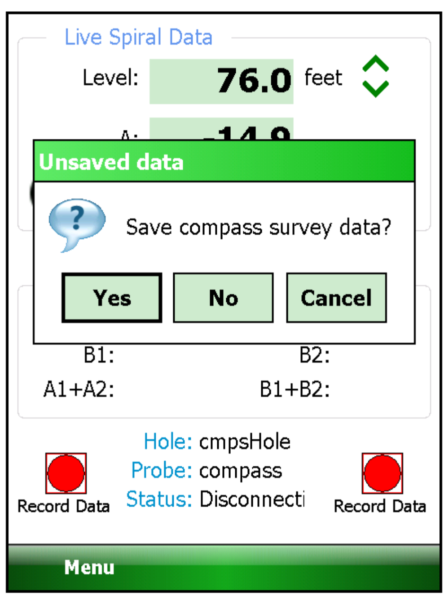

Figure 8 - Saving Compass Survey Data

10) The survey data is saved into a “.gkn” file. This data file can be viewed (select “Raw Data as Table”) and/or exported for later use in analysis.

For more information, refer to the GK-604D instruction manual.

B.4 Analysis of the Data

Analysis of the data may be performed using spreadsheet programs to produce a plot showing the A groove orientation with depth. Depending on the magnitude of the twist, the operator must then decide whether a correction is needed to the measured borehole deflections. Spirals less than five degrees may safely be ignored. Even 10-degree spirals have little significance.

APPENDIX C. OVERCOMING BUOYANCY DURING INCLINOMETER INSTALLATION

Adding weights to the top of the inclinometer casing to prevent it from being forced out of the ground by buoyancy forces has the disadvantage of causing the casing to “snake” within the borehole. This is undesirable; the following methods have the advantage of keeping the casing straight.

The buoyancy force on a water-filled, 70 mm (2.75") diameter inclinometer casing is around one kilogram per meter.

C.1 Method 1: Insert Steel Pipe Inside the Casing Until the Grout has Set

This can be done when an external tremie pipe is used for grouting. Flushing must be carried out to ensure that there is no grout inside. Make sure that the bottom cap is securely attached to the casing using extra steel rivets.

C.2 Method 2: Insert PVC Pipe Inside the Casing Until the Grout has Set

This method is essentially the same as the first except that the weight of the pipe is lighter and may need supplementing by additional weights on top of the pipe. Make sure that the bottom cap is securely attached to the casing using extra steel rivets.

C.3 Method 3: Install a Special Anchor at the Bottom of the Casing

A Borros type anchor or other hydraulically actuated anchor can be attached to the bottom of the casing to hold the casing in place. Make sure that the bottom cap is securely attached to the casing using extra steel rivets

C.4 Method 4: Attach a Weight to the Bottom of the Casing

This method is limited to relatively shallow holes. A rope is required to lower the weight and casing into the borehole. Make sure that the bottom cap is securely attached to the casing using extra steel rivets