Model 6600

Inclinometer Casing

Instruction Manual

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1. INTRODUCTION

The Model 6600 Inclinometer Casing is intended for use with all commercially available inclinometer probes to monitor the stability of embankments, slopes, rock cuts, foundation and excavation walls, piles, etc. The casing sections are designed to be assembled quickly and easily, using self-aligning couplings which incorporate a Quick-Lock connection. It is suitable for installation in boreholes and piles, set into concrete, or attached to structures.

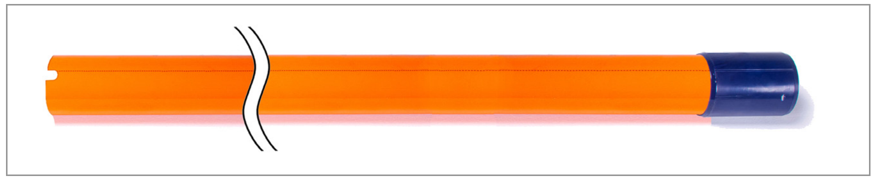

FIGURE 1: *Model 6600-1-10 Quick-Lock ABS Inclinometer Casing*

The casing and couplings have grooves spaced at ninety-degree intervals, which fit the wheels of the inclinometer probe thus maintaining the orientation of the probe as it is traversed up and down the casing. The probe accurately measures the change in the angle of tilt, from the vertical, at spacings along the casing. These incremental changes are added together to give a profile of the casing. Changes in the profile become a measure of the stability of the body or structure in which it is installed. The casing can also be used with in-place inclinometers, which are particularly well suited for real-time automatic monitoring.

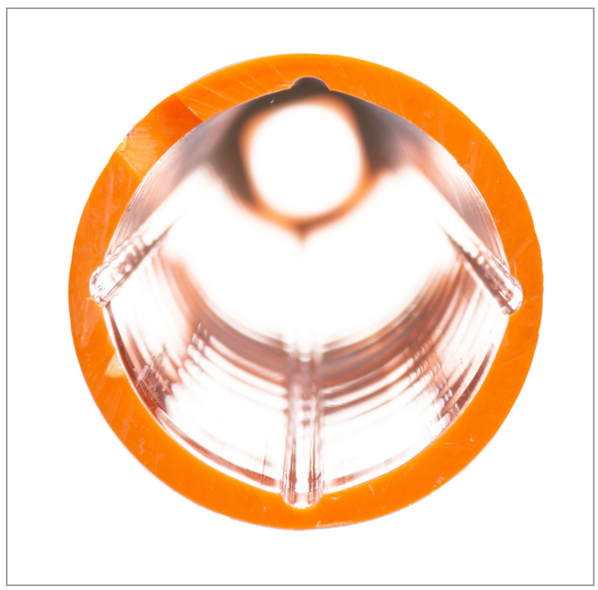

FIGURE 2: *Ninety Degree Spaced Grooves*

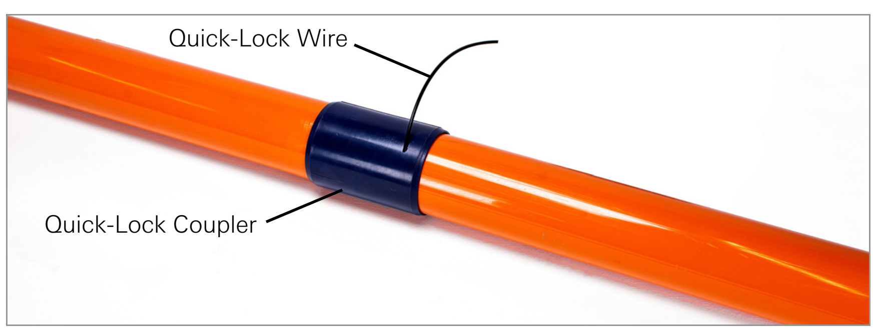

FIGURE 3: *Quick-Lock Connection System*

1.1 CASING STORAGE

Inspect casing lengths to insure that none were damaged in transit. Ensure that the casing is not warped, and that the inside of the casing is clean. Keep the joint and casing interior clean by removing the protective end caps only when you install the casing.

Store casing horizontally and supported evenly so it does not warp or bend. Prolonged exposure to direct sunlight can deform the casing, so store it in shade whenever possible.

Note: Do not assemble the casing prior to insertion in the borehole.

1.2 BOREHOLE DRILLING

Drill the borehole as vertical as possible, preferably within one degree of vertical. Flush the borehole clear of debris, and verify that the borehole is fully open to the bottom. Check the depth of the borehole before installing the casing. Also, consider that using a casing anchor or external weights will require a deeper borehole.

2. INSTALLATION

2.1 GROOVE ALIGNMENT

It is important to have one set of grooves oriented down slope, in the direction of expected movement. If the direction cannot be determined, orient North/South. **Alignment must be maintained throughout the installation, to avoid introducing torsion to the casing, thereby causing spiraling of the grooves. Never push the casing from the top or twist the casing during installation.**

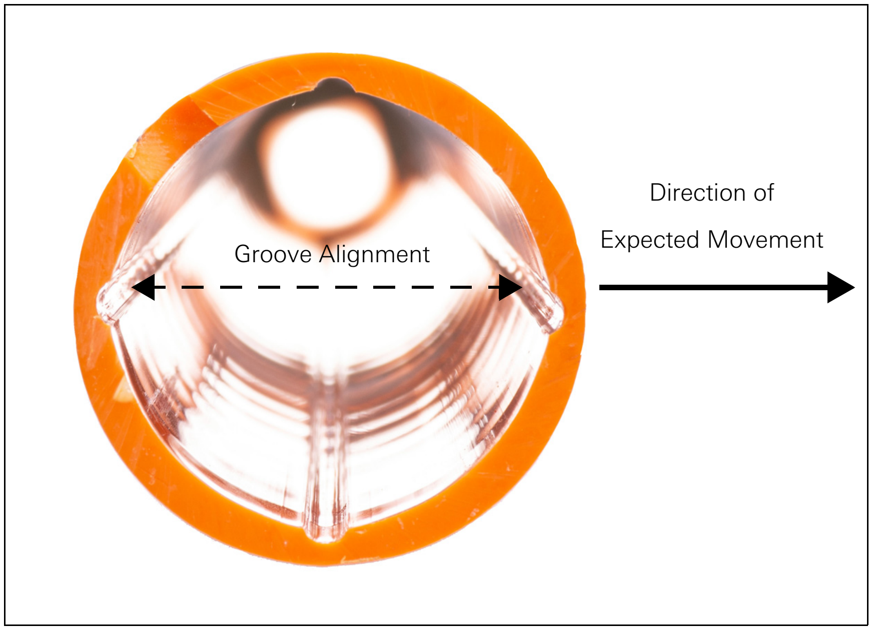

FIGURE 4: *Groove Alignment*

2.2 OVERVIEW

Insert the casing into the borehole one tube section at a time, using clamps to keep the sections positioned at the top of the borehole while you connect the sections. Use the provided Model 6600-2 Quick-Lock coupling wires to join the casing tube sections together. In dry boreholes, or in situations where down-hole problems seem likely, rig a safety line to provide extra security and a way to retrieve the casing if necessary.

2.3 INITIAL CASING SECTION

1. Number each casing section to confirm correct depth placement and to assist with placement of any external instruments (such as vibrating wire piezometers).
2. There are three options for sealing the bottom of the casing:
   - Model 6600-1B Bottom Cap: Apply ABS cement (must be sourced by the customer) to the inside of the cap and install it onto the tube, or use self-tapping screws following the procedure outlined in Appendix B, steps 6 and 7.
   - Model 6600-2A Casing Anchor Kit: Refer to Appendix B
   - Model 6600-2G and 6600-2G-1: Refer to Appendix F.
3. Attach a clamp to the tube near the coupling.
4. Lower the tube into the borehole, capped/anchored-end first, until the clamp rests on the borehole collar.

2.4 NEXT CASING SECTION

Caution: Casing alignment (end to end) is critical when joining casing sections together. If there is bending at the joints (especially critical during horizontal assembly), it is difficult to insert the Quick-Lock wire into the coupler hole and casing groove. In this case, move the casing sections back and forth at the joint until they align sufficiently to allow insertion of the Quick-Lock wire.

To maintain orientation of the casing sections, install the sections with one groove aligned toward anticipated direction of maximum movement (downslope or toward excavation).

1. Insert another casing tube section into the tube coupling.
2. Rotate the tube inside the coupling while pushing downward. The notch at the end of the tube should slide onto the tab inside the coupling as shown:

FIGURE 5: *Coupling Tab*

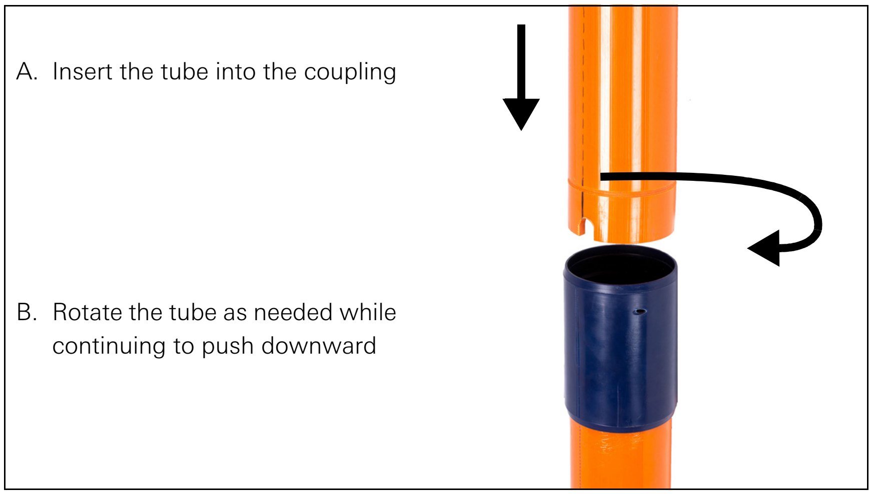

FIGURE 6: *Connecting the Casing Sections*

3. Insert a Quick-Lock coupling wire into the hole in the tube coupling. Keepthreading the wire into the hole until you meet significant resistance. Note: Keep the wire clean and wire hole free of debris to avoid clogging.

FIGURE 7: *Secure with Model 6600-2 Quick-Lock coupling wire*

Note: Model 6600-2 Quick-Lock coupling wire is sold in 406 mm (16") increments.

4. If desired, pull upward gently on the coupling to verify it is secure.

   Note: For additional protection, wrap caulking tape around the the top of the coupler to seal the joint. Then wrap electrical tape around the caulking tape and then around the end of the wire to secure it to the coupler.

5. Attach another clamp to the tube near the free end, or as high as you can reach.
6. Remove the first clamp and lower the assembled section into the borehole, until the second clamp rests on the borehole collar.
7. If necessary, repeat steps 5-6 as needed until the free end of the tube is at an accessible height.

2.5 SUBSEQUENT CASING SECTIONS

Repeat the steps in the Section 2.4 for the rest of the casing sections until you reach the desired depth.

If possible, verify the alignment of the grooves by running a dummy probe to the bottom of the hole. If the probe will not pass, jumps track, or returns in another set of grooves, pull the casing and check each tube section for proper alignment.

2.6 CASING BUOYANCY

If the borehole is filled with water or drilling mud, filling the casing with clean water can neutralize the casing's buoyancy, making it easier to submerge.

Additional weight may be necessary for boreholes with drilling mud, as the weight of the casing and the water may not be enough to overcome the buoyancy. Steel water pipe or clean chain can be carefully added into the casing (in such a way as to be retrievable) to provide additional down force.

Note: Be careful not to damage the bottom cap or sealed joint when lowering objects into the casing.

Caution: The differential pressure introduced by the head of water may cause the casing to fail if it exceeds the 15 bar (217 psi) burst capacity of the casing.

BUOYANCY DURING GROUTING

Casing also becomes buoyant during the process of grouting the borehole.

Use one of the following methods to prevent the casing from floating out of the borehole during grouting:

- Insert steel water pipe or clean chain inside the casing. Be careful not to damage the bottom cap or sealed joint when lowering solid objects down inside the casing.
- Grout the casing in stages:
    - Secure the bottom of the casing with an initial batch of grout, letting it set up overnight.
    - Grout the next section of casing, up to ground surface (if remainder of casing section can accommodate the pressure of the fluid grout).
- The Model 6600-2A Casing Anchor can resolve buoyancy issues, but it renders the installation permanent once deployed.

CAUTION: Applying a down force to the top of the casing will likely distort the casing profile. Never use the drill rig as a reaction force, or wedge into the collar of the borehole. Doing so can cause the casing to shift or "snake" within the borehole, which can affect the accuracy and precision of the inclinometer system.

2.7 GROUTING

Properly mixed grout must be thin enough to pump, but thick enough to set in a reasonable amount of time, and should be designed for the application. Very stiff grouts should not be used in a very soft soil formation, and similarly, a very soft grout mix should not be used for stiff soils or shoring wall systems.

Ensure that the grout is free of lumps. If the mixture is too watery, it will shrink excessively, leaving the upper portion of the borehole un-grouted. Avoid the use of grouts that cure at high temperature since these may damage the casing.

Use a tremie system to deliver the grout as directed by the engineer. Grouting, via a high shear filtered grouting machine is recommended to avoid problems with lumps obstructing the tremie tube.

The surface level of the water in the casing can indicate casing collapse or grout ingress. Grout ingress into the casing is likely to cause the water level to rise.

Note: Ensure that differential pressures are kept to a minimum, as the casing will collapse at 217 PSI differential.

Deeper boreholes will likely require a staged grouting procedure, with appropriate stages dependent on borehole water level, grout density, grout pump type, etc.

Note: Proper grouting of inclinometer casing is crucial to a successful inclinometer installation. The installer should have experience with grouting, and be able to work with the drill crew to determine the proper grout mixture. Grout consistency is very important to ensure proper curing, and to avoid separation of the solids and water. Grout with the proper viscosity is easier to pump.

Note: Site conditions can vary, making each inclinometer installation unique. Good judgment, by on-site personnel, and previous experience are the keys to success. GEOKON can provide suggestions on grout mixes based on the soil or rock type where the inclinometer application is to be installed.

2.8 INSTALLING THE MODEL 6501-6-4 PROTECTIVE HOUSING

The Model 6501-6-4 Protective Housing is grouted in place around the inclinometer casing where it protrudes from the ground. It consists of a 0.91m (3') × 100 mm (4") diameter galvanized steel pipe with lockable cap which threads onto the top of the steel pipe to protect the casing from vandalism.

FIGURE 8: *Model 6501-6-4 Protective Housing with Lockable Cap*

2.9 CASING EXTENSION

When using the Model 6501-6-4 Protective Housing it will be necessary to extend the top of the casing above the top of the cap such that the pulley assembly can be attached.

APPENDIX A. SPECIFICATIONS

Casing ID	58 mm (2.28")
Casing OD	70 mm (2.75")
Casing Length	3 m (10')
Coupling OD	75 mm (2.95")
Bottom Plug OD	72 mm (2.83")
Material	ABS plastic[1]
Collapsing Pressure	15 bar (217 psi)
Groove Spiral	<0.2 degrees/m (0.06 degrees/ft)
Temperature Range	−20 to 80 °C (−4 to 176 °F)
Weight	1.06 kg/m (0.71 lbs/ft)

[1]Density: 1.0 (±0.1) g/cm^3 | Tensile Strength: 40 MPa | Breaking Elongation: 20% | Elastic Modulus: 2700 MPa

TABLE 1: *Casing Specifications*

Telescopic Section OD	85 mm (3.35")
Compressed Length	3 m (10')
Extended Length	3.2 m (10.5')
Range	152 mm (6")
Weight	4.35 kg (9.6 lbs)

TABLE 2: *Telescopic Casing Specifications*

APPENDIX B. MODEL 6600-2A CASING ANCHOR

B.1 CASING ANCHOR COMPONENTS

GEOKON provides the following parts:

- Casing anchor
- O-ring
- Four self-tapping screws
- Caulking tape
- Electrical Tape

FIGURE 9: *Anchor Kit Components*

In addition, you will need the following parts:

- ABS cement (locally-sourced)
- Release cord of desired length, rated for 250 kg (500 lb).

  Alternatively, GEOKON can provide part number 07-062G, galvanized aircraft cable 1.59 mm (1/16") diameter for this purpose.

B.2 CASING ANCHOR INSTALLATION

1. Use one hand to press the two anchor legs closed against the shaft of the anchor.
2. Slip the O-ring over the top of one leg. Be careful to avoid the sharp edge.
3. Stretch the O-ring around the pipe and loop it over the top of the other leg.

FIGURE 10: *Installing the O-Ring*

FIGURE 11: *O-Ring Correctly Installed*

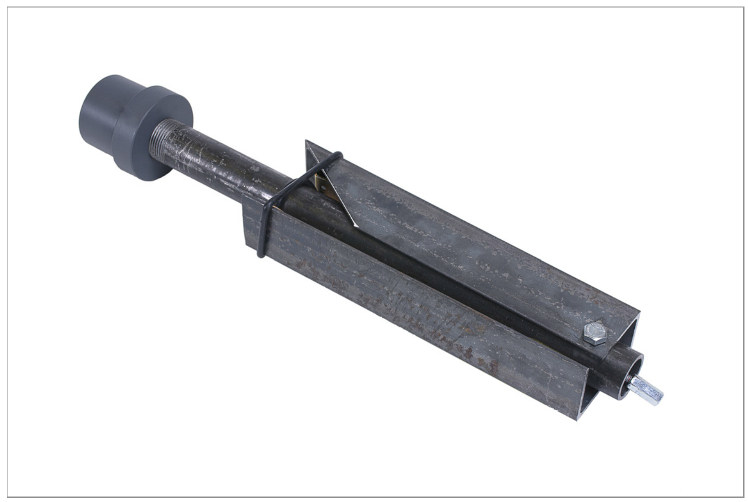

FIGURE 12: *Anchor Ready for Mounting to Bottom Section of Casing*

4. Apply ABS cement to the top of the anchor.
5. Insert the anchor into the open end of the tube.

FIGURE 13: *Installed Anchor*

6. Use the self-tapping screws to secure the tube to the anchor.

FIGURE 14: *Install the Self-Tapping Screws*

7. To prevent the entry of grout, use caulking tape and electrical tape to completely cover the screw heads and the seam where the bottom of the casing joins the top of the anchor.

FIGURE 15: *Installed Anchor with Tape for Grout Protection*

8. Fasten the release cord onto O-ring, as indicated in the figure below.

FIGURE 16: *Release Cord, made using GEOKON part number 07-062G*

9. Lower the casing into the borehole. Feed the release cord with the casing as you lower it.

For detailed instructions on installing the casing into the borehole, see Section 2.

B.3 DEPLOYING THE ANCHOR

Do the following when the casing reaches the desired depth:

1. Pull the release cord to dislodge the O-ring from the anchor legs, which then expand into the surrounding earth, holding the anchor in place.
2. Remove the entire length of release cord from the borehole.
3. Backfill the borehole with grout as necessary.

APPENDIX C. TELESCOPING CASING SECTIONS

The Model 6600-1TS is a telescoping tube section for applications that are expected to experience settlement or heave of the ground.

The telescoping section can accommodate up to 152 mm (6 inches) of movement. The most common application is for conditions where settlement is expected. For this application, the telescoping section should be installed in the fully extended position.

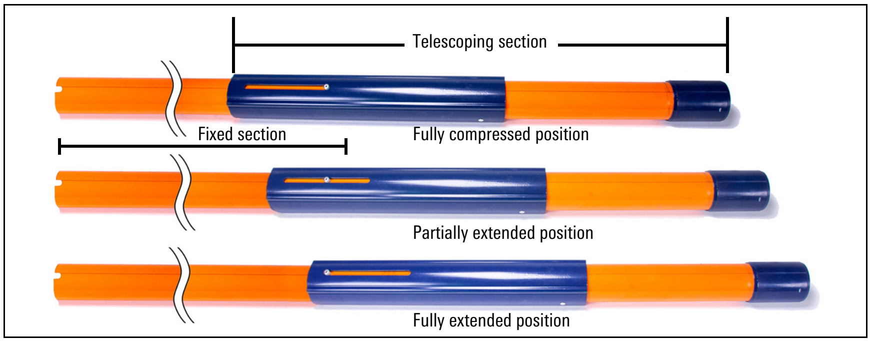

FIGURE 17: *Model 6600-1TS Telescoping Tube Section (shown without shrink-fit tubing)*

The telescoping casing sections are provided with shrink-fit tubing secured over the telescoping joints, which prevents grout and debris from inhibiting the sliding components of the system. The shrink-fit tubing is sealed at the ends and allows the casing to expand/contract as needed. During installation, the pressure differential between the inside of the casing and the outside should not exceed 30 m (100 ft) of water. Excessive pressure may cause the shrink-fit tubing to fail.

INSTALLATION METHODOLOGY

Where settlement is expected, the telescoping casing sections are extended after the bottom of the casing has been secured using a casing anchor, grout, or by adding sufficient weight in the interior of the casing.

Once secure, extend the telescoping casing section(s). Make note of the original height of the top of casing, and then, based on the number of telescoping section, calculate the height of the casing after pulling it up.

For installations where heave is expected, or where the bottom of the casing may sink (e.g., tunnel passages), then the telescoping sections should remain compressed during installation. A wrap of duct tape, applied to the joint of the telescoping section, will help keep it compressed during installation.

APPENDIX D. CASING REPAIR

If an inclinometer casing becomes damaged, it can be repaired. The following items are required:

- Model 6600-1C Replacing Coupler
- Model 6600-2 Quick-Lock Coupling Wire
- Model 6600-2RT Reconnect Alignment Tool
- Model 6600-1-10 Section of Inclinometer Casing
- Model SUP-806 Duct Tape
- ABS cement (supplied locally)

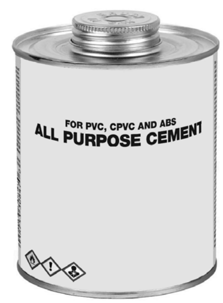

FIGURE 18: *ABS Cement (example)*

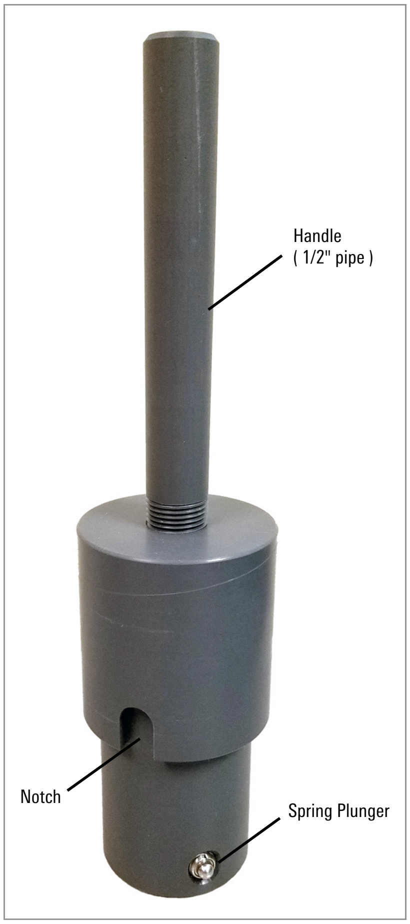

FIGURE 19: *Model 6600-2RT Reconnect Alignment Tool*

Typically, the damaged section of a casing is in the upper few feet of the installation, where the casing is most vulnerable.

The procedure to replace a damaged section of casing is as follows:

1. Determine the length of replacement casing needed for the process.

   Note: Be sure to include the length of the replacing coupler when making your determination.

2. Cut the existing casing below the damaged section according to the measurements completed in Step 1. Make the cut as perpendicular as possible to the axis of the casing.
3. Cut the replacement casing to the appropriate length.
4. Debur the edges of both cut casing sections and clear any debris from the portion that will be coupled.
5. Apply ABS cement to the outside of the top of the existing casing.
6. Slip the replacing coupler onto the bottom of the alignment tool, to the point where the tab inside the coupler slides into the notch in the tool.
7. Grasp the tool by the handle and slide the coupler onto the top of the existing casing.
8. Twist the tool until the silver spring plungers on the tool slip into the grooves on the inside of the existing casing.
9. Press the tool downward until you meet solid resistance.
10. Press down on the coupler to keep it in place while you pull upward to separate the tool from the coupler.
11. Allow the cement to cure.

APPENDIX E. PARTS LIST

The following table lists components of the Model 6600 Inclinometer Casing.

Part Number	Description
6600-1-10	Quick-Lock ABS inclinometer casing, 70 mm (2.75"), 3 m (10') length
6600-1B	Bottom Cap for Quick-Lock inclinometer casing. (**Note:** Requires ABS cement, local supply)
6600-1C	Replacing Coupler for Quick-Lock inclinometer casing. (**Note:** Requires ABS cement, local supply)
6600-1T	Top Cap for Quick-Lock inclinometer casing
6600-1TS	Telescoping Section for Quick-Lock inclinometer casing, 3 m (10') length x 152 mm (6") range
6600-2	Quick-Lock coupling wire, 300 mm (12") length. One required per coupling.
6600-2A	Casing Anchor Kit
6600-2G	Bottom cap with Grout Adaptor
6600-2G-1	Female Grout Adaptor
6600-2RT	Reconnect Alignment Tool
6501-5	Inclinometer casing coupling waterproof tapes (enough for 24 couplings) ADH-116 Putty Tape SUP-802 Electrical Tape SUP-806 Duct Tape
6501-6-4	Inclinometer casing protective housing, 0.91 m (3') × 100 mm (4") galvanized steel pipe with lockable cap. For use with 70 mm (2.75") casing.
6000-20	Pulley for 0.25" cables
6000-20A	Pulley for 0.3125" cables
07-062G	Galvanized aircraft cable, 1.59 mm (1/16”)

Note: ABS cement must be supplied locally.

TABLE 3: *Model 6600 Available Accessories*

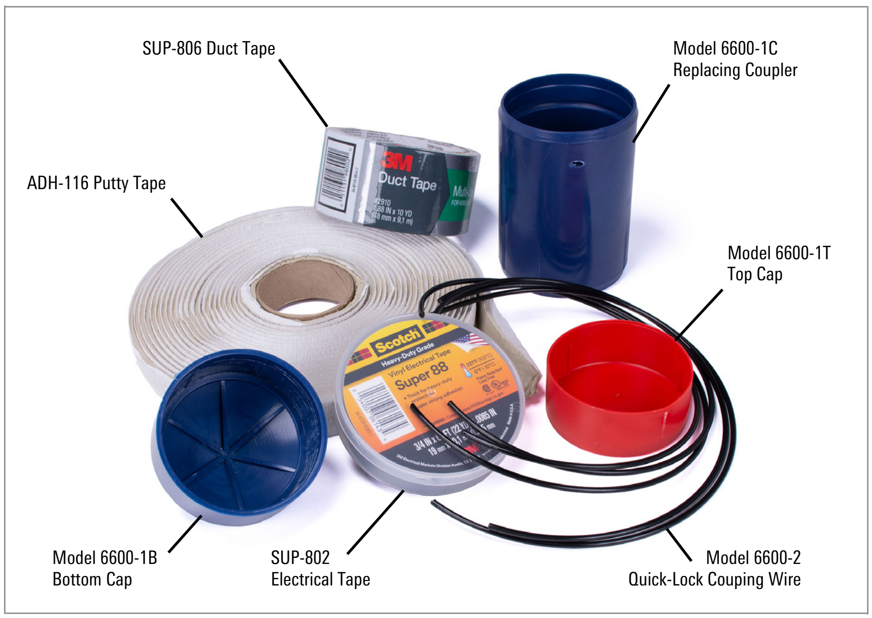

FIGURE 20: *Model 6600 Accessories*

APPENDIX F. MODEL 6600-2G GROUT ADAPTOR

F.1 PREREQUISITES

- Suitable grout mix design – typically water-cement–bentonite to achieve suitable (low) strength, anti-wash, slow set, easily pumpable mix. Sand in the grout mix is not recommended as sand can prevent closing of the check valves during removal of the grout line. The pumped product should be completely lump free, with no tendency to separate or clump.
- Suitable grout batching, mixing, and pumping equipment with surface hoses, water supply, gauges, etc.
- Wrenches, chain clamps etc.
- Sufficient 3/4" Schedule 40 metal (steel, galvanized, aluminum etc.) pipe in 10-foot sections and couplings to reach from the grouting adapter to the casing stickup. Teflon thread tape is recommended, particularly with aluminum pipe. Measure and number the pipes to permit accurate vertical control.

F.2 INSTALLATION

1. Ensure that the borehole is clear to the required depth.
2. Fit the grouting adapter to the bottom of the casing, and install the casing per the standard instructions, typically adding clean water as needed to counteract buoyancy.

NOTE: The inclinometer casing should extend above ground surface so that when grout is applied any overflow at the ground surface doesn’t flow into the casing.

3. Connect the female quick connector to section number one of 3/4" pipe using Teflon tape. Lower into the hole and continue adding pipe sections in number sequence until the quick connector engages. Check that the relative positions of the casing and pipe make sense.
4. Make a suitable surface hold-down for the grout pipe to prevent the grout pipe lifting off at the quick connect under pumping pressure. If the grouting adapter is not fitted with an inclinometer casing anchor, the casing will float, and downward pressure will need to be applied at the top of the casing to hold it down.

NOTE: It is strongly advised that a casing anchor is used to avoid the necessity of a surface weight. Applying downward pressure on the top of the casing will cause the casing to snake as well as put stress on the casing joints. This can potentially affect the performance of the measurement system as a whole.

5. Make connections from the 3/4" grout pipe to the grout pump and circulate water to ensure that the quick connect is correctly engaged. Water should return at the collar, outside the casing. The water level in the casing should not rise or overflow.
6. Batch the grout and start pumping. Monitor the grout pressure, which should stay low.
7. When undiluted grout returns at the collar of the hole, release the grout pipe hold-down and remove the grout pipe from the casing.
8. Top up the casing interior with clean water and monitor for any rise in level or overflow, which would indicate ingress of grout.
9. Flush the grout pipe and female quick connect with clean water the female quick connect can be manually opened by pressing in the middle with a 1/4" wooden dowel or similar object.
10. If step nine indicates ingress of grout, reinsert the grout pipe without the quick connect and circulate clean water

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