Model 6650

Inclinometer Casing

Instruction Manual



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1. INTRODUCTION

GEOKON Model 6650 Inclinometer Casing is engineered for compatibility with a wide range of commercially available inclinometers, ensuring reliable performance monitoring of the stability of embankments, slopes, rock cuts, foundation and excavation walls, piles, and other structures. GEOKON casing sections are designed for rapid and straightforward assembly to save time and money on-site.

Integrated o-rings seal the casing from groundwater or grout. The casing has grooves spaced at 90° intervals around the inside perimeter, which guide the wheels of the inclinometer to maintain a consistent orientation as it traverses the casing. When used in conjunction with an inclinometer probe, inclinometer casing allows a user to reliably measure angular tilt of the casing, providing a means for determining change in tilt over time, which can be used to determine 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.

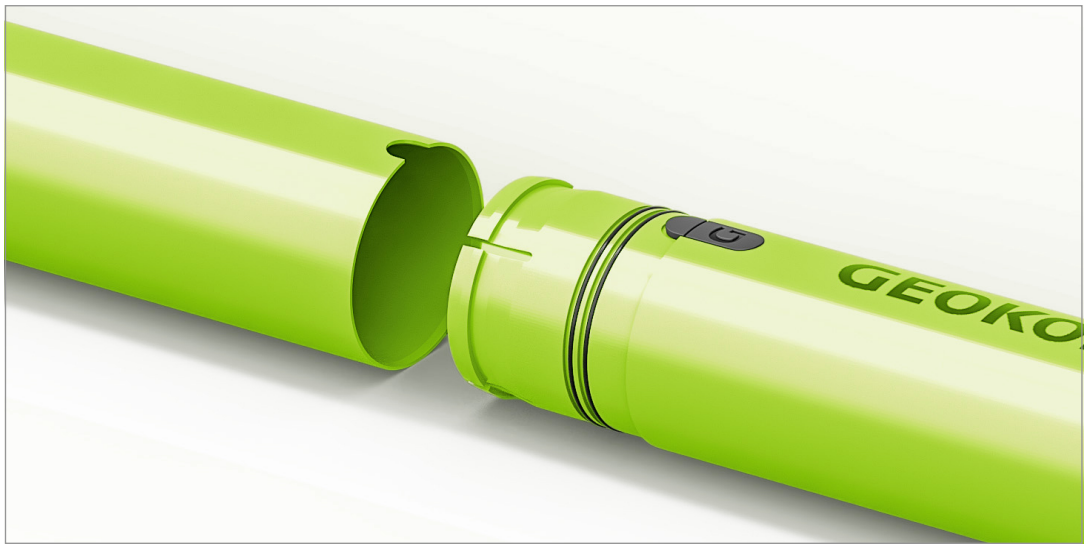


FIGURE 1: *Connection System*



FIGURE 2: *90° Spaced Grooves*

2. PRIOR TO INSTALLATION AND OTHER CONSIDERATIONS

2.1 CASING STORAGE

Inspect casing lengths to insure that none were damaged in transit, especially at the connection joints. 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.

Important! Do not assemble the casing prior to insertion in the borehole.

2.2 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.

If installing the Model 6650-ENCL Protective Enclosure with Lock, see Appendix D for additional borehole requirements.

3. INSTALLATION

3.1 CASING ORIENTATION

It is important to have one set of grooves oriented down slope, or toward the direction of expected movement. Alignment must be maintained throughout the installation to avoid introducing torsion to the casing, thereby causing spiraling of the grooves. Periodically look down the casing to make sure the grooves are in line with each other. The printed graphics along the exterior of the casing will also be aligned when casing is assembled.

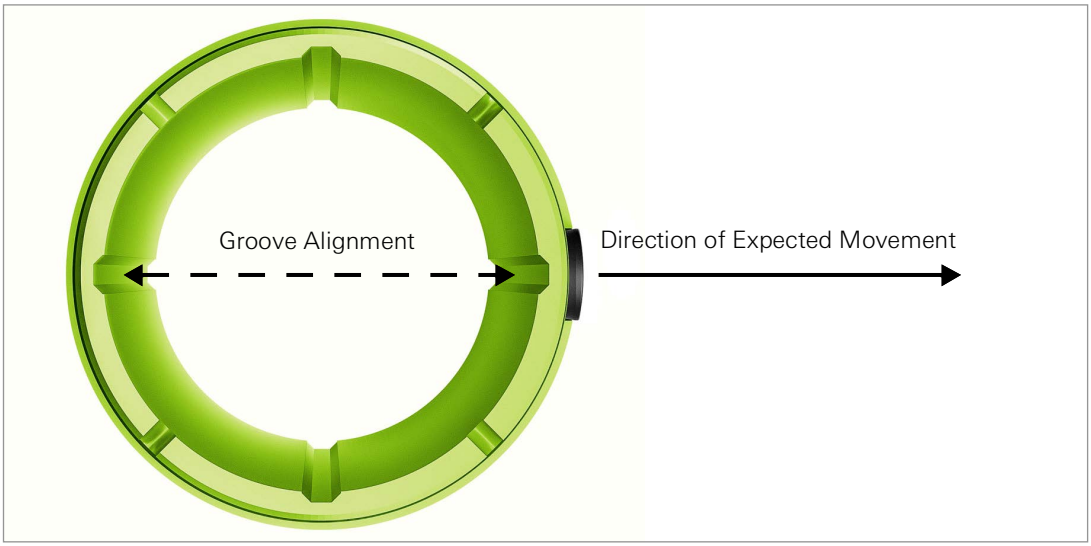


FIGURE 3: *Groove Alignment*

3.2 CASING INSTALLATION

Casing sections are shipped with a shipping cap and plug. These will need to be removed and discarded prior to installation.

Casing is made of ABS, GEOKON recommends using Oatey Medium Black ABS Cement. If this is not available, an all-purpose plastic cement designed for use on ABS or PVC may be used.

1. Number each casing section to confirm correct depth and to assist with placement of any external instruments (such as vibrating wire piezometers).
2. A terminating end is used to cap the casing at the bottom of the borehole. There are four options available:
   - Bottom Cap (Model 6650-70MM-BC): A plain cap that seals the bottom of the casing.
   - Bottom Anchor (Model 6650-70MM-ANC): Uses deployable barbs to firmly anchor the casing from the bottom to counteract buoyancy from groundwater or grout. Customer must supply and attach a pull cable to deploy the barbs when the desired depth is reached (see Appendix B).
   - Grout Cap (Model 6650-70MM-GC): A bottom cap with a grout coupling and outlet for tremie pipe, through which grout is pumped to fill the space between the borehole and the casing (see Appendix C).
   - Grout Anchor (6650-70MM-GA): Combines the features of the grout cap with a deployable anchor. It performs the same functions as Model 6650-70MM-ANC **and** Model 6650-70MM-GC.

   Apply ABS cement to the terminating end. Install it onto the first casing section by lining up the alignment tab and pushing it onto the casing (Figure 4). Gently pull on the coupling to verify it is secure.

Note: For added strength, applying ABS Solvent to the casing at each connection is recommended.

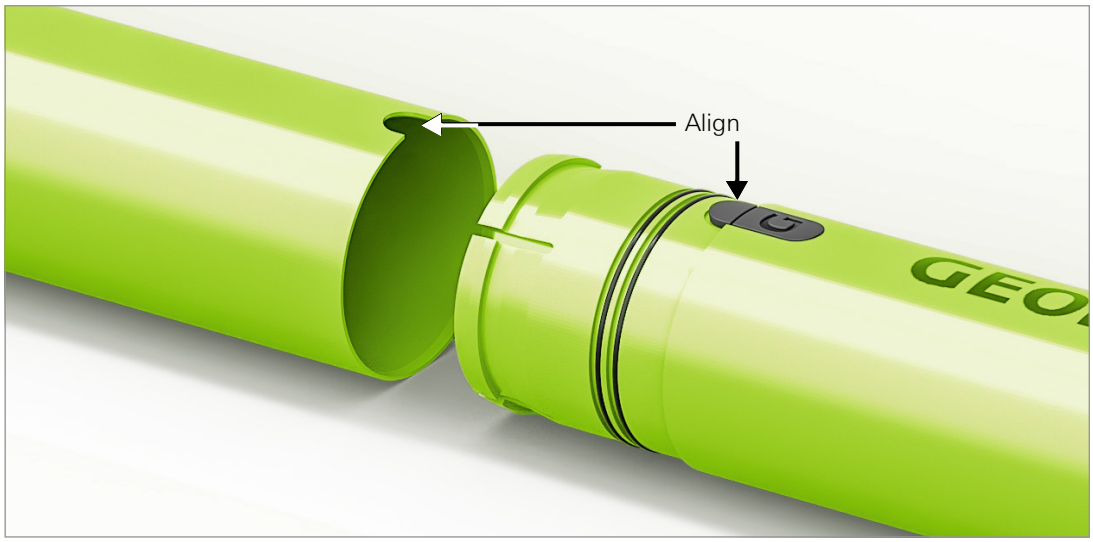


FIGURE 4: *Tab Alignment*

3. Attach a clamp to the casing tube below the coupling.

Note: It is recommend that a safety line is attached to the end of the casing as a way to retrieve it, should it be dropped during installation.

4. Lower the casing into the borehole, terminating end first, until the clamp rests on the borehole collar. Orient the casing as indicated in Section 3.1.
5. Apply ABS cement to the male end of the casing (do not apply to the female end, as excess cement can obstruct the internal grooves). Line up the alignment tab with the notch in the next piece of casing, and push together firmly. Gently pull on the coupling to verify it is secure.

Note: Wrapping the joint with duct tape is recommended for additional strength.

6. Remove the clamp, lower the casing, and re-attach the clamp to the casing tube below the coupling. Rest the clamp on the borehole collar.

Important! Never push the casing from the top. If the casing alignment must be adjusted, be cautious not to introduce torsion and spiraling of the casing grooves.

7. Repeat Step 5 and 6 to install subsequent casing sections.

3.3 CASING BUOYANCY

In water-filled boreholes, or when the borehole is being filled with grout, there can be a significant buoyant force acting on the casing assembly. This force is approximately 8 kg (18 lbs) per 3m (10') in water, and up to 18 kg (40 lbs) per 3m (10') in grout. Buoyancy can be helpful in that it pulls the casing straight once the bottom is anchored, but it can also create issues during installation if not handled properly.

Caution! Applying a downwards force to the top of the casing to counteract buoyancy is not recommended. It will cause the casing column to distort and possibly damage the casing joints. The casing may "snake" along its length and negatively affect the accuracy of the inclinometer system. If telescoping sections are used, downward pressure may prematurely collapse them into the compressed position.

To prevent the casing from floating upwards during installation and grouting, GEOKON suggests the following methods.

SECURE THE BOTTOM OF THE CASING TO THE BOREHOLE WALLS:

- ☐ The Model 6650-70MM-ANC Bottom Anchor and Model 6650-70MM-GA Grout Anchor can be used to lock the casing into place once the final depth is reached. See Appendix B.

Note: Once deployed, the Bottom Anchor will lock into place and render the casing installation permanent. The casing will be able to move further downwards, but will not be able to move upwards or rotate. Ensure the casing column is in the final orientation before deploying anchor.

FILL THE CASING TO WEIGH IT DOWN:

- ☐ A retrievable and clean chain, or a steel pipe can be placed into the casing.

Important! Use caution when inserting and removing these items. Be careful not to damage the internal grooves of the casing.

- ☐ Because ABS is slightly more dense than water, the casing can be filled with water to sink it in water-filled boreholes, then either pumped out or left in place (as long as the water will not interfere with the inclinometers used).

Note: Water alone will not be able to overcome the buoyant forces developed during grouting.

3.4 SURFACE TERMINATION SECTION

If installing the Model 6650-ENCL Protective Enclosure with Lock, refer to Appendix D.

If installing the Model 6650-70MM-TC Top Cap, cut the casing off at the desired height above grade. Install the top cap by pushing it firmly into the top of the casing, ensuring it is fully seated. The top cap is designed to vent air from the casing as ambient temperatures fluctuate.

Note: The top of the casing must be cut off for the top cap to fit properly.



FIGURE 5: *Model 6650-70MM-TC Top Cap*

3.5 GROUTING

Caution! Do not exceed a pressure differential of 1.5 MPa (217 psi) between the outside and inside of the casing, as this may cause it to collapse (or burst if the height of the water inside the casing exceeds the surrounding pressure on the casing). If the pressure differential is expected to exceed this limit, grout must be applied in stages, allowing for a substantial cure before additional grout is applied. With a grout density of 2000 kg/m^3, the maximum vertical depth of uncured grout that can be applied is:

- ☐ 70 m (230') for dry casing (not filled with water)
- ☐ 140 m (460') for water-filled casing

Grout requirements vary by site and soil conditions. Good judgment and past experience are critical to successful grouting of Inclinometer Casing. GEOKON can provide recommendations and advice for proper grout mixes and grouting techniques.

Note: If the casing is filled with water, changes in the water level can help to indicate problems. A sudden rise in water level may mean that the casing has collapsed. A slow rise may indicate grout ingress.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 6650 SPECIFICATIONS

Material	Casing: 100% Virgin ABS Casing Adapter: 100% Virgin ABS Bottom Anchor: 100% Virgin ABS & Stainless Steel Bottom Cap: 100% Virgin ABS Lockable Protective Enclosure: Galvanized Steel Grout Anchor: 100% Virgin ABS & Stainless Steel Grout Cap: 100% Virgin ABS & Galvanized Steel Top Cap: LDPE Telescoping Section: 100% Virgin ABS & PVC
Collapsing Pressure	1.5 MPa (217 psi)
Groove Spiral	<0.1° per 3 m (10')
Temperature Range	-20 to +80 °C
Weight	1.1 kg/m (0.75 lb / ft)
Connection Tensile Strength	450 kg (1,000 lb)
Casing Diameter	OD: 70 mm (2.75") ID: 59 mm (2.32")
Casing Length	6650-70MM-5: 1.5 m (5') 6650-70MM-10: 3 m (10')
Telescoping Section	165 mm (6.5") travel 497 mm (19.5") compressed length (assembled) 662 mm (26") extended length (assembled) OD: 73 mm (2.87")

TABLE 1: *Model 6650 Inclinometer Casing Specifications*

Tensile modulus = 340,000 psi approximately (per ASTM D638)

Poisson's ratio = 0.35 approximately.

A.2 PARTS LIST

6400-2RT	Reconnect Alignment Tool
6650-70MM-5	70 mm inclinometer casing, 1.5 m (5') length
6650-70MM-10	70 mm inclinometer casing, 3 m (10') length
6650-70MM-ADP	Casing adapter for 70 mm casing
6650-70MM-ANC	Deployable bottom anchor
6650-70MM-BC	Plain cap that seals the bottom of the casing column
6650-ENCL	Lockable protective enclosure
6650-70MM-GA	Grout anchor, a deployable bottom anchor with grouting adapter
6650-70MM-GC	Bottom cap with grouting adapter
6650-70MM-TC	Top cap that protects against rain and wildlife incursion *For protection against mechanical damage or vandalism, see Model 6650-ENCL*
6650-70MM-TS	Telescoping section, 165 mm (6.5") travel in compression or tension

TABLE 2: *Model 6650 Parts List*

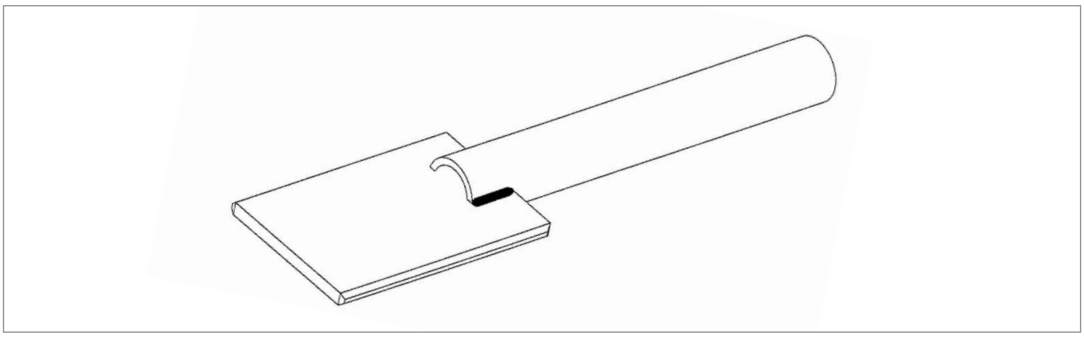


FIGURE 6: *Model 6400-2RT Reconnect Alignment Tool*

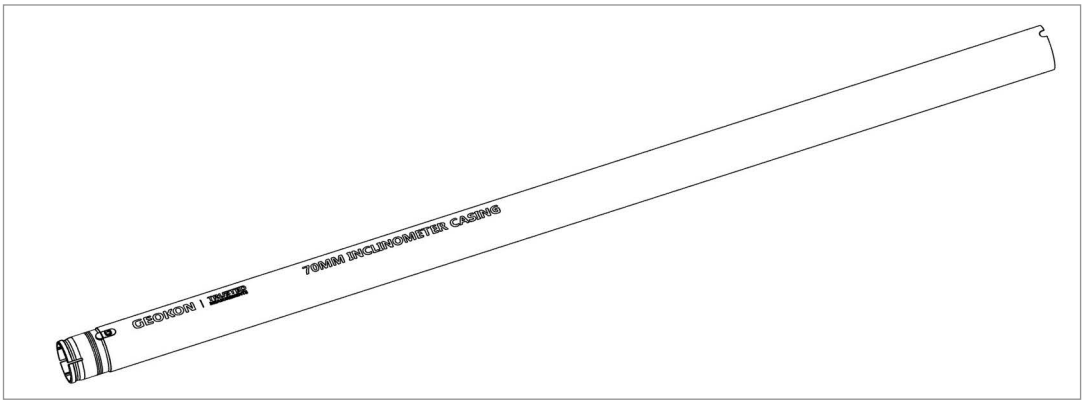


FIGURE 7: *Model 6650-70MM-5 (5') and 6650-70MM-10 (10', not pictured) Inclinometer Casing*

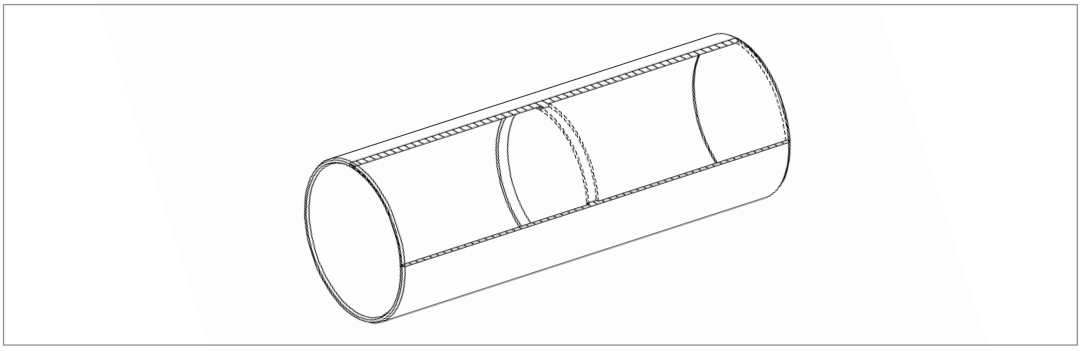


FIGURE 8: *Model 6650-70MM-ADP Casing Adapter for 70 mm casing*

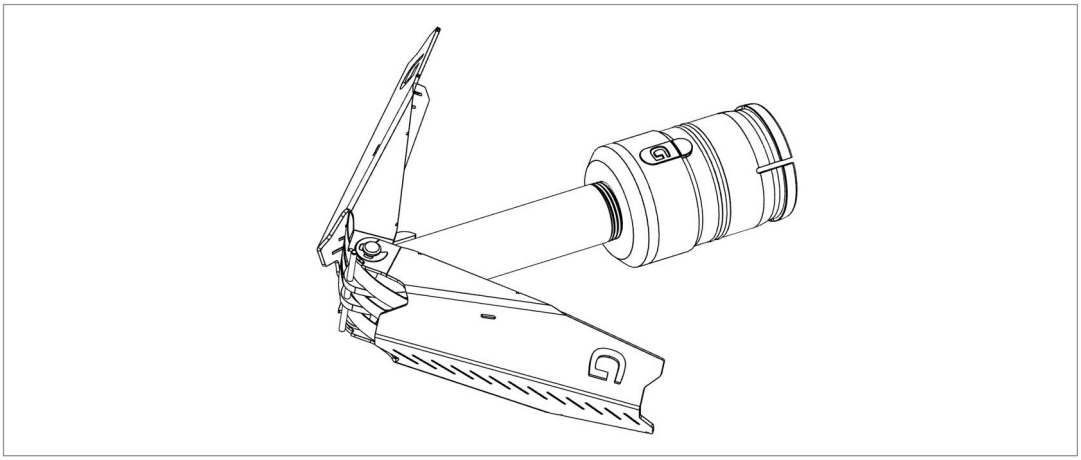


FIGURE 9: *Model 6650-70MM-ANC Deployable Bottom Anchor*

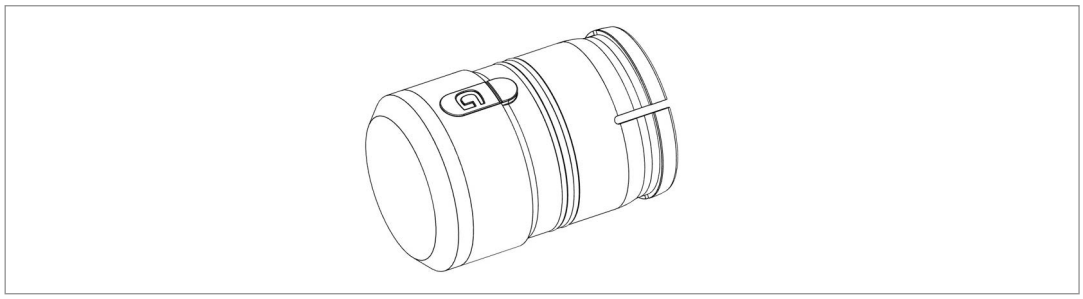


FIGURE 10: *Model 6650-70MM-BC Bottom Cap*

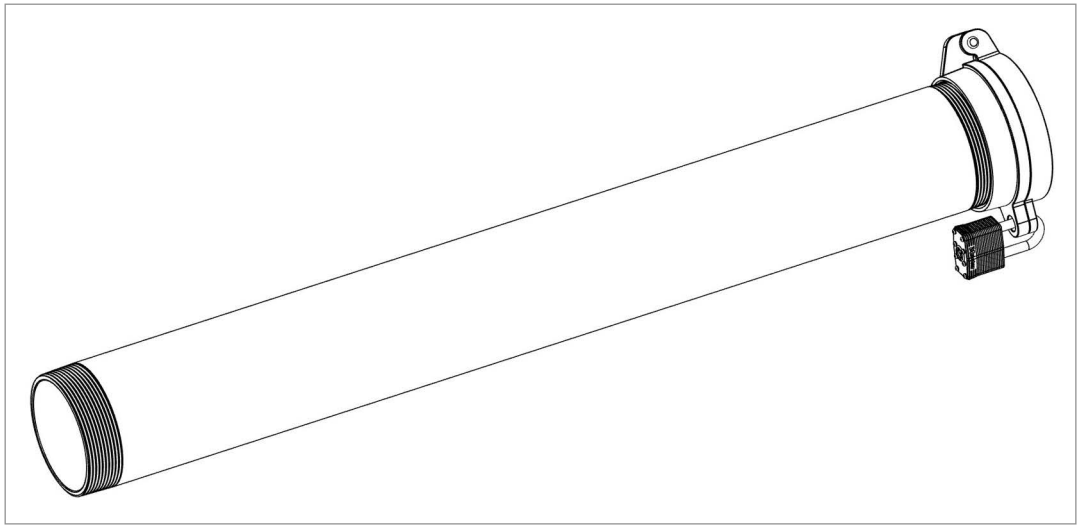


FIGURE 11: *Model 6650-ENCL Lockable Protective Enclosure*

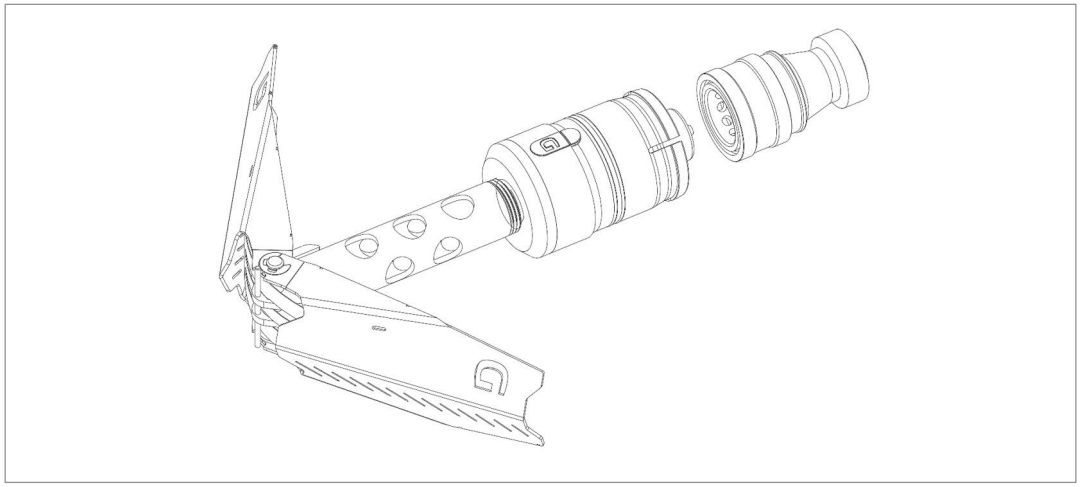


FIGURE 12: *Model 6650-70MM-GA Grout Anchor*

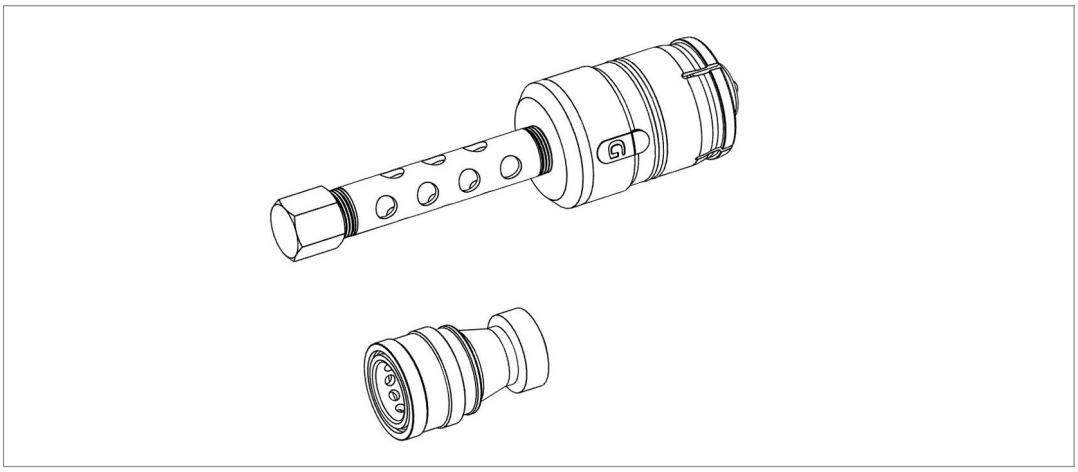


FIGURE 13: *Model 6650-70MM-GC Bottom Cap with Grouting Adapter*



FIGURE 14: *Model 6650-70MM-TC Top Cap*

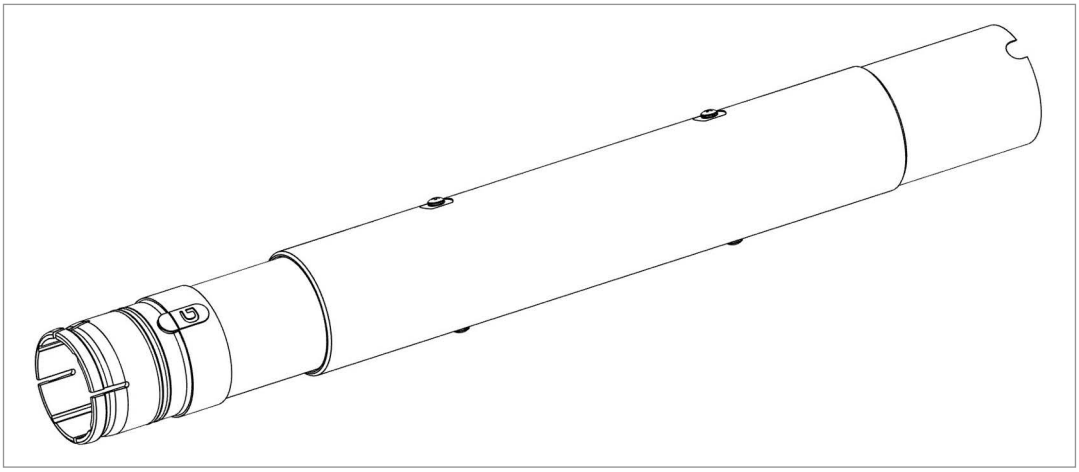


FIGURE 15: *Model 6650-70MM-TS Telescoping Section*

APPENDIX B. BOTTOM ANCHOR

GEOKON offers two standard accessories for anchoring casing to the bottom of a borehole and preventing the casing column from floating upwards during grouting:

- Model 6650-70MM-ANC Deployable Bottom Anchor firmly grips the walls of boreholes up to 12" in diameter. It features a breakaway tab that, when pulled, causes two barbs to spring outwards and engage with the walls of the borehole.
- Model 6650-70MM-GA Grout Anchor combines the features of the grout cap with a deployable anchor. It performs the same anchoring function as Model 6650-70MM-ANC, while the added hydraulic adapter allows users to pump grout directly through the tremie pipe and through the bottom of the casing, while preventing backflow into the casing.

Note: These anchors are not a substitute for proper installation technique. The casing should not be pushed downwards from above, as it will cause the casing to "snake" in the borehole and could place excessive stress on the connections. The anchors are designed to prevent flotation only after the casing has reach its final depth.

To install either anchor:

1. Install a cable (not included) onto the clip that holds the anchor barbs closed. The cable should be at least as long as the planned installation depth, and have a tensile strength of at least 20 kg (50 lbs). The cable will be retrieved and can be re-used on the next hole.
2. Once the cable is affixed, install the anchor onto the first piece of casing (Section 3.2, Step 2) then proceed with installation of each additional casing segment.

Important! Carefully manage the cable as the casing is lowered. Any snag on the surface could apply enough force to prematurely deploy the anchor barbs, or restrict removal of the cable.



FIGURE 16: *Model 6650-70MM-ANC Anchor Barb Clip Attachment Point Shown*

3. Once the casing has reached its final depth, ensure the internal grooves are aligned with the desired axis of measurement. After the anchor is deployed, the casing can be pushed deeper but will not be able to come back up or rotate.

Important! If the casing alignment must be adjusted, be cautious not to introduce torsion and spiraling of the casing grooves.

4. To deploy the anchor, pull firmly on the cable (deployment requires at least 14 kg, or 30 lbs of force). The cable can then be pulled to the surface and re-used.

APPENDIX C. GROUT CAP

GEOKON offers two standard accessories that allow users to pump grout directly through the tremie pipe and into the borehole through the bottom of the casing. This method helps prevent air bubbles in the grout by filling the borehole from the bottom. It can be utilized in situations where an external grout pipe cannot be used.

- The Model 6650-70MM-GC Grout Cap is a bottom cap with an integrated hydraulic grout valve. The included hydraulic coupler fits on the end of 3/4" NPT tremie pipe and facilitates pumping of grout through the tremie pipe. The female adapter has been modified so it will not lock onto the male adapter, meaning it can be retrieved, cleaned, and re-used.
- The Model 6650-70MM-GA Grout Anchor combines the features of the grout cap with a deployable anchor. It performs the same function as Model 6650-70MM-GC, while the deployable barbs anchor the casing into borehole walls and prevent flotation during the grouting process.



FIGURE 17: *Model 6650-70MM-GC Grout Cap with Female Connector*

Note the following prerequisites:

- Suitable grout mix: typically a water-cement-bentonite mix to achieve suitable strength, anti-wash, slow-set, easily-pumpable mix. Sand in the mix is not recommended as it can prevent closing of the grout cap's check valve after the tremie pipe is removed. Grout should not have a compressive strength larger than that of the surrounding formation, but should also not be so weak/soft that displacements/deformations will not transmit effectively to the casing.
- Suitable grout batching, mixing, and pumping equipment with surface hoses, water supply, gauges, etc.
- Wrenches, casing clamps, etc.
- Sufficient 3/4" SCH40 metal pipe and couplings to assemble a tremie pipe long enough to reach the grouting adapter at the bottom. The grouting adapter has a 3/4" NPT female threaded connection. Teflon tape is recommended at each connection.

To use the grout cap or grout anchor, follow the procedure below:

1. Install the grout cap on the first piece of casing (Section 3.2, Step 2), then proceed with installation of each additional casing segment.

2. **Model 6650-70MM-GA Only:** Follow the steps outlines in Appendix B for installation and use of the anchoring function.
3. Once all the casing has been assembled and lowered into the borehole, assemble the tremie pipe. Connect the female adapter to a 3/4" NPT threaded tremie pipe using Teflon tape. Install additional lengths of tremie pipe, with Teflon tape at each joint, until the bottom of the casing is reached.

Caution! Lower the tremie pipe carefully into the casing until it reaches the adapter at the bottom. Dropping the pipe may damage the grout cap and compromise the casing.

4. Once the final depth is reached, ensure the tremie pipe has a secure connection to the grout adapter. Pump water through the tremie pipe and ensure that the water level outside the casing is rising. If the water level inside the casing rises, it means the grout adapter is not making a secure connection.
5. Ensure proper hold-down of the grout pipe to prevent it from lifting off and disconnecting from the adapter during pumping.
6. Mix the grout and start pumping it through the grout pipe. Keep in mind the maximum depth of grout as described in Section 3.5.
7. When done grouting, top off the casing interior with clean water and monitor for any rise in level that would indicate grout ingress.

Note: If grout ingress is detected, stop pumping and flush the borehole with clean water. After the first batch cures, grouting can continue using an external tremie pipe.

8. After the grout pipe is retrieved, the female grout adapter can be re-used for future installations by depressing the valve and flushing with water.

APPENDIX D. PROTECTIVE ENCLOSURE WITH LOCK

The GEOKON Model 6650-ENCL Protective Enclosure with Lock consists of a 0.91m (3') × 100 mm (4") diameter galvanized steel pipe with lockable cap to protect the casing from vandalism, as well as direct exposure to thermal influences. This enclosure can be used if the inclinometer casing is allowed to extend above ground surface.

Note: If this enclosure is installed, and an externally mounted pulley system (such as the GEOKON Model 6000-22 External Casing Mount) needs to be used, Model 6650-70MM-ADP must be utilized to extend the casing above the enclosure to provide a clamping surface (see Appendix F, Section F.2).

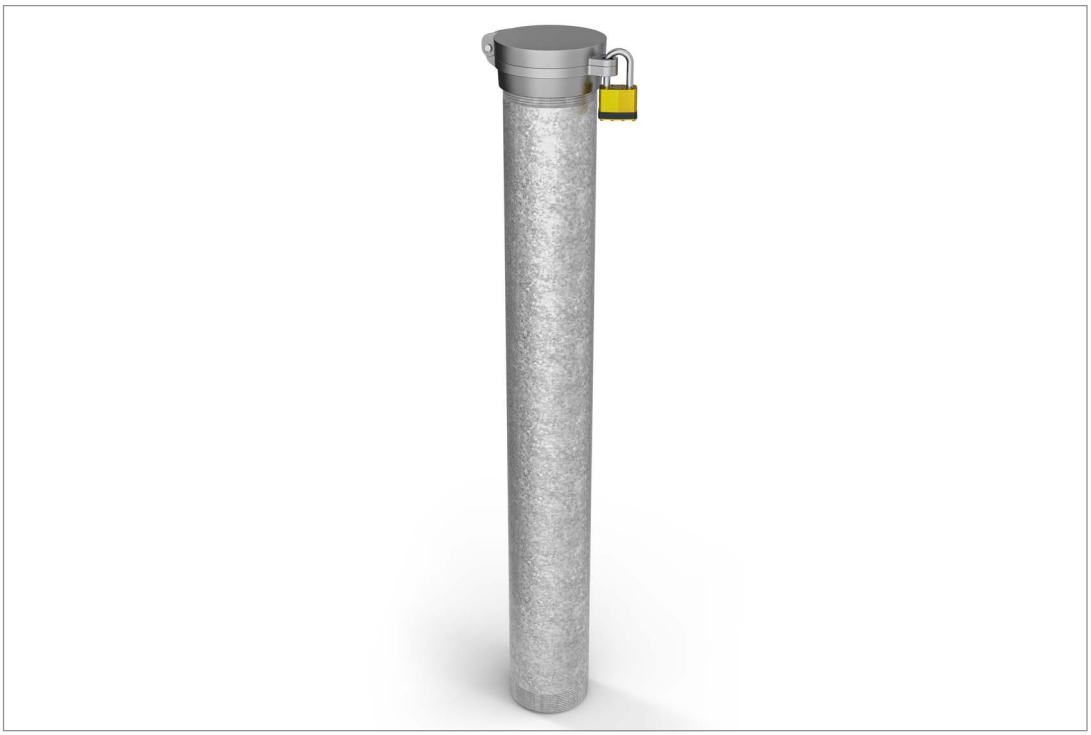


FIGURE 18: *Protective Housing*

When preparing an installation using the protective enclosure, the mouth of the borehole must be approximately 305 mm (12") deep with a minimum diameter of 203 mm (8"). The borehole may need to be enlarged (overcored) in order to meet these requirements.

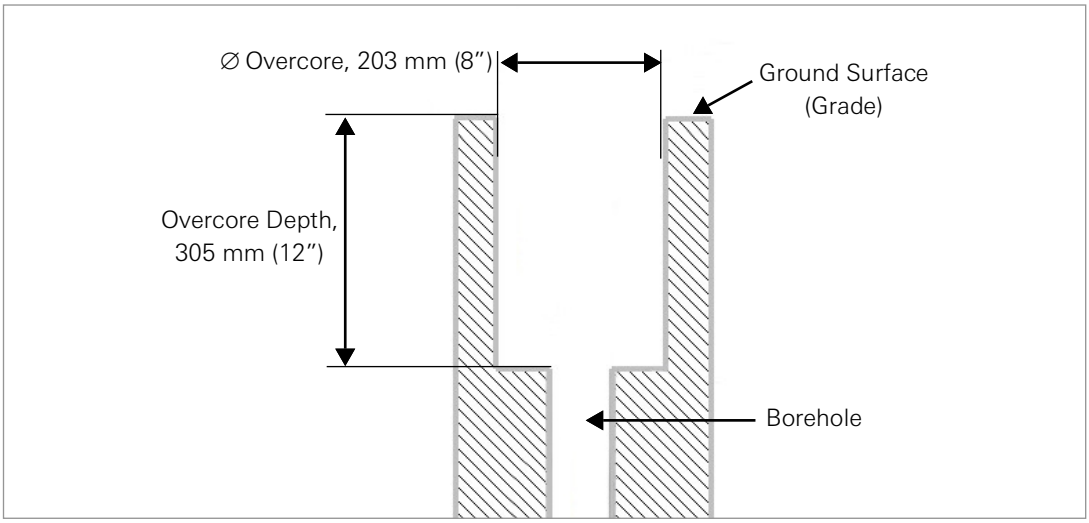


FIGURE 19: *Overcore*

To install the protective enclosure, follow the procedure below:

1. Cut the casing off 60 cm (2') from the top of the borehole (Figure 20).
2. Fill the borehole with grout up to the surface of the ground following the instruction in Section 3.5. Wile the grout is still wet, complete the next step.
3. With the cap closed, place the protective enclosure over the protruding casing. Ensure the protective enclosure is centered around the casing, hold in place with temporary clamps or by packing the surrounding area with soil until the grout has cured.
4. After the grout has cured, return and open the cover of the protective enclosure. Cut off the top 0.5" (12mm) of casing so it is flush with the top of the steel pipe.

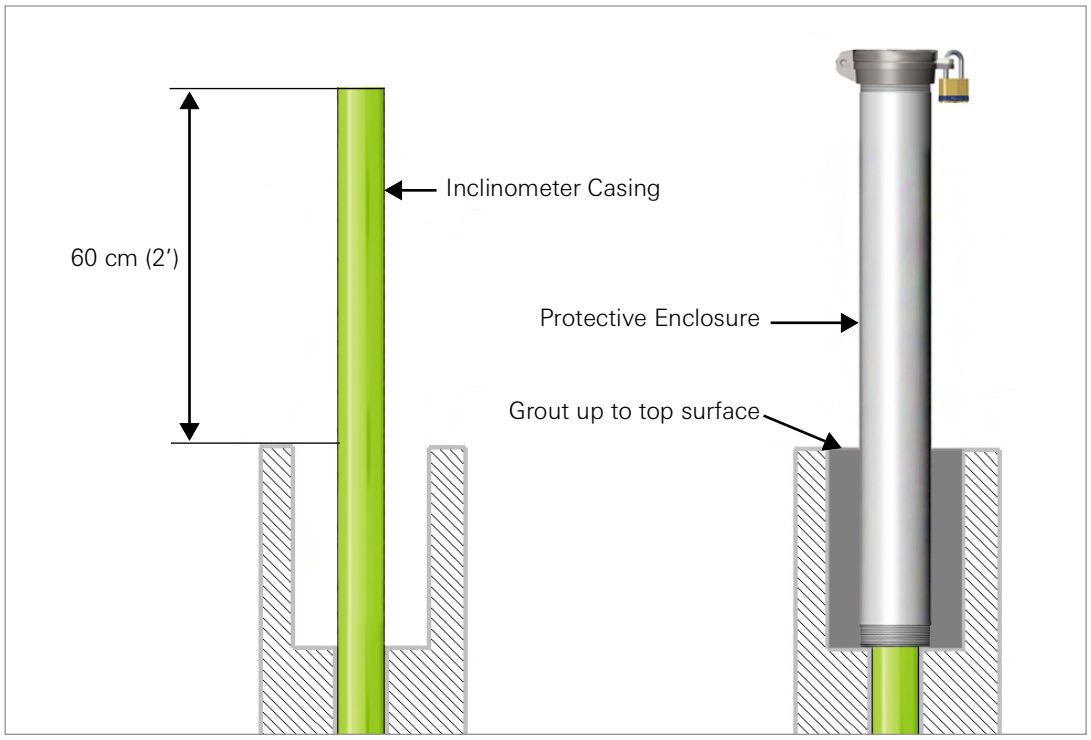


FIGURE 20: *Trimmed Casing (Left) and Installed Protective Cover (Right)*

APPENDIX E. TELESCOPING CASING SECTION

The GEOKON Model 6650-70MM-TS Telescoping Section is a section of casing that can expand or contract to relieve pressure (on the casing) caused by settlement or heave of the ground. The telescoping section can accommodate up to 165 mm (6.5") of movement. It ships in the extended position which is used where settlement is expected, but can be configured to the compressed position in the field, for installations where heave is expected.

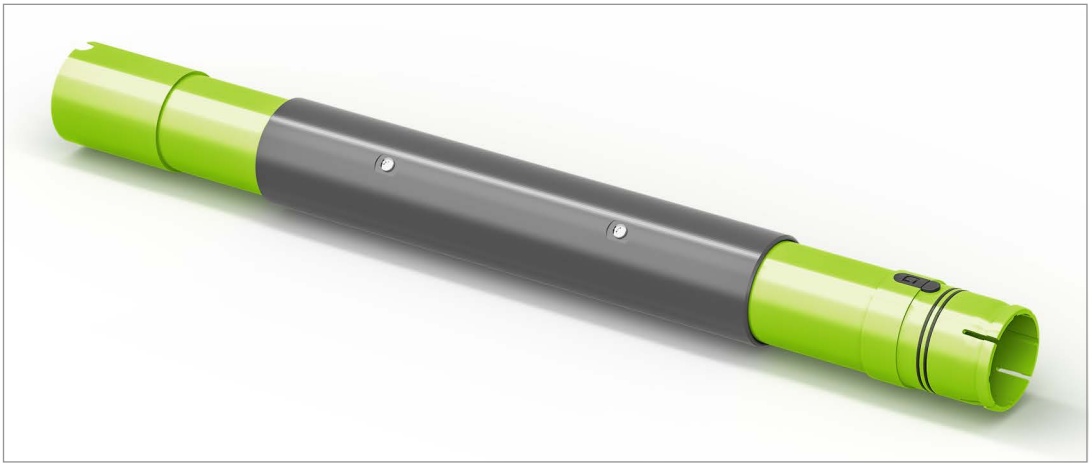


FIGURE 21: *Model 6650-70MM-TS Telescoping Section (Extended Position, Default)*

FOR INSTALLATIONS WHERE SETTLEMENT IS EXPECTED:

The 6650-70MM-TS is pre-configured in the extended position. It will hold this position until approximately 100 kg (220 lbs) of compressive force is applied, after which the section will be free to move up to 165 mm (6.5") from its original length. During installation, be careful to not exceed this amount of downward force on the casing column.

FOR INSTALLATIONS WHERE HEAVE IS EXPECTED:

The telescoping section has four screws that retain and guide the casing segments. The screws stick down into holes that prevent the telescoping section from collapsing until a force threshold is reached. To configure the telescoping section into its compressed state, back the four screws out until the section can be collapsed, then tighten them, ensuring the ends go into the machined slots of each casing piece.

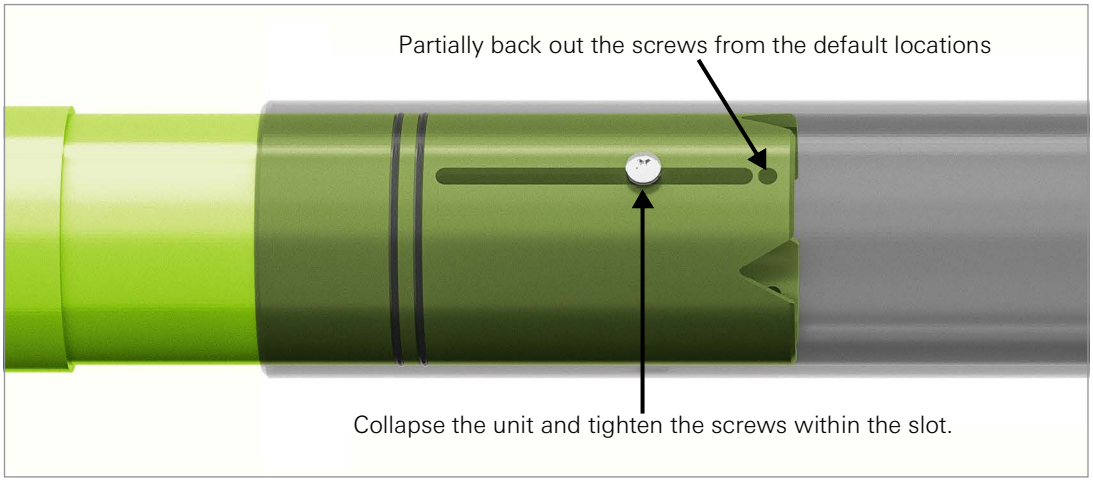


FIGURE 22: *Back out Screws and Re-Install into the Slot Location*

When finished, check that the telescoping section can extend and collapse freely. Also check the alignment by making sure the alignment tab and notch are in line, and look down from the end to make sure the internal grooves are still aligned. (Compressed position shown in Figure 23.)

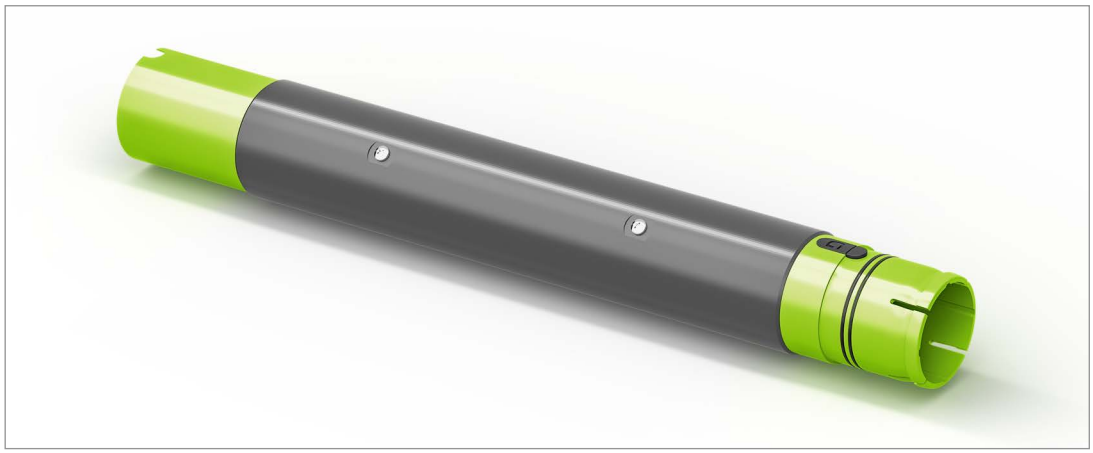


FIGURE 23: *Model 6650-70MM-TS Telescoping Section (Compressed Position)*

APPENDIX F. CASING ADAPTER

The GEOKON Model 6650-70MM-ADP Casing Adapter is a section of pipe designed to slip over the outside of the casing and serves a multitude of functions:

- Used in the process of repairing damaged casing (see Section F.1).
- Allows users to convert 70 mm casing from other manufacturers to GEOKON Model 6650 Casing (see Section F.1).
- Facilitates the addition of new casing segments in installations where more fill is added after the casing is initially installed (see Section F.1).
- Allows an externally mounted pulley system (such as the GEOKON Model 6000-22 External Casing Mount) to be used in conjunction with the Model 6650-ENCL Protective Enclosure (see Section F.2).

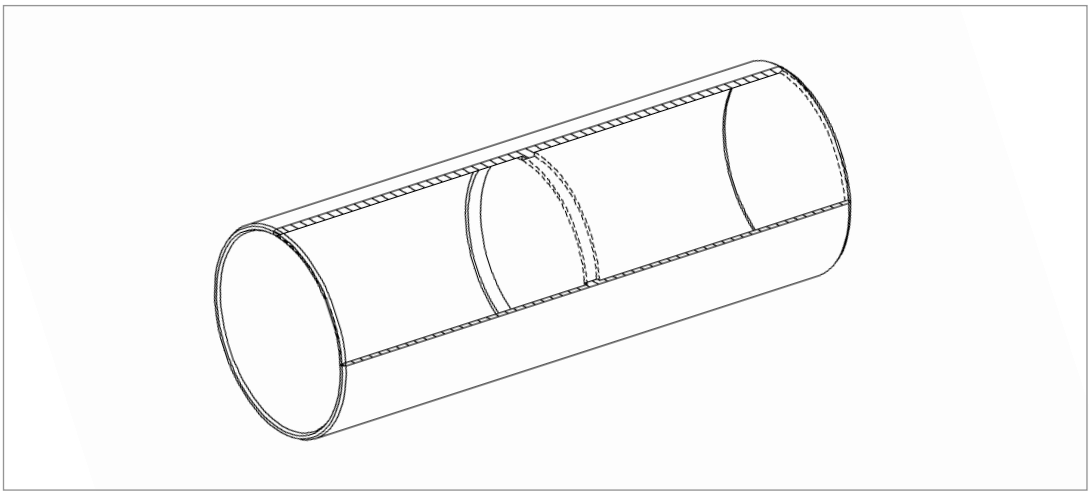


FIGURE 24: *Casing Adapter, Cutaway View Shown*

F.1 REPAIRING, EXTENDING, OR CONVERTING CASING

The Model 6650-70MM-ADP Casing Adapter and the Model 6400-2RT Reconnect Alignment Tool can be used to create a permanent joint between two casing segments. This is helpful when repairing damaged casing, converting casing from other manufacturers to GEOKON Model 6650 Casing, or when extending the casing column to facilitate added fill, such as in tailings monitoring. The casing adapter will fit over any casing as long as it has an outside diameter of 70 mm.

The casing adapter is made of ABS, which must be considered when selecting an appropriate adhesive for your application. Because most commercially available inclinometer casing is also made of ABS, GEOKON recommends using Oatey Medium Black ABS Cement. If this is not available, an all-purpose plastic cement designed for use on ABS or PVC may be used. If the adapter is being attached to a different material, ensure a suitable adhesive is used.

Note: Consult the instructions of the transition cement's manufacturer, including surface cleaning, preparation, and cure times.

Refer to the steps below to repair damaged casing. There steps can also be used as a general guide to convert or extend casing.

1. Cut off the in-place casing below the damaged area. Deburr the cut, and clean the topmost 153 mm (6") of casing so it is free of dirt and oils.
2. Apply transition cement to the outer circumference of the casing, to the topmost 102 mm (4"). Also apply inside one mating end of the casing adapter.

3. Slip the casing adapter over the casing and slide it down until fully seated. Wipe excess cement from the inside of the casing, ensuring the internal grooves are clean and clear of obstruction.
4. Prepare the next segment of GEOKON Model 6650 Casing by cutting off the female connection end. Deburr the cut and clean the first 153 mm (6”) of casing above the cut so it is free of dirt and oils.
5. Attach a steel retrieval cable (customer supplied) through the two holes on the Model 6400-2RT Reconnect Alignment Tool. Insert the retrieval cable into the mating side of the new casing segment, threading it out to the far end, then insert the alignment tool so it protrudes approximately 2" out of the mating end.
6. Apply transition cement to the outer circumference of the new casing segment, to the bottommost 102 mm (4”). Also apply inside the mating end of the casing adapter, then slot them together. Ensure the reconnect alignment tool rests within the grooves of both pieces of casing by applying a gentle twisting force to the new casing segment.
7. Allow the transition cement to set per the manufacturer's instructions. Allow extra time in cold environments. Once set, pull the cable to remove the reconnect alignment tool.

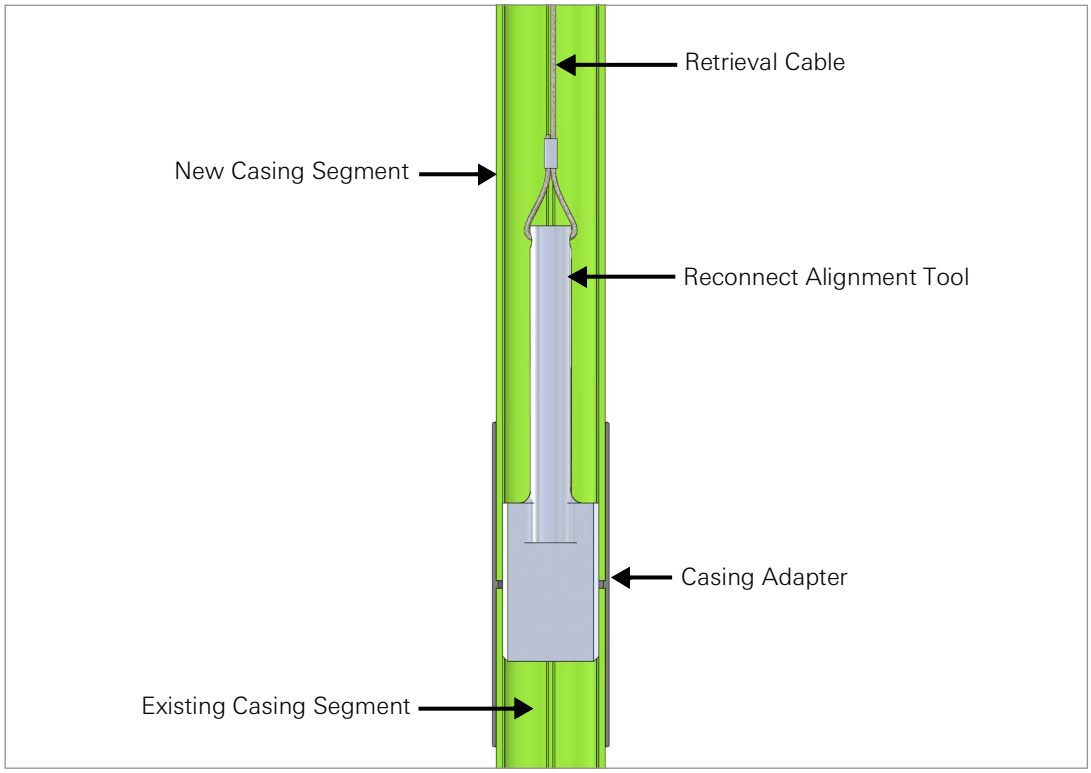


FIGURE 25: *Repairing Casing Using the Casing Adapter and Reconnect Alignment Tool*

F.2 EXTENDING THE CASING ABOVE THE PROTECTIVE ENCLOSURE

If using an externally mounted pulley system (such as the GEOKON Model 6000-22 External Casing Mount) in conjunction with the Model 6650-ENCL Protective Enclosure, the Model 6650-70MM-ADP Casing Adapter must be used. The casing adapter extends the top of the casing so the pulley can be clamped around it.

To install, slide the casing adapter over the top of the casing (without the use of adhesives) and line up the inner grooves. Clamp the pulley directly to it, being careful to not over-tighten the clamps.

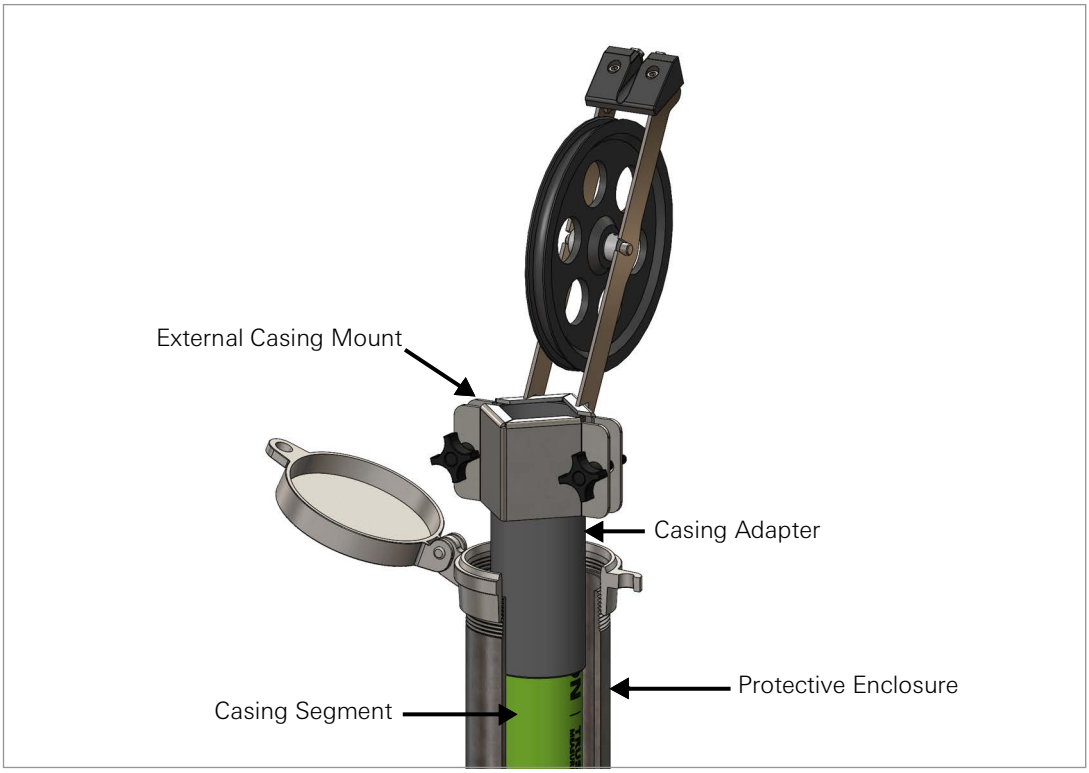


FIGURE 26: *Model 6000-22 External Casing Mount Used in Conjunction with the Casing Adapter to Extend the Casing Above the Protective Enclosure*

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