Model 1610

GEOKON / Ealey

Tape Extensometer

Instruction Manual

GEOKON®

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1. INTRODUCTION

The Model 1610 Tape Extensometer is designed to measure changes in the distance separating two fixed points. Most often the points are located on opposite sides of an underground opening, such as a tunnel, and the measurement is usually of closure of the tunnel walls, (Figure 1), or roof/floor convergence caused by pressure in the surrounding ground. The tape extensometer is particularly useful for the measurement of deformation of the shotcrete tunnel linings used as part of the "New Austrian Tunneling Method" (NATM). It also finds use in the measurement of closure between the walls of open cuts, in cut and cover operations and between the walls of deep foundation excavation. Other applications include structures, buildings and unstable slopes. By using the same fixed points to locate a leveling staff or EDM target, it is possible to incorporate tape extensometer data into a more comprehensive monitoring survey.

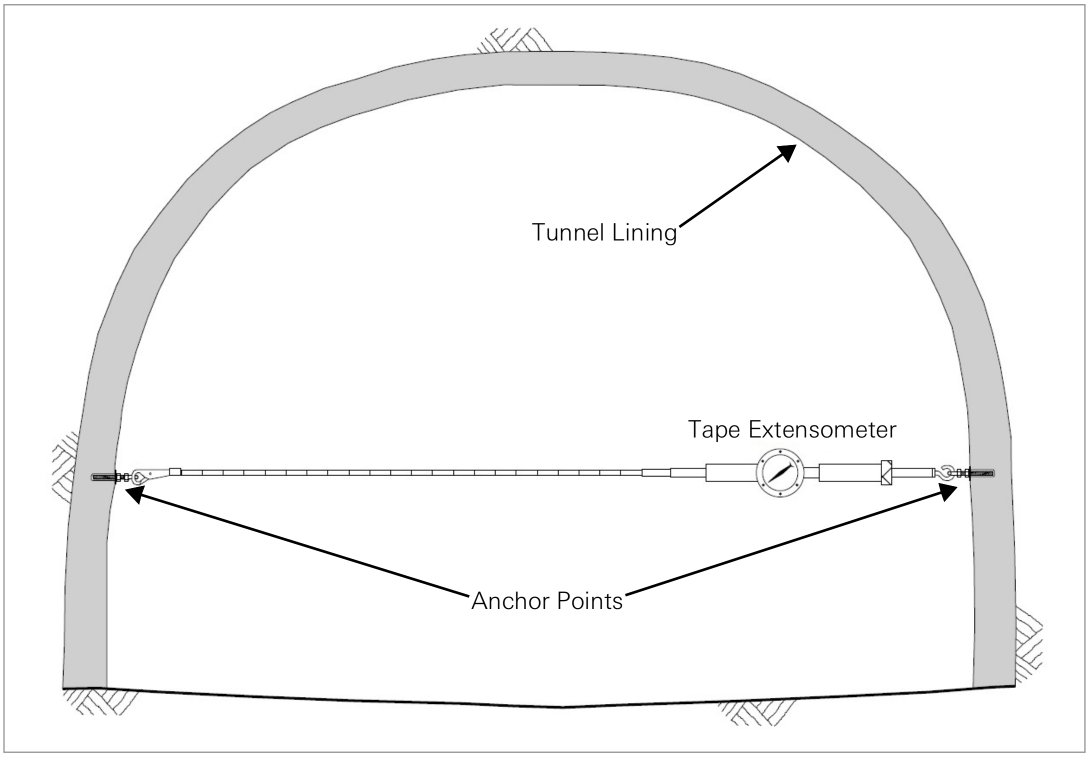

FIGURE 1: *Typical Installation*

The Model 1610 uses a stainless steel measuring tape in which holes have been punched at precise intervals every 50 mm (2 inches). The tape is held inside a frame, which also houses a digital micrometer and electronic tensioning device. Tapes are available in a variety of different lengths, including metric (20, 30, and 50 m) and English (66 and 100 ft) options.

The tape is stretched between two points located on opposite sides of the underground opening via a hook on the end of the tape and another on the back end of the tape extensometer. A locating pin attached to a slotted clip is designed to engage one of the punched holes in the tape. The tape extensometer can be shortened and the tape tensioned, by rotating a tensioning handle until the correct tension indicator light is illuminated.

The precision of the instrument will depend to a large degree on the skill of the operator in achieving a consistent and repeatable tape tension. Techniques that will maximize accuracy are described in Section 3.2.

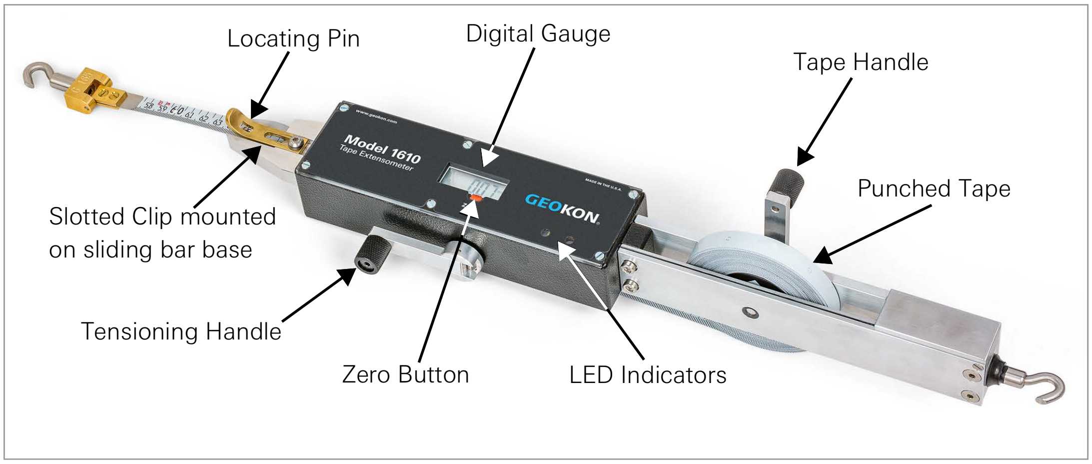

FIGURE 2: *Model 1610 Tape Extensometer*

2. INSTALLATION

Eye bolts are installed at fixed points from which the Model 1610 Tape Extensometer will measure. Eye bolts can be anchored using three different methods as shown below.

2.1 GROUTABLE ANCHORS

The Model 1610-12 Groutable Anchor option is a 13 mm (1/2”) (#3) diameter, 76 mm (3”) long rebar with an attached eyebolt. The rebar is grouted inside a short borehole, or cast inside the shotcrete lining (NATM). These are used in applications where the reference points will be installed on uneven surfaces, the surface area has poor strength or conditions, or where significant temperature fluctuations are expected.

To install the anchors, follow the procedure below.

1. Drill a hole into the surface, slightly larger in diameter than that of the anchor and to an appropriate depth.

Note: The hole can be drilled deep so the eye bolt can be installed close to the surface (to help reduce potential damage to the eye bolt from activities in the area) or slightly shallow to keep the eye bolt away from the surface (to assist with connection of the hooks on the instrument).

2. Fill the hole three-quarters full of grout or epoxy.
3. Insert the anchor into the hole, rotating it slightly to engage the anchor with the grout/epoxy.
4. Temporarily wedge the anchor in place until the grout/epoxy cures.

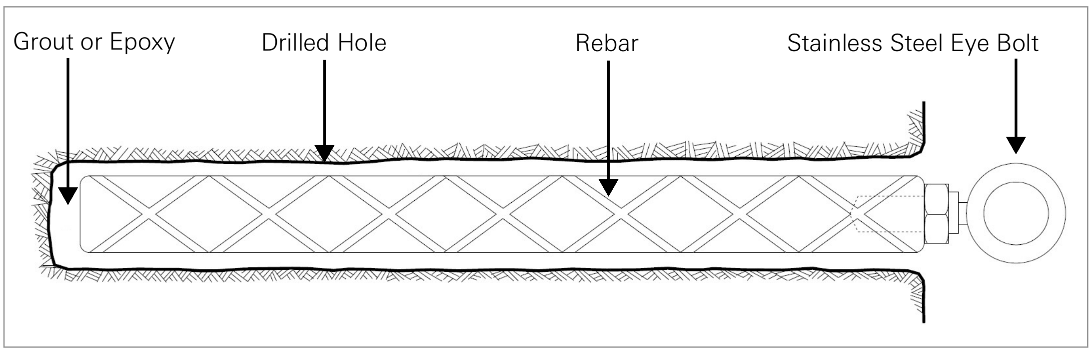

FIGURE 3: *Groutable Anchor*

2.2 RAWL DROP-IN ANCHORS

The Model 1610-13 Rawl Drop-In Anchor is 6.4 mm (1/4”) in diameter and comes with an eye bolt. This style of anchor is typically used in concrete, rock, or other competent material, and requires a Model TLS-208 Setting Tool.

To install the anchors, follow the procedure below.

1. Drill a 10 mm x 25 mm (3/8” x 1”) hole into the surface.
2. Insert the drop-in anchor, threaded side up, into the hole. Insert the Model TLS-208 Setting Tool into the anchor and strike with a hammer until the lip of the anchor touches the lip of the setting tool.
3. Remove the setting tool and install the eye bolt into the anchor. The eye bolt can be fixed in place with thread lock material and the securing nut.

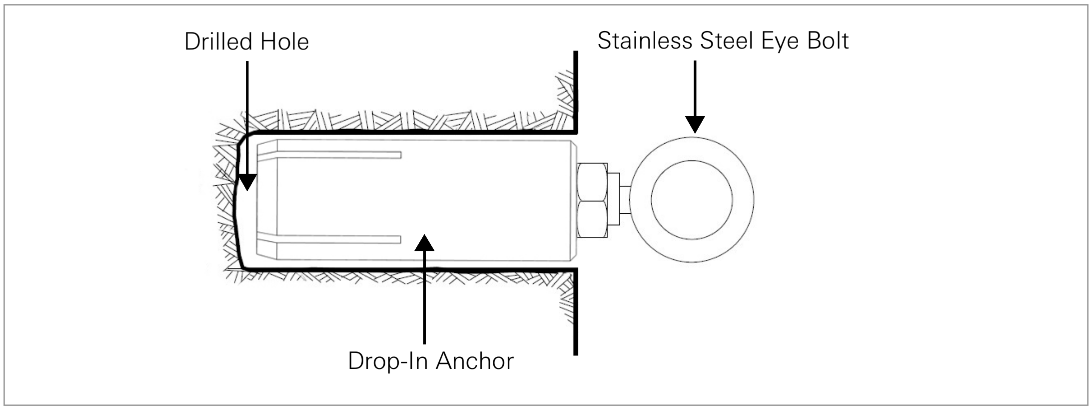

FIGURE 4: *Rockbolt Expansion Anchor*

2.3 WELDABLE / EPOXY ANCHORS

Occasionally anchors may be located on steel ground supports such as tunnel arches, steel tubing or on soldier piles. The Model 1610-14 Weldable/Epoxy Anchor is ideal for these surfaces. An eye bolt is attached to a small steel plate, which is then welded to the structure. Alternately, these anchors can be mounted to the surface with epoxy (this method is only recommended for short-term monitoring applications), or an eye bolt can be screwed directly into a 1/4-20 hole drilled and tapped in the steel member.

To install the anchors via welding, follow the procedure below.

1. Clean the installation location using a wire brush or flap wheel. Remove all scale, rust, dirt, and oil.
2. Press or clamp the anchor firmly against the steel surface. Weld in place.
3. Clean away all welding slag using a chipping hammer and wire brush.
4. Optional: Paint over the anchor and the surrounding surface to provide protection against corrosion.

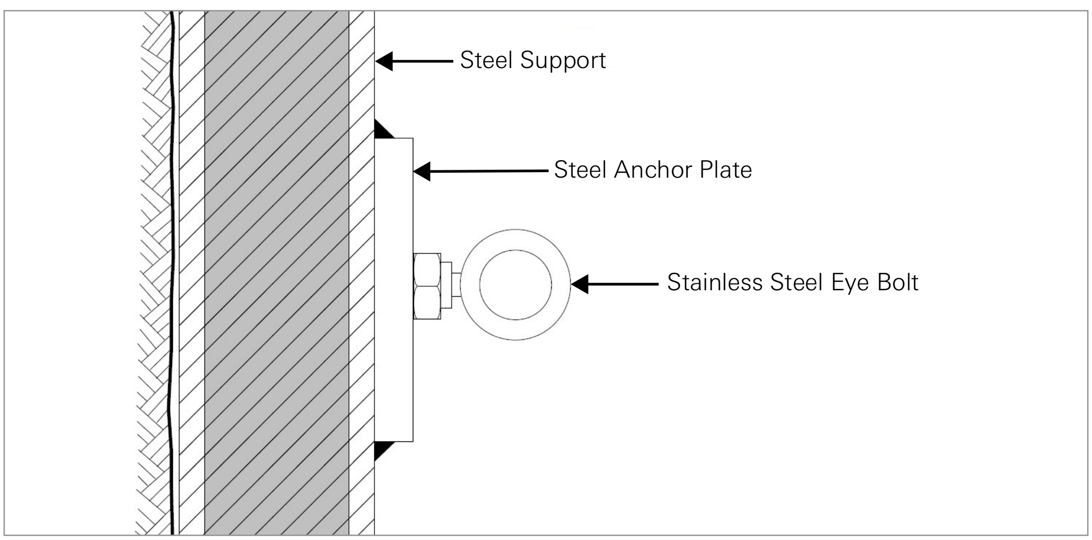

FIGURE 5: *Weldable Anchor*

3. TAKING READINGS

GEOKON recommends measurements be performed in a zero stability control area before starting a measurement survey to further confirm the accuracy of the tape extensometer. This verifies the instrument is in good working order and does not need servicing, while also maximizing accuracy through practice readings. Refer to Appendix B for the setup of a zero stability control area.

The most important reading in the field is the first reading; it is the base reading to which all subsequent readings will be compared. Measure at regular time intervals, preferably at the start of each measurement survey, to ensure that the self-length of the tape extensometer does not change with time. It is important that zero readings be accurate, so repeat the reading a number of times (five or more) until the accuracy of the recorded value is beyond doubt.

All survey readings should be compared with previous readings as soon as they are taken. In this way, sudden changes of readings can be instantly checked to see if they are real or a reading error. If the changes are real, the observer is alerted to the possibility of serious ground movements, or they may indicate the need for servicing and recalibrating the instrument (See Section 5.4).

Installation Video

For a visual demonstration of the procedure below, watch the [Model 1610 Installation Video.]

3.1 PRELIMINARY

Always make a careful note of the instrument and tape serial numbers when beginning a set of readings. Also note the ambient temperature at the measurement location. Do not assume that the temperature underground will remain constant.

There is no on/off switch for the tension indicator lights; the tension device operates automatically. Ensure that the battery holder contains a charged 9-volt battery before commencing and that the digital gauge is on. If the gauge is off, switch it on by moving the tensioning handle. The gauge will switch itself off after a period of inactivity.

Before commencing, make sure that the display reads 0.00 mm or 0.000”, when the tensioning handle is turned fully clockwise until it comes to a natural stop. **Do not force the tensioning handle.** If the reading on the digital gauge does not show 0.00 mm or 0.000”, depress the “zero” button located just below the display window. Periodically check the zero reading from time to time, especially at the start of each set of measurements.

Turn the tensioning handle counterclockwise until the sliding bars are fully extended, the gauge should read at least 55 mm or 2.200”.

If the display is not showing the correct unit (millimeters or inches), perform the following:

1. Remove the face plate and gasket by unthreading the six flathead screws.
2. Depress the “mm/inch” button on the digital gauge to switch between Metric and English units.

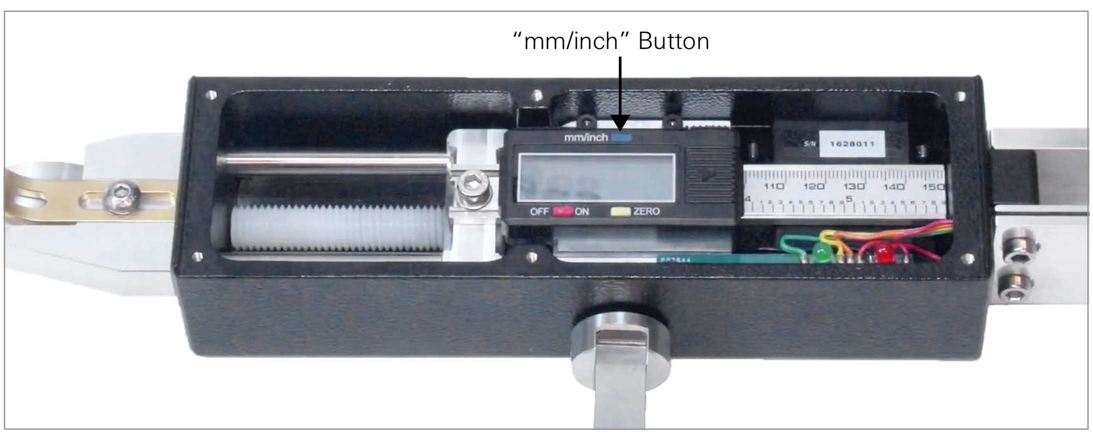

***FIGURE 6:** Face Plate and Gasket Removed*

3. Re-install the gasket and face plate.

3.2 TENSIONING THE TAPE

Correctly tensioning the tape requires a certain amount of skill. It is recommended that the operator practice the recommended technique using a zero stability control area (Appendix B) until it can be performed rapidly and consistently.

1. Hook the tape onto the first eye bolt, unwind the tape using the tape handle until the frame reaches the second eye bolt, hook the frame onto the second eye bolt.
2. Turn the tape handle clockwise to reel in the tape, removing as much slack as possible.
3. Place the nearest punched hole on the tape over the locating pin and secure in place by sliding the slotted clip all the way over the tape and pin.

FIGURE 7: *Engage Slotted Clip On Tape/Pin*

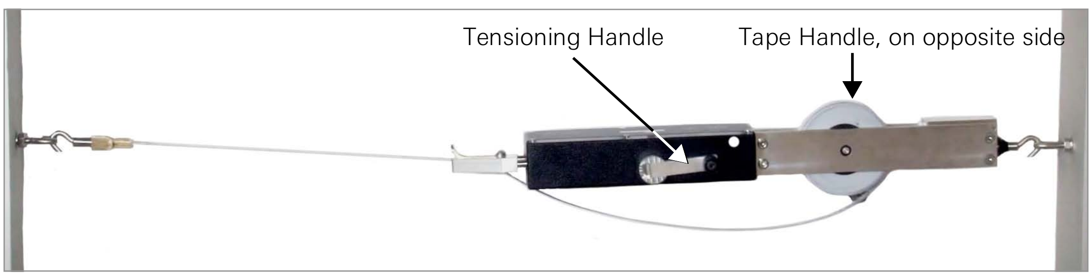

FIGURE 8: *Extensometer Ready to Tension*

4. Turn the tensioning handle clockwise until one or both of the indicator lights comes on. Turn the tensioning handle back a small amount until both lights go off.
5. Turn the tensioning handle clockwise, in small increments, until only the green light is on when the instrument is at rest, untouched by the operator.
6. Place a finger under the tape, as shown in Figure 9, and gently lift the tape so as to relieve a small amount of tension on the tape – the green light should go off. Gently removing the finger, with the tape at rest, should cause the green light to come on again.
   - If the red light comes on when the tape is at rest, the tape is over-tensioned. Turn the tensioning handle counterclockwise and return to Step 4. Alternatively, it may be that the finger pressure being applied to the tape is too great or being applied too roughly.

Note: The red light is set to illuminate between 0.2 to 0.3 mm after the green light. Over long distances (15 meters or more), tape flutter may cause the red light to come on too soon. If this is the case, return the instrument to the supplier for adjustment, specifying the conditions under which the instrument is required to operate.

- If the green light stays off when the tape is at rest, turn the tensioning handle clockwise a small amount until enough tension is being applied so that the green light goes on and off again with gentle placing and removing of the finger under the tape.

FIGURE 9: Tensioning Relief Test

3.3 TAKING THE READING

The total distance between the eye bolts is the sum of the length along the tape indicated by the punched hole location used in the tensioning process, plus the digital gauge reading, plus any correction that is required to account for temperature variations (Section 4).

Note: The tape measurement takes into account the length of the extensometer housing.

Once satisfied that the correct tape tension has been applied, note the length on the tape at the punched hole and also the reading on the digital gauge.

Note: It may be necessary to twist the instrument in order to read the gauge and this may cause the red or the green light to come on. However, the reading on the digital gauge will remain the same so long as the tensioning handle is not moved.

After the reading has been taken, turn the tensioning handle counterclockwise, until the sliding bars are fully retracted, then remove the locating pin from the tape. The instrument is now ready for the next reading. For better accuracy it is recommended that all readings be repeated a number of times and the average taken.

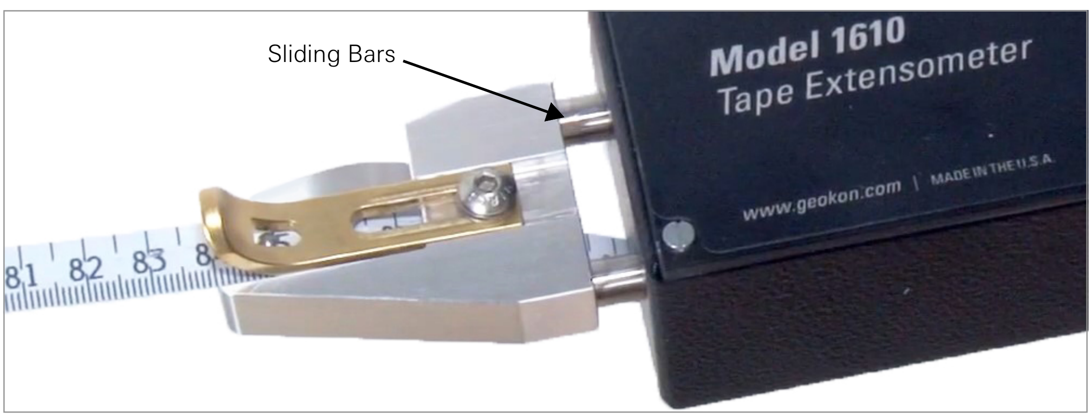

FIGURE 10: Remove Tension until Sliding Bars are Extended

The travel of the digital gauge is slightly larger than the pitch of the punched holes. As a result it may be possible to take readings on two adjacent punched holes. Continued movements may carry the readings beyond the range of the slide bars. Before that happens, take readings on both tape holes that are within range of the slide bars. For example, if the reading increases to a reading on the digital gauge higher than 52 mm or 2.050” switch to the next tape hole and take a second reading of around 1 mm or 0.039”, (or vice versa if the reading decreases to below 1 mm or 0.039”), then continue to use this new tape hole in subsequent readings.

4. TEMPERATURE CORRECTIONS

The effect of temperature on measurements along the tape are shown in Table 1 for distances from 3 to 16 meters and for temperature changes of up to 15 degrees Celsius. Displacement corrections shown are in millimeters. For increasing temperatures the corrections should be added and for decreasing temperatures the corrections should be subtracted.

Change in Temperature (Celsius)	Distance of the Tape Only, at the Pin Location (Meters)													
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
15	0.450	0.495	0.556	0.661	0.796	0.945	1.095	1.245	1.441	1.622	1.805	2.012	2.220	2.460
14	0.420	0.462	0.520	0.615	0.741	0.885	1.023	1.165	1.345	1.515	1.682	1.875	2.075	2.295
13	0.395	0.430	0.483	0.575	0.690	0.820	0.950	1.076	1.249	1.405	1.559	1.742	1.925	2.132
12	0.360	0.395	0.445	0.525	0.636	0.755	0.875	0.995	1.150	1.295	1.440	1.610	1.775	1.966
11	0.331	0.365	0.408	0.485	0.585	0.695	0.805	0.914	1.055	1.189	1.321	1.475	1.627	1.805
10	0.301	0.330	0.370	0.442	0.530	0.631	0.732	0.833	0.965	1.082	1.201	1.342	1.481	1.642
9	0.270	0.296	0.335	0.397	0.475	0.565	0.655	0.745	0.865	0.974	1.081	1.205	1.333	1.475
8	0.240	0.265	0.295	0.353	0.424	0.504	0.585	0.665	0.768	0.865	0.961	1.072	1.185	1.311
7	0.210	0.231	0.260	0.309	0.372	0.441	0.510	0.581	0.672	0.755	0.841	0.939	1.035	1.148
6	0.181	0.198	0.222	0.265	0.318	0.379	0.439	0.498	0.575	0.648	0.721	0.805	0.889	0.985
5	0.150	0.165	0.185	0.220	0.265	0.315	0.365	0.415	0.480	0.542	0.605	0.671	0.740	0.821
4	0.120	0.133	0.148	0.175	0.212	0.252	0.292	0.330	0.385	0.432	0.480	0.535	0.592	0.655
3	0.090	0.100	0.111	0.132	0.160	0.189	0.219	0.250	0.288	0.325	0.360	0.405	0.445	0.491
2	0.060	0.065	0.075	0.088	0.105	0.125	0.145	0.165	0.193	0.215	0.240	0.251	0.295	0.325
1	0.030	0.033	0.037	0.045	0.055	0.064	0.073	0.083	0.095	0.109	0.119	0.128	0.148	0.164

TABLE 1: *Temperature Displacement Corrections in Millimeters*

For measurements or temperature changes beyond what is shown in Table 1, a temperature correction equation can be used to find the displacement correction. The equation is as follows:

$$\text{Correction} = [0.0074 + 0.00028(D - 6)] \times D \times (T_1 - T_0)$$

EQUATION 1: *Temperature Correction*

Where:

D = Distance of the tape only, at the pin location (in meters)

T = Temperature (in Celsius)

4.1 TEMPERATURE CORRECTION EXAMPLE

An extensometer in an ambient temperature of 20 °C (T_0) measures with the tape pin hole located at 10.45 meters while the reading on the digital gauge is 32.34 mm (0.03234 meters). Added together, this is the initial reading (R_0): $10.45 + 0.03234 = 10.48234$

A subsequent reading (R_1) taken at a temperature of 0 °C (T_1) measures with a total sum of 10.49654 meters. So the apparent displacement is $R_1 - R_0$ = 0.01420 meters or = +14.20 mm.

Use Table 1 to find the displacement correction (if applicable), or use the temperature correction equation as follows:

$$\text{Correction} = [0.0074 + 0.00028(D - 6)] \times D \times (T_1 - T_0)$$

$$\text{Correction} = [0.0074 + 0.00028(10.45 - 6)] \times 10.45 \times (0 - 20)$$

$$\text{Correction} = -1.807\ \text{mm}$$

So the true displacement is:

$$\Delta D_{true} = \text{apparent displacement} + \text{displacement correction}$$

$$\Delta D_{true} = 14.20 + (-1.807)$$

$$\Delta D_{true} = 12.39\ \text{mm}$$

5. MAINTENANCE

5.1 CARE OF THE TAPE / CHANGING TAPES

The ease of which the tape can be wound on the spool is controlled by the adjustment screw underneath the tape handle. If the tension on the handle is too tight or loose, minor adjustments can be made using a hex wrench.

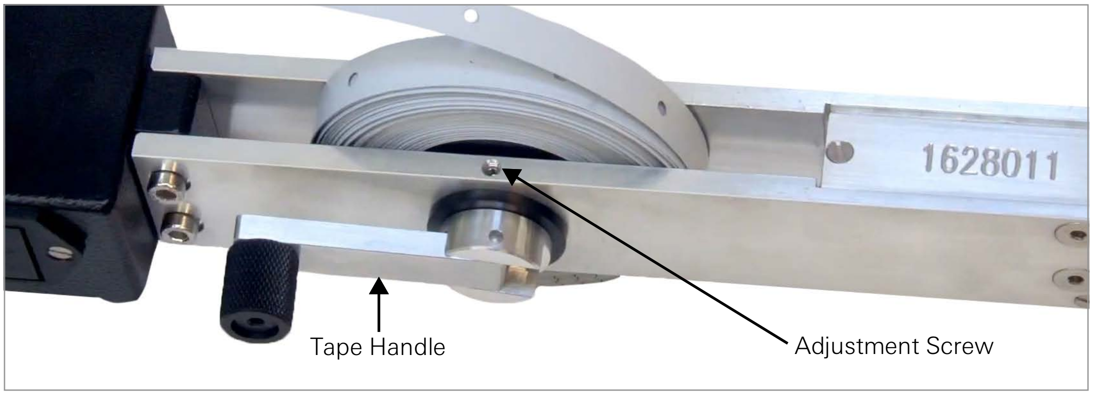

FIGURE 11: *Adjusting the Tape Handle*

Care should be taken to keep the tape clean. The tape should be treated with the same care as any precision surveying tape. The greatest danger is kinking the tape. **Do not drag the tape along the ground.** Extreme care should be taken to prevent traffic from damaging the tape while in use. When reeling in the tape pass it through an oily rag to remove dirt and moisture and apply a thin film of oil. Broken tapes can be replaced easily, new tapes are available for purchase through GEOKON.

Note: Consider applying a couple of bright orange sticky notes at mid-span while measuring to increase visibility and reduce the potential for accidental traffic damage.

To replace an old tape:

1. Grip the tape spool and turn the tape handle counterclockwise until the tape spool comes loose.
2. Remove and replace the tape spool, positioning the new tape so the eye bolt is towards the backside of the unit and facing extensometer housing.

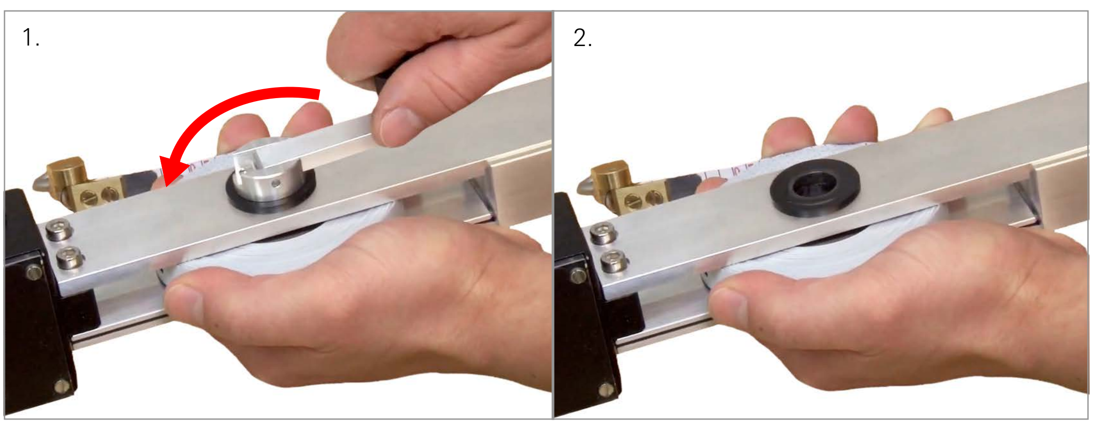

FIGURE 12: *Replace the Tape Spool*

3. Re-install the tape handle to secure the tape spool in place.

Important! New baseline readings should be taken when replacing a tape, as there may be minor differences between tapes.

5.2 CARE OF THE INSTRUMENT

The instruments working life will be extended if care is taken to keep the instrument clean. Whenever the instrument has been exposed to dirt or moisture clean it with a soft cloth at the end of the day, paying particular attention to the sliding bars

Store the instrument with the sliding bars retracted so that the gauge reads between three and five millimeters.

5.3 CARE OF THE BATTERIES

5.3.1 THE 9-VOLT BATTERY

The 9-Volt battery powers the indicator lights. It can be removed if the instrument is to be stored for any length of time. The 9-Volt battery holder is located on the rear face of the casing. The 9-Volt battery should be replaced at least once every year or sooner if the indicator lights start to fade. Failure to replace the battery after it has gone flat will prevent the tape tension lights from coming on which may lead to tape damage if the tape is over-tensioned.

FIGURE 13: *9-Volt Battery Location*

5.3.2 THE DIGITAL GAUGE BATTERY

A coin type battery, Model LR44, powers the digital gauge. In order to preserve the life of the battery it automatically switches itself off after about five minutes of idleness. Note that if the battery switches itself off between readings the zero setting will not be lost when the battery switches itself back on. A low battery indication is given when the display begins to flash on and off.

To change the battery:

1. Remove the face plate and gasket by unthreading the six flathead screws.
2. Slide open the battery cover on the gauge and replace the battery.

Note: Removing the battery will cause the gauge to automatically reset to millimeters. If this happens with an English unit, depress the “mm/inch” button on the digital gauge.

FIGURE 14: *Face Plate and Gasket Removed, Digital Gauge Battery Location Shown*

3. Re-install the gasket and face plate.

5.4 SERVICING THE INSTRUMENT

It is recommended that the instrument be returned to the supplier at least once per year, for service and calibration. The instrument may be returned for a calibration check and the issue of a new calibration certificate at any time.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 1610 SPECIFICATIONS

Available Ranges[1]	Metric: 20 m, 30 m, 50 m English: 66 ft, 100 ft
System Accuracy[2]	±0.1 mm (±0.004")
Repeatability[3]	±0.1 mm (±0.004")
Tension on the Tape	10 kg (22 lbs)
Overall Length	520 mm (20.5")
Operating Temperature	-0 to +50 °C
Case Dimensions	500 × 350 × 125 mm (20 × 14 × 5")
Weight (with Case)	2 kg (4.4 lbs)
Indicator and Digital Gauge Battery	9-volt, Coin Type LR44

TABLE 2: *Model 1610 Tape Extensometer Specifications*

Note:

[1] Other ranges available.

[2] Accuracy of the digital gauge equal to the resolution (±1 graduation) = 0.01 mm

[3] Repeatability is the system accuracy to be expected under normal conditions and takes into account trained operator error, friction in the system, temperature variations and placement errors. The repeatability is affected by the environmental conditions under which the readings are taken and may be significantly worse than as shown.

A.2 PARTS LIST

1610-3-66	Spare steel tape with punched holes, 66 ft
1610-3-100	Spare steel tape with punched holes, 100 ft
1610-4-20	Spare steel tape with punched holes, 20 m
1610-4-30	Spare steel tape with punched holes, 30 m
1610-4-50	Spare steel tape with punched holes, 50 m
1610-9	Zero stability frame
1610-10	Hook manipulator starter kit, 1.8 m (5.9 ft) long. Allows for an average size person to reach the soffit of a 4 m (13 ft) diameter tunnel
1610-11	Additional 1.8 m (5.9 ft) long extension rod for Model 1610-10 Hook Manipulator
1610-12	Groutable anchor, #3 rebar, 76 mm (3") long, with eye bolt
1610-13	Rawl drop-in anchor, 6.4 mm (1/4") diameter, with eye bolt. Requires a Model TLS-208 Setting Tool
1610-14	Weldable/Epoxy anchor, with eye bolt
4425-6-1	Spare eye bolt
TLS-208	Setting tool for Model 1610-13 Rawl Drop-In Anchor

TABLE 3: *Model 1610 Parts List*

APPENDIX B. ZERO STABILITY CONTROL

To set up a zero stability control area, two eye bolts must be mounted on a stable structure whose dimensions do not change. This can be between two walls of a stable underground opening or between opposite sides of a steel framework (such as the GEOKON Model 1610-9 Zero Stability Frame) kept in a stable temperature environment. It is good practice to install the zero stability control area outside of the monitoring survey location, where it will not be affected by movements.

It is important that the test point eye bolts are stable, that is, firmly fixed and immovable. Eye bolts attached to objects, which can move even slightly, will make it impossible to record consistent readings.

Use these test points at regular time intervals, preferably just before each measurement survey, to ensure that the self-length of the tape extensometer does not change with time and also to practice technique and consistency. It is important that zero readings be accurate, so repeat the reading a number of times (five or more) until the accuracy of the recorded value is beyond doubt.

Any gradual or sudden change in the zero reading will indicate the need for servicing and recalibrating the instrument.

APPENDIX C. THE USE OF THE HOOK MANIPULATOR

The Model 1610-10 Hook Manipulator Starter Kit is a simple, portable, and effective system that allows a person of average height to reach the roof of a 4 m (13 ft) tunnel. Extension rods are available for higher locations.

FIGURE 15: *Hook Manipulator in Use*

To reach an overhead eye bolt complete the following steps:

1. Fit the tape extensometer hook through the hole in the end of the hook manipulator. Secure in place with the set screw using the provided Allen wrench.
2. With the magnet engaged on the end of the hook manipulator, raise the tape and hook it onto the eye bolt.
3. Pull the hook manipulator away to disengage the magnet.
4. After taking readings, re-engage the hook manipulator to the magnet and remove the tape extensometer from the eye bolt.

FIGURE 16: *Hook Manipulator to Tape Extensometer Connection*

APPENDIX D. TYPICAL VERIFICATION CERTIFICATE

TRUSTED MEASUREMENTS™

VERIFICATION CERTIFICATE

GEOKON/EALEY TAPE EXTENSOMETER
MODEL 1610

SERIAL NO:	2429930
SELF LENGTH:	500 mm
MASTER TAPE S/N (LENGTH):	1440051 (20 m)
TENSION:	10 kg
DATE:	07/15/24
ZERO READING:**	45.21 mm
TECHNICIAN NAME:	
SIGNATURE:	______________________

** Zero reading on test point: A. For factory use only.

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FIGURE 17: *Typical Verification Certificate*