V1.1 November 2018

GEO-XB2™
BOREHOLE ROD EXTENSOMETERS
SINGLE & MULTI-POINT

INSTRUCTION MANUAL

CE

GEOSENSE

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1.0 INTRODUCTION

This manual is intended for all users of the **GEO-XB2™** range of rod extensometers and provides information on their installation, operation and maintenance**.**

It is VITAL that personnel responsible for the installation and use of a GEO-XB rod extensometers, READS and UNDERSTANDS this manual, prior to working with the equipment.

1.1 General Description

The **GEO-XB2™** rod type extensometer range is used to measure and locate settlement, displacement and deformation in most mediums, including soil, rock and concrete.

An extensometer consists of one or more in-hole anchors, each of which is placed at a known distance along a borehole, connected to a reference head by either rigid or flexible rods running inside sleeves to keep the rods de-bonded from the grout.

As the soil, rock or concrete deforms, the distances between the in-hole anchor change, as do the distances between the individual anchors and the reference head. The movement of the anchor is reflected at the reference head by the de-bonded rods. The magnitude, distribution and rate of deformation can be accurately measured at the reference head by comparing the relative positions of the rods and the head.

The **GEO-XB2™** rod type extensometer range is available in a range oc combinations of reference heads, anchors, rods and measuring sensors.

A **GEO-XB2™** rod type extensometer comprises of the following components:-

A - REFERENCE HEAD (SINGLE OR MULTI-POINT)

The reference head comprises of the following components:-

- Protective cap
- Top flange
- Guide tubes
- Bottom flange

They are available in two options as follows:-

- Manual - readings taken manually by depth gauge or similar
- Automatic - displacement sensors which can be read automatically

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1.1 General Description contd..

MEASUREMENT SYSTEMS
Measurement of the changes in relative position between the anchor and the reference head can be achieved using the following options:-

Manual
Readings are carried out using a mechanical digital depth gauge.

Electrical
Reading is carried out using an electrical sensor fixed into the reference head.

B - SENSORS
The following sensor types are available:-

- Vibrating wire displacement gauge

- Linear Potentiometer

1.1 General Description contd..

C - RODS

Rods are used to connect the anchors to the reference head and are available in rigid or flexible forms.

Rigid
Made from stainless steel and come in short lengths of 1,2 or 3 metres, with flush threaded joints.

A short starter rod is connected to the anchor and an adjustable section at the head end.

Flexible
Glass & carbon fibre rods in a continuous length, factory cut to meet specific project requirements.

Rigid steel rods showing threaded connectors

D - SLEEVES

Sleeves allow the rods to move freely by preventing bonding of the rod to grout or concrete.

Flexible
Made from flexible nylon and available in either short lengths with external couplers for use with rigid rods, or in continuous lengths for use with flexible rods.

Flexible rod and sleeve fitted with groutable anchors.

1.1 General Description contd..

E - ANCHORS
The anchors connect the rods to the surrounding material (soil / rock / concrete) and are available in the following types:-

- Groutable
- Hydraulic standard
- Hydraulic Borros (Single or Double acting)
- Snap ring
- Packer type

Groutable type

Packer anchor type

Single Acting Borros type

Snap ring* type

* Anchors can be designed and built to suit particular project requirements

1.2 How it works

Anchor movements are detected by measuring changes in the relative positions of the exposed rod ends in the reference head with respect to the head itself. This can be done by either manually using a digital depth gauge, or electronically using Vibrating Wire or Potentiometric type displacement transducers.

1.3 Applications

The **GEO-XB2** range rod extensometers are typically used for (but not limited to) the measurement of: -

- Deformation of dam abutments & foundations
- Ground movement around tunnels & mines
- Ground movement behind retaining walls & sheet piles
- Ground movement within open cast mines
- Deformation of mine pillars
- Fracturing in roofs of underground caverns
- Deformation of concrete piles
- Settlement & heave in soft soil excavations

Typically the following **preferred** installation configurations are adopted:-

MEDIUM	**Orientation**	**Anchor**
Rock & firm soils (Easily grouted)	Vertically downwards	Groutable
Softer Soils	Vertically downwards	Borros
Rock (Fractured)	Any angle	Hydraulic Packer
Poor quality concrete	Any angle	Hydraulic Groutable
Hard competent rock and good concrete	Vertically upwards	Hydraulic Groutable
(very smooth bore***)**	Any angle	Snap ring

* ± 1 mm accuracy of bore required

2.0 CONFORMITY

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Declaration of Conformity

We Geosense Ltd at above address declare under our sole responsibility that the product detailed below to which this declaration relates complies with protection requirements of the following harmonized EU Directives,

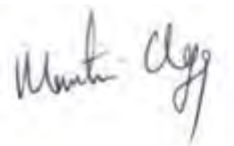
The Electromagnetic Compatibility Directive 2004/108/EC
Restriction on the use of certain Hazardous Substances RoHS2 2011/65/EU

Equipment description	**GEO-XB2™ Single & multi-point borehole rod extensometers**
Make/Brand	**Geosense**
Model Numbers	GXB2-M-F, GXB-VW-F

Compliance has been assessed with reference to the following harmonised standard:

EN 61326-1:2006 Electrical equipment for measurement, control and laboratory use.
EMC requirements. General requirements.
.

A technical file for this equipment is retained at the above address



Martin Clegg
Director

Bury St Edmunds

August 2016

3.0 MARKINGS

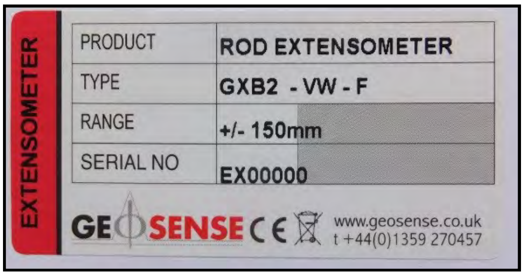
Geosense **GEO-XB2™ borehole rod extensometers** are labelled with the following information:-

Manufacturers name & address

Product type

Model

CE mark



Reference head

In addition, when electrical sensors are used, the individual displacement gauges are labelled with their own individual markings & serial numbers.

4.0 DELIVERY

4.1 Packaging

GEO-XB2™ borehole rod extensometers are factory packed for transportation to site. Packaging is suitably robust to allow normal handling by transportation companies. However, inappropriate handling techniques may cause damage to the packaging and the enclosed equipment. The packaging should be carefully inspected upon delivery and any damage MUST be reported to both the transportation company and Geosense.

4.2 Handling

Whilst they are a robust devices, **GEO-XB2™ borehole rod extensometers** are precision measuring devices. They and their associated equipment should always be handled with care during transportation, storage and installation.

Once the shipment has been checked (see below), it is recommended that **GEO-XB2™ borehole rod extensometers** remain in their original packaging for storage or transportation.

Cable should be handled with care. Do not allow it to be damaged by sharp edges, rocks for example, and do not exert force on the cable as this my damage the internal conductors and render the instrument un-useable.

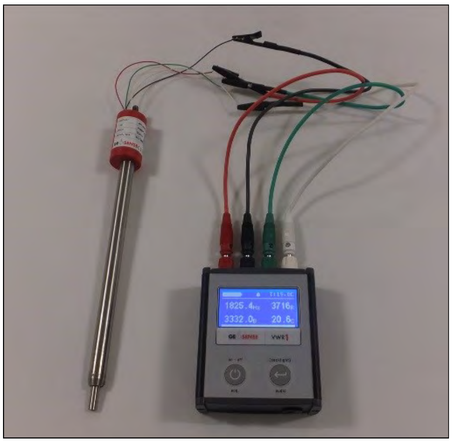
4.0 DELIVERY contd..

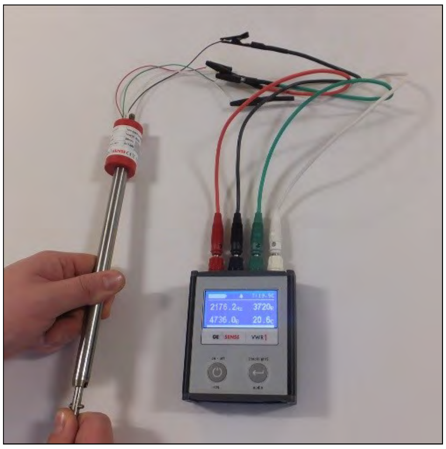
4.3 Inspection & functionality

It is vital to check all the equipment in the shipment as soon as possible after taking delivery and well before installation is to be carried out. Check that all the components that are detailed on the documents are included in the shipment. Check that the equipment has not been physically damaged.

The VW displacement gauges are supplied separately and a function check should be carried out by connecting the readout cable to the readout as in the pictures below. (Other sensors should be checked using appropriate readouts).

Prior to carrying out the function checks, ensure that the displacement transducers have been stored in a reasonably stable temperature for at least 2 hours. Connect the wires from each transducer to the corresponding connectors on the readout. Switch on the readout (see readout instructions) and, where possible, select the audio function on the readout to listen to the 'ring' of the gauge.





Carefully pull out the transducer connector from the cylinder a little way (see above) taking care not to twist it, and observe the reading change on the readout. The 'ring' from the transducer will also change its sound which should be clear and un-distorted. Check that the readings correspond to the calibration certificate (see page 51). If the values differ about 40 digits please contact Geosense.

4.4 Storage

All equipment should be stored in an environment that is protected from direct sunlight.

It recommended that cables be stored in a dry environment to prevent moisture migrating along the cable in the unlikely event of prolonged submersion of exposed conductors. Storage areas should be free from rodents as they have been known to damage cables.

No other special requirements are needed for medium or long-term storage although temperature limits should be considered when storing or transporting associated components, such as readout equipment.

5.0 INSTALLATION

The following sections describe typical installations for Geosense **GEO-XB2™ borehole rod extensometers** but individual projects will vary in their requirements.

It is VITAL that personnel responsible for the installation and use of the system READ and UNDERSTAND the manual, prior to working with the equipment.

****

As stated before, it is vital to check all the equipment in the shipment soon after taking delivery and well before installation is to be carried out. Check that all components that are detailed on the shipping documents are included.

5.1 Overview

Flexible rods & sleeves are pre-assembled so no on-site assembly is required, prior to installation.

Rigid rod systems require assembly on site.

Where space allows, pre-assemble the extensometer rods & sleeves on the surface and attached the grout tube so as to fabricate the full length of the assembly. When lifting the assembly, take care to avoid it bending to a radius less than 3 metres. For vertical downward installations try to maintain a large radius when lowering the assembly into the borehole (if possible lift the assembly over a site vehicle, for example).

Where space is limited, the rod extensometer will have to be assembled as it is installed into the borehole. When installing into a hole with drill casing, careful organisation and sequencing is required because each anchor, rod & sleeve may need to be installed independently, starting with the deepest anchor. A safety chord should be attached to the anchors to prevent loss and to support the rod / anchor assembly during casing removal. This process may take some time, so sufficient time should be allowed in the drilling and installation programme.

5.1.1 Grout mix

Rod extensometers require to be grouted and this can be done prior or after installation depending on the site conditions/restriction.

Grout would normally be mixed in a purpose designed grout mixer so as to ensure a complete mix. However, grout can also be mixed in a large container using a high volume pump for circulating, mixing and placing the liquid.

The grout specification should be provided by the Site/Design engineer and designed to mimic the surrounding soil conditions. However as extensometer installations may have a combination of soil types it is recommended to err on the softer side of the spectrum.

5.0 INSTALLATION contd...

5.1.1 Grouting mix contd..

Grout strength decreases with water-cement ratio and controlling this ratio is the most important factor for grouting and it is therefore recommended that the water and cement is mixed first. Water and cement ratios greater than 0.7 - 1.0 by weight will segregate without the addition of Bentonite or other filler to keep the cement in suspension and it is recommended that Bentonite normally be used as it is readily available.

The tables below provide guidelines for typical mixes that may be adopted for varying soil types but are only a guideline and the installer should request the project specification from the Engineer.

	HARD SOILS		MEDIUM SOILS		SOFT SOILS	
Materials	Unit	Weight ratio	Unit	Weight ratio	Unit	Weight ratio
Cement (OPC)	50Kg	1	50 Kg	1	50 Kg	1
Bentonite	15 Kg	0.3	15 Kg	0.3	20 Kg	0.4
Water	125 Lit	2.5	225 Lit	4.5	325 Lit	6.5

Other compounds can be added to the grout mixture to alter its characteristics but should always be specified by the Design Engineer:-

- Expanding agents are added to introduce small bubbles into a cement and water mix as it cures to prevent it from shrinking. This helps to ensure a good bond between the grout and both the anchors and the borehole walls.
- Plasticisers can be added to a mixture to allow it to flow more freely through small bore pipe work, typically associated with this type of installation.
- Fillers are added to provide weight and / or bulk to the mixture for use where grout may have a tendency to flow through the borehole walls.

GEO-XB2™ Packer Anchors - it is recommended to use the following mix:-

25 Kg Cement (OPC)

20 litres Water

Multi-point **GEO-XB2™ borehole rod extensometer reference heads** have cut-outs on the reference head top flange which allows for grouting tubes & bleed tubes to be used.

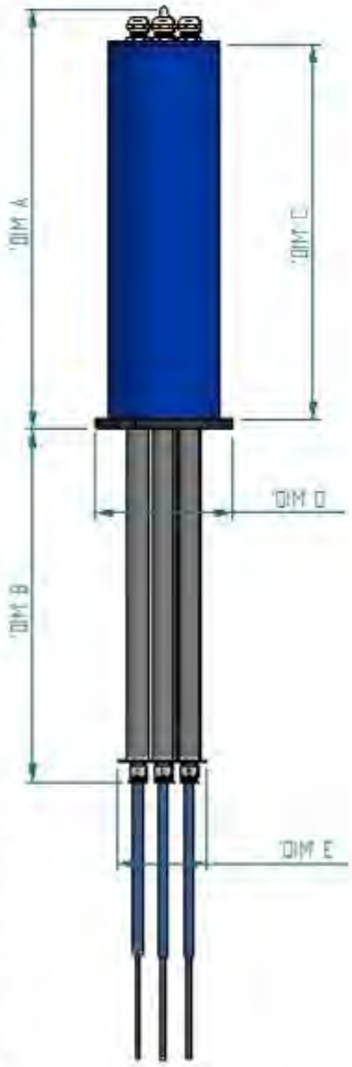
5.0 INSTALLATION contd...

5.1.2 Borehole requirements

Before installing the GEO-XB2™ borehole rod extensometers it is important to ensure all considerations are taken for the borehole diameter (cased versus uncased), depth below ground level for protective cover or recess depth for the reference head cap. The table below shows the dimensions for all types and ranges

EXTENSOMETER SYSTEM LENGTHS

Extensometer Lengths		
Gauge Length (mm)	'DIM'	Length (mm)
12.5, 25, 50, 75, 100	A	445
	B	358
	C	400
	D	140
	E	97
150	A	539
	B	486
	C	494
	D	140
	E	97
200	A	637
	B	615
	C	594
	D	140
	E	97
300	A	839
	B	873
	C	794
	D	140
	E	97
500	A	1239
	B	1375
	C	1384
	D	140
	E	97
MANUAL 100	A	145
	B	358
	C	100
	D	140
	E	97
MANUAL 150	A	145
	B	486
	C	100
	D	140
	E	97
SINGLE POINT HEAD	D	75
	E	N/A



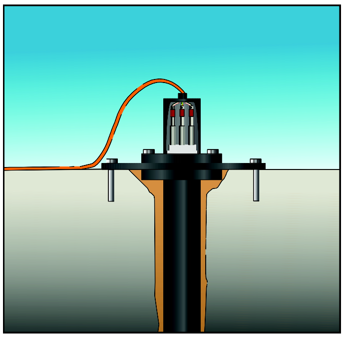
Boreholes should be drilled approximately 1 metre deeper than the deepest anchor.

5.1.3 Anchor spacing

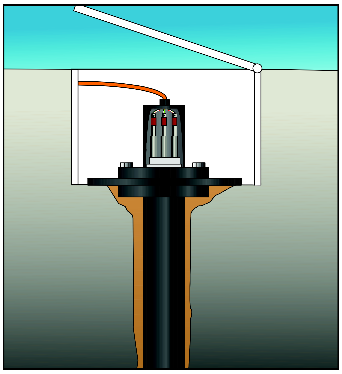
The anchor spacing should be determined from the requirements of the Engineer and the deepest anchor should be located in stable ground so that it can serve as a non-moving point of reference for all of the other anchors. Where installation is within tunnels the deepest anchor should be installed at least one tunnel diameter or preferably two tunnel diameters from the tunnel wall.

5.0 INSTALLATION contd...

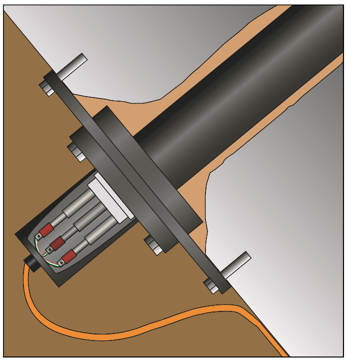
5.1.4 Reference head protection - reference heads can be protected by various methods and some are illustrated below.



A - Surface mounted, flanged reference head externally mounted with protective cap.



B - Flanged reference head mounted below surface with protective cap.



C - Flanged reference head, semi or fully recessed, installed into upward borehole, with protective cap.

THE REFERENCE HEAD MUST ALWAYS BE PROTECTED FROM DAMAGE

5.0 INSTALLATION contd...

5.1.5 Installation tools

The following tools (available from Geosense) are recommended* for the installation of **GEO-XB2™ borehole rod extensometers.**

Qty	Description
1 set	Screw drivers
2	Medium size 'vice grips'
1 set	Allen keys
1	Small hacksaw
1	Tape measure
1	Marker pen
1	250ml PVC solvent cement
1	250ml PVC cleaner
1	50ml metal adhesive
1	Sharp knife
1 set	Grout tube & fittings
1 set	Hydraulic inflation tubes
1	Hydraulic pump
1	Hydraulic pump hose
As required	Hydraulic oil
As required	Anchor support chord

5.2 Flexible rod and sleeve

Flexible rods are factory pre-assembled with flexible sleeves, rods and anchors and therefore no on-site assembly is required. They can simply be lowered down the borehole to the required depth.

MAKE SURE THE RODS HAVE UNIQUE REFERENCES FOR ANCHOR DEPTHS

All assemblies come with each anchor and corresponding reference labelled. Make a note of these numbers especially where automatic displacement sensors are used.

Flexible **GEO-XB2** Rod Extensometer fitted with groutable anchors

Flexible **GEO-XB2** Rod Extensometer fitted with Borros hydraulic anchors

5.0 INSTALLATION contd...

5.3 Groutable anchors

A temporary length of studding is fitted to each rod to prevent the rod from moving during transport and to avoid the sensor from overhanging.

Installation should be carried with the studding still in-place

DO NOT REMOVE THE STUDDING BEFORE INSTALLING

With the top cap removed uncoil the assembly and gently lower into drill hole, taping together as required.

NOTE

The assembly is delivered with each anchor, tube and reference point marked but these should be noted.

Number 1 will always be the longest/deepest and will connect through the cable gland that is numbered 1.

Cable 2 should be the second longest and will connect through the cable gland that is numbered 2 etc.

Lower to the full depth and support the reference head at the correct position if necessary

5.0 INSTALLATION contd...

5.4 Hydraulic Borros type anchor

Hydraulic Borros anchors require the prongs to be extended once installed by means of a hydraulic pump and tubing.

For a flexible system the anchors & inflation tube will already be attached to the flexible rods & sleeves.

For a rigid rod system the anchor & inflation tube will be supplied already connected but will need to attached to the rods & sleeves as they are installed.

All Geosense hydraulic Borros anchors and tubing are factory filled and de-aired and care must be taken not to let any oil leak from the tubing during the inflation process.

ACTIVATE THE DEEPEST BORROS ANCHOR FIRST

To activate Borros anchors after installing in the borehole follow the steps below:-

Remove end cap from top of inflation tube

Fit nut and olive onto inflation & metal insert into tube end

DO NO NOT ALLOW OIL TO LEAK FROM TUBING

5.0 INSTALLATION contd...

5.4 Hydraulic Borros type anchor contd...

Screw the nut & olive on the end of the inflation tube onto the fitting on the needle valve on the end of the hydraulic pump hose and fully tighten.

DO NOT ALLOW THE OIL TO LEAK OUT OF THE INFLATION TUBE

IF OIL HAS LEAKED FROM THE TUBE, RE-FILL TUBE USING A PUMP UNTIL NO AIR CAN BE SEEN COMING OUT

Set pump vent to open by opening the filler cap

Pump oil into the inflation tube and monitor the pressure as you pump.

Top up the reservoir as required.

DO NOT LET THE OIL LEVEL IN RESERVOIR RUN LOW AS THIS WILL ALLOW AIR TO ENTER SYSTEM

5.0 INSTALLATION contd...

5.4 Hydraulic Borros type anchor contd...

NOTE - The prongs on the Borros anchor are extended by an internal piston and will start to move at approximately 15 bar.

As the prongs continue to extend the pressure will build up to approximately 60-80 bar.

So as to ensure maximum penetration into the surrounding soil, increase the pressure up to 150 bar but do not exceed this pressure.

DO NOT EXCEED 150 BAR

Release the pressure by turning the release valve on the pump.

Close the needle valve.

Unscrew the nut on the inflation tube and remove the nut & olive.

Re-fit the end cap onto end of inflation tube.

THE INSTALLATION OF THE ANCHOR IS NOW COMPLETE

However, it is strongly recommended that the borehole be filled with a cementitious grout to support both the rods and the anchors.

5.0 INSTALLATION contd...

5.5 Packer anchor

Packer anchors may or may not be part of a complete assembly. The following instructions are for when they are NOT part of the complete assembly

Connect the rod into adaptor on packer anchor and push a length of outer sleeve into the "One touch" fitting.

Check to see if firmly secured by trying to pull out tube

Push the Grout tube into the "One touch" fitting.

Check to see if firmly secured by trying to pull out tube

If possible connect all the anchors together ready to place into the borehole

5.0 INSTALLATION contd...

5.5 Packer anchor contd

The assembly can be lowered into a borehole

FOR A VERTICAL BOREHOLE REMEMBER TO SECURE THE SAFETY WIRES

The assembly can be pushed into a horizontal or inclined borehole

5.2.4 Installing VW displacement gauges

Once the grout has set unscrew the temporary studding in an anticlockwise direction and remove from cable gland.

Repeat for all remaining temporary studs.

5.0 INSTALLATION contd...

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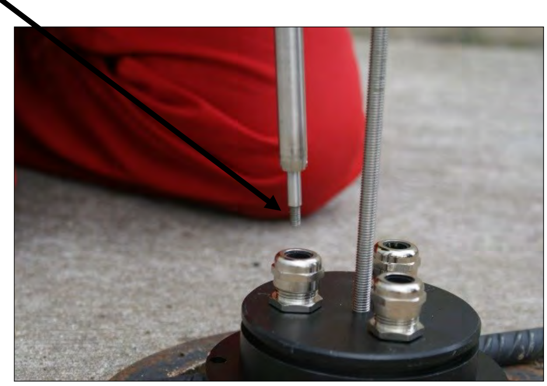
5.6 Installing VW displacement gauges

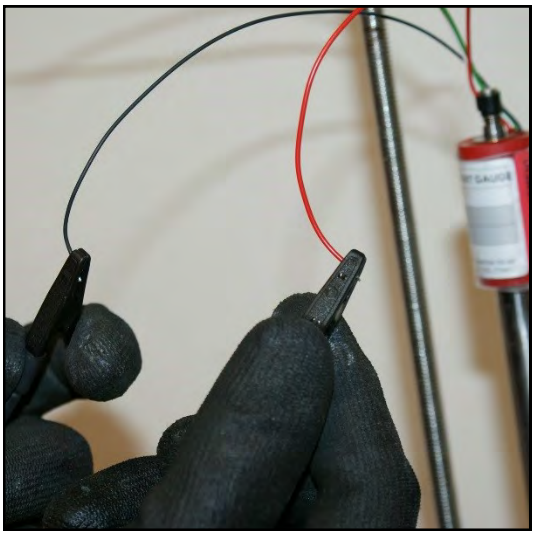
Loosen the top of the cable glands (you should be able to do this by hand) to allow room for gauges to be inserted.

Ensure the threaded adaptor is present at base of the extensometer before inserting into cable gland



Insert the displacement gauge through cable gland, and press down gently until you feel it locate into the centraliser. This will connect the sensor to the rod. Turn clockwise to lock.

Repeat this for each gauge.



Check the displacement gauge by connecting the readout to VW and thermistor cables as follows:-

Red	VW+
Black:	VW-
Green	Temp +
White:	Temp-

5.0 INSTALLATION contd...

5.6 Installing VW displacement gauges contd...

Connect cables to readout and check the connection by looking at the readout data.

Note: The temperature only needs to be read once when installing multiple extensometers in one unit.

Pull gauge up to tension and adjust until you reach the frequency required to start with.

A midrange point is advised if unsure e.g. if your gauge length is 100mm, pull the sensor to a displacement of 50mm (approx. 5000Hz).

Repeat this action for all gauges.

SETTLEMENT VERSUS HEAVE

If you are expecting **settlement**: You do not need to pull the gauge out in tension, as there should be no forces pushing against it (which could cause damage).

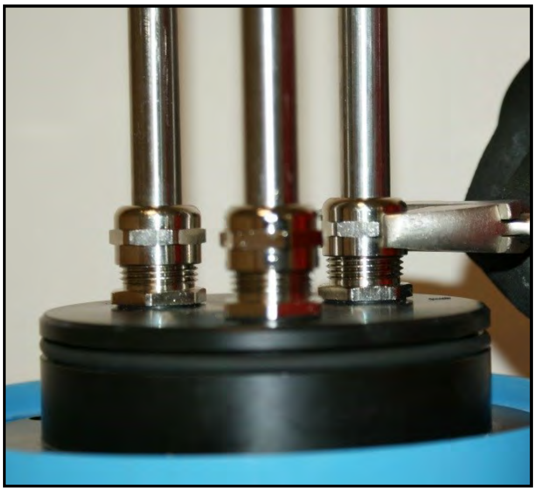
If you are expecting **heave**: You can pull the gauge out in more tension, so that it can compress. There should be no forces pulling it 9which could cause damage).

If you are **not sure**: Pull the displacement gauge out by 50mm. This will allow for 50m of movement in either direction.

5.0 INSTALLATION contd...

5.6 Installing the displacement gauges contd...

Once all readings are deemed accurate and all gauges have been locked, tighten gauge by adjusting the locking screw.



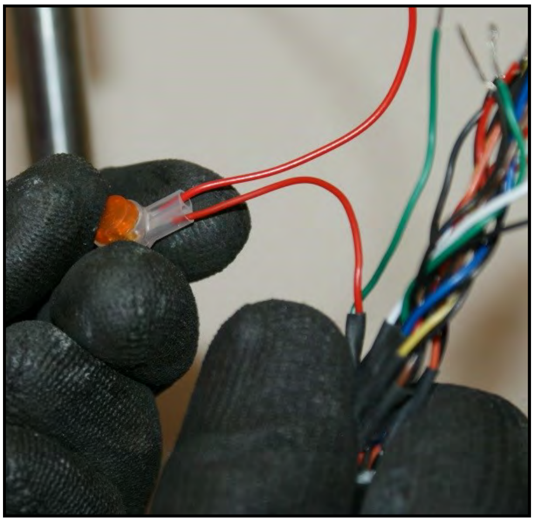
Thread the multicore cable through port in the top cap and through the top body. Pull enough cable through to allow secure

Note down the corresponding gauges and conductor colours so that you can assess the readings correctly

Using the connectors provided connect the 2 x VW cables and 2 x thermistor cables to the relevant conductors in the multicore cable.

Repeat this for all gauges, noting anchor number against the colour coding.

SEE APPENDIX FOR WIRING CONNECTION COLOUR CODING



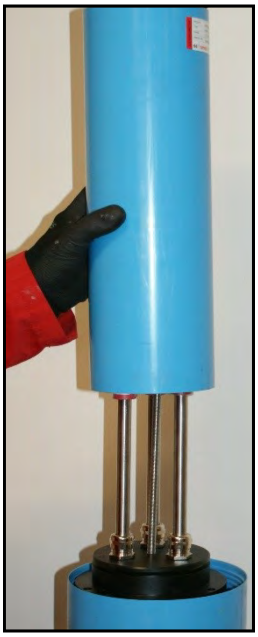
5.0 INSTALLATION contd...

5.6 Installing the displacement gauges contd...

Secure the multicore cable by tightening the cable gland on the top cap.

Once all sensors are connected to the multicore carefully slide the top cap over the sensors, making sure no wires are pulled or damaged.

Push the cap firmly down onto the O-ring seal



Thread any excess cable through the top lid, and then push it firmly into the top of the cap.

5.0 INSTALLATION contd...

5.6 Installing the displacement gauges contd...

Lock the top cap in position using the eye bolt.

5.0 INSTALLATION contd...

5.6.1 Installing the displacement gauges for use with WI-SOS 480 wireless Nodes

When connecting to vibrating wire Wi-SOS 480 nodes the VW and thermistor wires are pre-fitted and potted to the cable.

Each gauge requires one cable to connect to the node.

Installation is exactly the same as for standard gauges .

Once all gauges are located into the centraliser, and corresponding cable gland numbers have been noted; check sensor and cable function with an initial reading

Tension each gauge and lock into place with a locking nut.

Repeat for all gauges

5.0 INSTALLATION contd...

5.6.1 Installing the displacement gauges for use with WI-SOS 480 wireless Nodes contd...

Feed all the displacement gauge cables through the top cap

With all the cables pulled through, slide the top cap over the sensors and push firmly down onto the O-ring.

Once the cap is in place, insert the cable ends through individual cable glands in the top lid.

The number of cable glands in the lid will correspond with the number of gauges you have.

5.0 INSTALLATION contd...

5.6.1 Installing the displacement gauges for use with WI-SOS 480 wireless Nodes contd...

With cables fed through place the lid onto the cap and push firmly into place.

Tighten each cable gland

Secure the top lid with the eye bolt

5.0 INSTALLATION contd...

5.6.1 Installing the displacement gauges for use with WI-SOS 480 wireless Nodes contd...

Feed up to five individual cables through the cable glands of the node and connect the conductors within the node box.

For full details of how to install and test the **WI-SOS 480** Nodes see the **WI-SOS 480** Instruction Manual

5.0 INSTALLATION contd...

5.7 Wiring the electronic head (vibrating wire sensors)

The following tables show the wiring connections for the **GEO-XB™** range of multi-point rod extensometers.

ONE SENSOR

Sensor wiring	Geosense cable Orange 4 core	Function
Red & Black	Red & Black	Gauge 1
Green & White	Green & White	Thermistor gauge 1
No colour	Shield (1)	Earth

TWO SENSORS

Sensor wiring	Geosense cable 4 twisted pair black	Function
Red & Black	Red & Black	Gauge 1
Red & Black	Green & Black	Gauge 2
White & Green	White & Black	Thermistor gauge 1
White & Green (not connected)	(not connected)	Thermistor gauge 2
No colour	Shield (1)	Earth

THREE SENSORS

Sensor wiring	Geosense cable 4 twisted pair black	Function
Red & Black	Red & Black	Gauge 1
Red & Black	Green & Black	Gauge 2
Red & Black	Blue & Black	Gauge 3
White & Green	White & Black	Thermistor gauge 1
White & Green (not connected)	Not connected	Thermistor gauge 2
White & Green (not connected)	Not connected	Thermistor gauge 3
No colour	Shield (1)	Earth

5.0 INSTALLATION contd...

5.7 Wiring the electronic head (vibrating wire sensors) contd...

FOUR SENSORS

Sensor wiring	Geosense cable 7 twisted pair black	Function
Red & Black	Red & Black	Gauge 1
Red & Black	Green & Black	Gauge 2
Red & Black	Blue & Black	Gauge 3
Red & Black	Yellow & Black	Gauge 4
White & Green	White & Black	Thermistor gauge 1
White & Green (not connected)	Green & Black (not connected)	Thermistor gauge 2
White & Green (not connected)	Blue & Black (not connected)	Thermistor gauge 3
White & Green (not connected)	No cable	Thermistor gauge 4
No colour	Shield (1)	Earth

FIVE SENSORS

Sensor wiring	Geosense cable 7 twisted pair black	Function
Red & Black	Red & Black	Gauge 1
Red & Black	Green & Black	Gauge 2
Red & Black	Blue & Black	Gauge 3
Red & Black	Yellow & Black	Gauge 4
Red & Black	Orange & Black	Gauge 5
White & Green	White & Black	Thermistor gauge 1
White & Green (not connected)	Brown & Black (not connected)	Thermistor gauge 2
White & Green (not connected)	No cable	Thermistor gauge 3
White & Green (not connected)	No cable	Thermistor gauge 4
White & Green (not connected)	No cable	Thermistor gauge 5
No colour	Shield (1)	Earth

5.0 INSTALLATION contd...

5.7 Wiring the electronic head (vibrating wire sensors) contd...

SIX SENSORS

Sensor wiring	Geosense cable 7 twisted pair black	Function
Red & Black	Red & Black	Gauge 1
Red & Black	Green & Black	Gauge 2
Red & Black	Blue & Black	Gauge 3
Red & Black	Yellow & Black	Gauge 4
Red & Black	Orange & Black	Gauge 5
Red & Black	Brown & Black	Gauge 6
White & Green	White & Black	Thermistor gauge 1
White & Green (not connected)	No cable	Thermistor gauge 2
White & Green (not connected)	No cable	Thermistor gauge 3
White & Green (not connected)	No cable	Thermistor gauge 4
White & Green (not connected)	No cable	Thermistor gauge 5
White & Green (not connected)	No cable	Thermistor gauge 6
No colour	Shield (1)	Earth

5.0 INSTALLATION contd...

5.8 Grouting

Grouting can be carried out pre or post installation depending on project requirements and/or restrictions.

Mix grout as required using suitable mixer and pump. Note, for the packer anchors a mix of 25kg of standard cement mixed with 20kg of water is the optimal mix for firing the anchors. This should be pumped in using a hand pump for greater control.

Once the rods, sleeves and anchors have been placed at the correct level grouting can be done by running a grout tube down the side of the head

B

6.0 DATA HANDLING

The function of the instrument is to provide useful and reliable data.
Accurate recording and handling of the data is essential if it is to be of any value.

6.1 Taking readings (Vibrating wire version)

6.1.1 Portable Readouts

Geosense offer a range of readout and data logging options. Please refer to the specific operation manuals for each readout device.

Below is a brief, step-by-step procedure for use with the **VWR-1** portable readout.

1. Connect signal cable from the sensor to the readout following the wiring colour code. Conductor colours may vary depending upon the extension cable used.

RED	=	VW +
BLACK	=	VW -
GREEN	=	Temp
WHITE	=	Temp

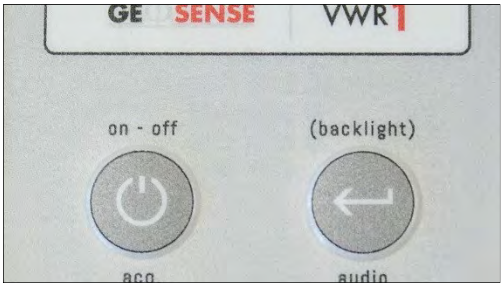
The **VWR-1** displays the current VW reading in frequency and B units together with resistance and a temperature reading in degrees Centigrade

To take readings

Press the ON-OFF button

Press acq.to take the readings

For an audible sound press the audio button



6.1.2 Data Loggers

Geosense provide a number of data loggers to automatically excite, interrogate and record the reading from Vibrating Wire instruments as follows:-

- GeoLogger Linx - available as 1, 4 & 8 channel standalone loggers
- GeoLogger 8 Plus - automatic data acquisition logger which can be connected to hundreds of sensors

6.0 DATA HANDLING contd...

6.1.3 Manual readings

Manual readings are best taken using a digital depth gauge.

Each rod is clearly marked by numbers and the corresponding reading should be noted against the location number.

Manual readings are taken using a digital depth gauge.

Press the ON button and select the units of measurement **INCH/MM**

Before taking the measurement the instrument should be "zeroed" by placing it onto the flat surface and pressing the Zero button

Push the slider down until it locates on the top of the rod within the reference head and note the reading.

6.2 Initial readings

The initial readings are the ones to which all subsequent readings are compared against. Carry out functional tests on the sensors , if not already done so, on the units prior to taking the base readings (see section 4.3).

It is advisable to take the initial readings once the system has stabilised which is normally after 2-3 days after installation. If movement is suspected of already occurring then initial readings should be taken straightaway.

REMEMBER TO TAKE BASE READINGS

6.0 DATA HANDLING contd...

6.3 Data Reduction

6.3.1 Overview

The readings taken at the reference head are used to calculate changes in distance between the reference elevation and each down hole anchor.

The following must however be taken into consideration:-

- If the reference head is located on stable ground then the movements of the anchors relative to the head can be calculated.
- If the reference head is not stable (e.g. due to settlement) then the deepest anchor is used as the reference point. The data must therefore be inverted so that the movements of each anchor are calculated relative to the bottom anchor.

If using a VW or potentiometric displacement sensor the readings must be converted into the required engineering unit. No conversions are necessary if using manual readings from a digital depth gauge.

The data should be organised into a table with rows labelled by date & columns labelled by anchor number/reference.

Construct the table of changes by subtracting the initial reading from subsequent readings for each anchor which shows movements relative to the reference head.

If the reference is the deepest anchor, invert the data to show movements relative to it. This can be done by subtracting the changes for each anchor from the changes at the deepest anchor

6.3.2 Converting readings from VW displacement sensor

Readings from a Vibrating Wire sensor are typically in a form that is a function of frequency rather than in units of length. Commonly the units would be either **Frequency** - Hertz, **Linear** - $Hz^2/1000$ or $Hz^2/1000000$ or **Period** - Time - (Seconds $x10^{-2}$ or $x10^{-7}$).

To convert the readings to units of length, calibration factors must be applied to the recorded values. For most Vibrating Wire sensors, these factors are unique and are detailed on the sensor calibration sheet. A unique calibration sheet is supplied with all Geosense Vibrating Wire Displacement Gauges.

If the readout display is in Period units (e.g. 0.03612 or 3612 - depending upon the readout used) the first step to producing an engineering value is to convert the reading to Linear Digits ($Hz^2/1000$) . Two examples of this calculation can be seen below. The first (1) where the readout includes a decimal point and displays the Period in ***Seconds***$^{-2}$ and the second (2) where the readout displays the Period in ***Seconds***$^{-7}$

6.0 DATA HANDLING contd...

6.3.2 Converting readings from VW displacement sensor contd..

(1)	Readout Display	=	0.03612
	Linear Digits ($Hz^2/1000$)	=	$(1 / 0.03612 \times 10^{-2})^2 / 1000$
		=	7664.8
(2)	Readout Display	=	3612
	Linear Digits ($Hz^2/1000$)	=	$(1 / 3612 \times 10^{-7})^2 / 1000$
		=	7664.8

If the readout displays 'Frequency' values, (e.g. 2768.5 Hz) only a simple calculation is required to convert the readings to Linear Digits.

$$\text{Linear Digits } (Hz^2/1000) = (2768.5)^2 / 1000 = 7664.6$$

Certain data loggers store their Vibrating Wire data in Linear Digits but further divided by 1000. In this case the data would have to be multiplied by a further 1000 to maintain the standard Linear Digits ($Hz^2/1000$) format for standard calculations.

There are many ways to achieve the conversion from recorded data to useful engineering values. The following are included as a guide only and as a basis for alternative approaches.

Linear Calculation

This is the most simple calculation to convert 'raw' data to engineering units. It can be easily carried out using a simple calculator. It assumes that the reading is in Linear Digits ($Hz^2/1000$). Where this is not the case, the reading should be converted to these units prior to application of the calibration factors. For most applications this equation is perfectly adequate and is carried out as follows:-

Displacement (mm) = Linear Factor mm (k) x (Current Reading - Base Reading)

Where the displacement is required in an alternative format, inches for example, a simple conversion using standard conversion factors can be applied to each factor or at the end of the equation. (1 inch = 25.4 mm for example).

An instrument calibration sheet similar to the example in the appendix of this manual includes the following information:-

Model	This refers to the Geosense model number.
Serial Number	This is a unique sensor identification number that can be found on the base of the displacement gauge
Works ID	Unique works batch and range code
Cal Date	Date the calibration was performed
Temp ^{o}C	Temperature at which the sensor was calibrated
DPI No.	Serial number of the calibration equipment
Readout No.	Serial Number of the readout used
R/O Cal Date	The date on which the Readout was calibrated to a traceable standard

6.0 DATA HANDLING contd...

6.3.2 Converting readings from VW displacement sensor contd..

Polynomial Calculation

The polynomial calculation can be more precise as it accommodates any slight deviation from a perfect linear correlation. However to use the polynomial equation the "C" Constant for the environment must be calculated using a "Site Zero" Reading at atmospheric pressure.

$$Site\ C = (-A \times Site\ Zero\ Reading^2) - (B \times Site\ Zero\ Reading)$$

Once the Site "C" Constant is established the polynomial formula can be used to convert Raw Data to Engineering Units.

$$Engineering\ Unit = (A \times Reading^2) + (B \times Reading) + Site\ C$$

The above formula essentially gives the relative change in the variable being measured

$$Eng\ Unit = (A \times Reading^2) + (B \times Reading) + (-A \times Site\ Zero\ Reading^2) - (B \times Site\ Zero\ Reading)$$

$$Eng\ Unit = A \times (Reading^2 - Site\ Zero\ Reading^2) + B \times (Reading - Site\ Zero\ Reading)$$

6.0 DATA HANDLING contd...

6.3.3 Thermistor Linearization

USING STEINHART & HART LOG

Thermistor Type: 3K @25°C

Resistance/ temperature equation:-

$$T= (1 / (A + B (LnR) + C(LnR)^3)) -273.2$$

Where:-

T = Temperature in degrees Centigrade
LnR= Natural log of Thermistor resistance.
A= $1.4051 * 10^{-3}$
B= $2.369*10^{-4}$
C=$1.019*10^{-7}$

(Applicable to the range –50 to + 150 Centigrade only)

Resistance versus temperature table

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	30	525.4	70	153.2	110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149

6.0 DATA HANDLING contd...

6.3.4 Tabulating data

Organise the data into a table with rows labelled by date and columns labelled by anchor number (see below).

A - ABSOLUTE READINGS

The table below shows typical raw data for a three anchor system with anchor 3 in stable ground.

The absolute displacement value is given by the following equation:-

Absolute reading = Current reading - Zero reading (calibration cert) x Gauge factor

Date	Reference head	Anchor 3 (20 metres) mm	Anchor 2 (10 metres) mm	Anchor 1 (5 metres) mm	Comments
20-4	0.00	38.1	25.19	34.75	Base reading (R_0)
21-4	0.00	38.91	26.01	35.51	
22-4	0.00	39.01	26.11	35.61	
23-4	0.00	39.12	26.16	35.61	
24-4	0.00	39.14	26.16	35.61	
25-4	0.00	40.18	27.13	35.58	Excavation
26-4	0.00	40.13	27.18	36.63	

B - MOVEMENTS RELATIVE TO REFERENCE HEAD

From the above raw data the displacements between the head and each anchor can be determined. This is done by subtracting the base reading R_0 from each of the subsequent readings. This gives the relative movement between the reference head and each individual anchor from the following equation:-

Relative movement (To Ref Head) = Current reading - Base reading

Date	Reference head	Anchor 3 (20 metres) mm	Anchor 2 (10 metres) mm	Anchor 1 (5 metres) mm	Comments
20-4	0.00	0.00	0.00	0.00	Installation
21-4	0.00	0.81	0.82	0.76	
22-4	0.00	0.91	0.92	0.86	
23-4	0.00	1.02	0.97	0.86	
24-4	0.00	1.04	0.97	0.86	
25-4	0.00	2.08	1.94	1.83	Excavation
26-4	0.00	2.03	1.99	1.88	

6.0 DATA HANDLING contd...

6.3.4 Tabulating data contd..

C - MOVEMENTS RELATIVE TO ANCHOR THREE
If however it is not the reference head that is stable but anchor 3 then the movement of each of the anchors needs to be calculated relative to anchor 3 and not the reference head. From the data below it can be seen that the apparent movement of anchor 3 is actually the absolute movement of the reference head relative to anchor 3 (stable ground).

Relative movement to anchor 3 = Relative movement anchor 1, 2, 3 or head - Relative movement of anchor 3

Date	Reference Head mm	Anchor 3 (20 metres)	Anchor 2 (10 metres) mm	Anchor 1 (5 metres) mm	Comments
20-4	0.00	0.00	0.00	0.00	Installation
21-4	0.81	0.00	0.01	0.05	
22-4	0.91	0.00	0.01	0.05	
23-4	1.02	0.00	0.05	0.16	
24-4	1.04	0.00	0.07	0.18	
25-4	2.08	0.00	0.14	0.25	Excavation
26-4	2.03	0.00	0.04	0.15	

From the above data it can be seen that the initial movement occurred in the zone closest to the surface during the first 3 days and then again on day 6 following significant excavation during that day.

If the raw data is exported in a csv file then it can be manipulated in Excel to produce graphs of the relative movements.

CONVENTION

A positive value indicates extension i.e. increasing distance between head & anchor

A negative value indicates compression i.e. decreasing distance between head & anchor

7.0 MAINTENANCE

The **GEO-XB2™ borehole rod extensometers** either as a manual or electrical version do not require regular maintenance as such as the subsurface components are non-retrievable and all the sensors are sealed.

However it is important to ensure that the rods do not become extended outside the permissible range, do not become fully retracted and remain free to move & do not twist. All of the above should be checked periodically and if necessary the rods adjusted to remain in their range

Maintenance of wiring connections between the sensors and any terminal panels / or loggers should involve occasional tightening of any screw terminals to prevent loose connections or cleaning contacts to prevent the build up of corrosion.

8.0 TROUBLESHOOTING

Vibrating wire version
It is generally accepted that when a Vibrating Wire instrument is producing a stable reading on a suitable readout, the value will be correct. Only on very rare occasions will this be untrue.

In almost all cases, a fluctuating reading is a sign of a faulty signal from the sensor. The fault could be in either the sensor, the connecting cable, any switch boxes or the readout. The best way to fault find an instrument is to isolate it from all other instruments and connections. Where possible begin fault finding from the sensor itself.

However if the unit fails to read the following steps should be taken:-

1. Check the coil resistance. Nominal resistance is 180 Ω ± 10 plus cable resistance (22 gauge copper = approximately 15 Ω per 333m)

   A.) If the resistance is high or infinite a cut cable should be suspected.

   B.) If the resistance is low or near to zero a short should be suspected.

   C.) If the resistances are within the nominal range and no readings are obtainable on any transducer then a faulty readout should be suspected and Geosense contacted.

2. If cuts or shorts are found the cable may be repaired in accordance with recommended procedures (contact Geosense for kits & procedures).

Unstable readings may also result from electrical noise such as nearby power lines or electrical equipment. If possible the readings should be taken when the equipment is not operating.

GEOSENSE

9.0 SPECIFICATION

REFERENCE HEADS

Type	Reference head type	Measurement sensor	Rod type	Sleeve type	No of points
GXB2-M-R	Manual	Rigid rod	Rigid	Flexible	1 - 6
GXB2-M-F	Manual	Flexible rod	Flexible	Flexible	1 - 6
GXB2-E-VW-R	Electric VW	Vibrating wire	Rigid	Flexible	1- 6
GXB2-E-VW-F	Electric VW	Vibrating wire	Flexible	Flexible	1 - 6
GXB2-E-LP-R	Electric LP	Linear Potentiometer	Rigid	Flexible	1 - 6
GXB2-E-LP-F	Electric LP	Linear Potentiometer	Flexible	Flexible	1 - 6

DISPLACEMENT GAUGES

Description	Ranges
Manual	0 - 150mm
Vibrating Wire	25, 50, 75, 100, 150, 200mm
Linear potentiometer	10, 20, 30, 50, 125,100,150mm

RODS

Available as 1,2,3m lengths

Stainless steel rods are flush threaded

ANCHORS

Description	Connection
16mm Groutable anchor	Rigid sleeve
16mm Groutable anchor	Flexible sleeve
16mm Groutable anchor BZP	Rigid sleeve
16mm Groutable anchor BZP	Flexible sleeve
Single hydraulic Borros type	Rigid sleeve
Double Borros type	Rigid sleeve
Snap ring anchor*	Rigid sleeve
Snap ring anchor*	Flexible sleeve
Packer anchor	Rigid sleeve
Packer anchor	Flexible sleeve

SLEEVES

Description
10mm x 1m flexible sleeve
10mm x 2m flexible sleeve
10mm x 3m flexible sleeve
10mm coupler

10.0 SPARE PARTS

As a Vibrating Wire Embedment Strain Gauge is a sealed unit, it is neither serviceable nor does it contain any replaceable parts.

Civil engineering sites are hazardous environments and instrument cables can be easily damaged, if they are not adequately protected. Geosense can therefore provide the following parts that my be required to effect repairs to instrument cables:

- PU coated 4 Core cable with foil shield and copper drain.
- PVC coated, armoured, 4 Core cable suitable for direct burial.
- Epoxy jointing kit for forming a waterproof cable joint.

Please contact Geosense for price and availability of the above components.

11.0 RETURN OF GOODS

11.1 Returns procedure

If goods are to be returned for either service/repair or warranty,
the customer should contact Geosense for a **Returns Authorisation Number,** request a **Returned**
Equipment Form QF034 and, where applicable, a **Returned Goods Health and Safety Clearance Form QF038** prior to shipment. Numbers must be clearly marked on the outside of the shipment.

Complete the **Returned Equipment Form QF034**, including as much detail as possible, and enclose it with the returned goods.

All returned goods are also to be accompanied by a completed **Returned Goods Health and Safety Clearance Form QF038** attached to the outside of the package (to be accessible without opening the package) and a copy of both forms should be faxed in advance to the factory.

11.1.1 Chargeable Service or Repairs

Inspection & estimate
It is the policy of **Geosense®** that an estimate is provided to the customer prior to any repair being carried out. A set charge for inspecting the equipment and providing an estimate is also chargeable.

11.1.2 Warranty Claim

(See Limited Warranty Conditions)
This covers defects which arise as a result of a failure in design or manufacturing. It is a condition of the warranty that the **GEO-XB2™ borehole rod extensometers** must be installed and used in accordance with the manufacturer's instructions and has not been subject to misuse.

In order to make a warranty claim, contact **Geosense®** and request a **Returned Equipment Form QF034.** Tick the warranty claim box and return the form with the goods as above. You will then be contacted and informed whether your warranty claim is valid.

11.2 Packaging and Carriage

All used goods shipped to the factory **must** be sealed inside a clean plastic bag and packed in a suitable carton. If the original packaging is not available, Geosense should be contacted for advice. **Geosense®** will not be responsible for damage resulting from inadequate returns packaging or contamination under any circumstances.

11.3 Transport & Storage

All goods should be adequately packaged to prevent damage in transit or intermediate storage.

GEOSENSE

12.0 LIMITED WARRANTY

Geosense, warrants the **Geosense® GEO-XB™ borehole rod extensometers** manufactured by it, under normal use and service, to be free from defects in material and workmanship under the following terms and conditions:-

Sufficient site data has been provided to **Geosense®** by the purchaser as regards the nature of the installation environment to allow **Geosense®** to check suitability of the **Geosense® GEO-XB™ borehole rod extensometers** and other component parts.

In the absence of any site data being provided by the purchaser standard construction materials will be supplied. All costs for subsequent modifications will be borne by the purchaser.

The **Geosense® GEO-XB2™ borehole rod extensometers** equipment shall be installed in accordance with the manufacturer's recommendations.

The equipment is warranted for 1 year from the date of shipment from the manufacturer to the purchaser.

The warranty is limited to replacement of part or parts which, are determined to be defective upon inspection at the factory. Shipment of defective part or parts to the factory shall be at the expense of the Purchaser. Return shipment of repaired/replaced part or parts covered by this warranty shall be at the expense of the Manufacturer.

Unauthorised alteration and/or repair by anyone which, causes failure of the unit or associated components will void this **LIMITED WARRANTY** in its entirety.

The Purchaser warrants through the purchase of the Geosense® GEO-XB2™ borehole rod extensometer that he is familiar with the equipment and its proper use. In no event shall the manufacturer be liable for any injury, loss or damage, direct or consequential, special, incidental, indirect or punitive, arising out of the use of or inability to use the equipment sold to the Purchaser by the Manufacturer.

The Purchaser assumes all risks and liability whatsoever in connection with the **Geosense® GEO-XB2™ borehole rod extensometers** equipment from the time of delivery to Purchaser.

13.0 CALIBRATION CERTIFICATE

All displacement gauges have their own individual calibration certificate as below and should be used to check the functionality before installation and then for data reduction.

GEOSENSE QUALITY FORM	
FORM No G/QF/125	
ISS.	6
DATE :	Jan-16
SIG.	GC

Calibration Sheets contain VITAL information about the piezometer. They MUST be stored in a safe place

VIBRATING WIRE DISPLACEMENT TRANSDUCER CALIBRATION

Model	**VWDT 5000**
Serial	**507389**
Works ID	**5**
Cable m	**0**
Readout No.	**6703**
R/O Cal.Date	**18/04/2016**

Cal date	**07-Jul-16**
Master	**09140262**
Temp °C	**20**
Batch	**71**
Range mm	**150**

CALIBRATION FACTORS

Linear factor k (mm)

mm / digit
0.035853772

Polynomial factors (mm)

	mm / digit
A	**1.34312E-07**
B	**0.034507075**
C	

Applied Displacement	$Hz^2 *10^{-3}$			Indicated Displacement (mm)		Linear Error	Polynomial Error	Deviation	Hysteresis
mm	1 up	1 down	Avg.	Linear	Poly.	% FSO	% FSO	Digit	%
0.00	2921.7	2920.3	2921.0	-0.32	0.00	-0.21%	0.00%	1	0.02
30.00	3770.8	3767.6	3769.2	30.09	30.03	0.06%	0.02%	2	0.04
60.00	4615.6	4604.2	4609.9	60.23	59.98	0.16%	-0.01%	6	0.14
90.00	5452.0	5438.1	5445.1	90.18	89.93	0.12%	-0.05%	7	0.17
120.00	6282.9	6279.8	6281.3	120.16	120.11	0.11%	0.07%	2	0.04
150.00	7085.0	7122.4	7103.7	149.65	149.96	-0.24%	-0.03%	19	0.45

Calibration of Linear potentiometer S/N: 09140262 valid from 26 September 2014. UKAS Certificate of calibration No.320982 (UKAS Accredited Calibration Laboratory 0495)

Calibration of CR3000-RMA S/N 7935 valid from 30th April 2015, Calibrated using equipment which provides traceability to UKAS standards (Certificate NO 150430626)

Calibration of AVW200 S/N: 6703 valid from 18th April 2016, Calibrated using equipment which provides traceability to UKAS standards (UKAS Laboratory No 0152)

Users must establish site zero pressure readings for Linear calculation purposes

Linear calculation [mm] = k (mm) * (Current Reading - Site Zero Reading)

Polynomial calculation [mm] = A * (Reading)2 + B * (Reading) + C

C = -A*(Site Zero Reading²) - B*(Site Zero Reading)

Note: Readings are taken in frequency squared units.

Please refer to User Manuals if reading in period or frequency units

THIS CERTIFICATE IS VALID ONLY WHEN CARRYING THE OFFICIAL ORIGINAL STAMP OF GEOSENSE

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