VIBRATING WIRE ANCHOR LOAD CELLS

VWLC 5000 SERIES

INSTRUCTION MANUAL

CE

GEOSENSE

CONTENTS

1.0 INTRODUCTION

This manual is intended for all users of **Vibrating Wire Anchor Load Cells VWLC-5000 Series** manufactured by Geosense and provides information on their installation, operation and maintenance**.**

It is VITAL that personnel responsible for the installation and use of the VWLC-5000 Load Cells READS and UNDERSTANDS the manual, prior to working with the equipment.

1.1 General Description

The primary uses for **VWLC-5000** series are measuring loads acting on:-

- Ground Anchors
- Rock bolts
- Tie backs

Particular features of the **VWLC-5000** series are:-

- Robust steel construction
- Accommodates eccentric loading
- Reliable long term performance
- Rugged, suitable for demanding environments
- High accuracy
- Data logger compatible

The Geosense **VWLC-5000** series load cell consists of a cylinder of high strength steel with 3 to 6 vibrating wire strain gauges (depending on capacity) mounted parallel to the longitudinal axis arranged equidistant around the circumference which measure the compression of the cylinder under load.

With the multi sensor configuration it is possible to obtain accurate readings under mildly eccentric loading conditions as the sensors are read individually.

The readings from the individual sensors are averaged and when used in conjunction with a calibration factor, supplied with each cell, allow the applied load to be calculated.

In multi strand anchors it is therefore possible to tension the strands uniformly by monitoring the load in each sensor as appropriate.

The abutment plate (provided locally) is normally made to suit specific site requirements and load distribution plate pairs (supplied by Geosense) should be used to minimise eccentric loading and provide a smooth parallel bearing surface and evenly spread the load to the cell. These should be inserted between the load cell and the anchor head.

1.2 Theory of operation

Vibrating wire gauges consists of two end blocks with a tensioned steel wire between them. The strain gauge operates on the principle that a tensioned wire, when plucked, vibrates at its resonant frequency. The square of this frequency is proportional to the strain in the wire.

Around the wire is a magnetic coil which when pulsed by a vibrating wire readout or data logger interface plucks the wire and measures the resultant resonant frequency of vibration.

The Geosense **VWLC-5000** series load cell consists of a cylinder of high strength steel with 3 to 6 vibrating wire strain gauges (depending on capacity) mounted parallel to the longitudinal axis arranged equidistant around the circumference which measure the compression of the cylinder under load.

As the **VWLC-5000** anchor load cell undergoes compression the end blocks of the internal vibrating wire sensors will move relative to each other. The tension in the wire between the blocks will change accordingly thus altering the resonant frequency of the wire.

The frequency is read either by a portable readout or data logger and the load calculated as in section 6.6.

2.0 CONFORMITY

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www.geosense.co.uk

Declaration of Conformity

We Geosense Ltd at the above address declare that the equipment detailed below complies with the requirements of the following EU Directive:-

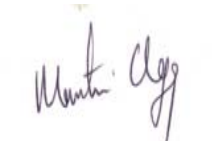
Low Voltage Directive 73/23/EEC (as amended by 93/68/EEC)
The Electromagnetic Compatibility Directive 2004/108/EC

Equipment description:	**Vibrating wire anchor load cells**
Make/brand:	**Geosense**
Model numbers:	**VWLC-5000 range**

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.

EN 61010-2-032:2002
Safety requirements for electrical equipment for measurement, control, and laboratory use.



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

Martin Clegg
Director

Rougham, December 2012

3.0 MARKINGS

Geosense Vibrating Load Cells are labelled with the following information:-

Manufacturers name & address

Product type

Model

Serial number

CE mark

4.0 DELIVERY

This section should be read by all users of **VWLC-5000** series manufactured by Geosense.

4.1 Packaging

VWLC-5000 anchor load cells are packed for transportation to site. Packaging is suitably robust to allow normal handling by transportation companies. 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, **VWLC-5000** anchor load cells 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 it is recommended that **VWLC-5000** anchor load cells 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 interim conductors and render the installation useless.

4.3 Inspection

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 detailed on the documents are included in the shipment. Check that the equipment has not been physically damaged.

ALL Geosense **VWLC-5000** anchor load cells carry a unique identification serial number which is located on the cable connection block.

All **VWLC-5000** anchor load cells are supplied with individual calibration sheets that include their serial numbers and these will shipped with them.

Calibration Sheets contain VITAL information about the VWLC-5000 anchor load cells . They MUST be stored in a safe place.
Only copies should be taken to site.

4.4 Storage

All **VWLC-5000** anchor load cells and associated equipment should be stored in an environment that is protected from direct sunlight.

It is also recommended that cables be stored in a dry environment to prevent moisture migrating along inside them in the unlikely event of prolonged submersion of exposed conductors. The cables should also be protected from rodents and traffic.

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

This section of the manual is intended for all users of **VWLC-5000** anchor load cells manufactured by Geosense and is intended to provide guidance with respect to their installation.

It is VITAL that personnel responsible for the installation and use of the VWLC-5000 anchor load cells READS and UNDERSTANDS the manual, prior to working with the equipment.

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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 General Issues

- Note serial number against location
- Mark cables for future identification. Use an appropriate coding system and mark cables at frequent intervals, not just at the ends.
- Protect the ends of the signal cable. Cables should be terminated at a waterproof box or with waterproof connectors.

5.2 Load distribution plates

To obtain stable measurements and minimise errors due to eccentricity, the **VWLC-5000** anchor load cells should be installed using a pair of load distribution plates which are supplied by Geosense. An abutment plate should be made locally to suit the local site requirement.

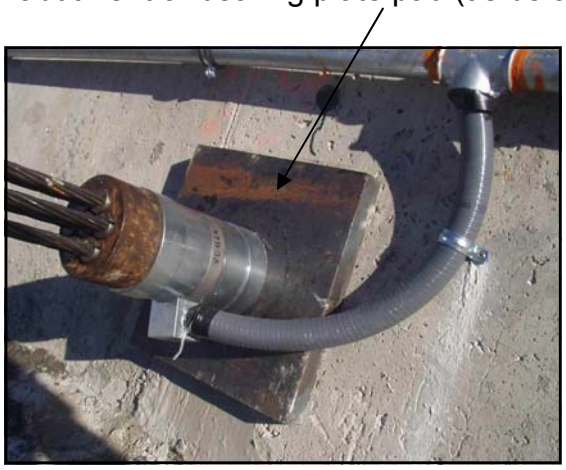
5.3 Anchors (multi-strand & solid bar)

Installation of **VWLC-5000** anchor load cells should be carried out as follows:-

1. Ensure that the internal diameter of the cell is correct for the anchor strands or bolt head.

2. Ensure that the capacity of the cell is sufficient for the anchor including the testing.

3. If necessary fabricate an abutment or bearing plate/pad (as below).



4. Place the base load distribution plate over the anchor strands or bolt followed by the cell and then the top load distribution plate.

5. Place the anchor stands through the wedge plate or nut. Connect the signal cable to the load cell and then to either a portable readout or a data logger. Record the output when it is ZERO load.

6. Place pressure jack onto top of cell and carry out the necessary tests recording the outputs and checking what load is being applied (see DATA HANDLING).

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 Monitoring the Load Cell Readings

Geosense **VWLC-5000** loads cells contain temperature sensors. Where a loads cell is installed in a zone where its temperature is likely to fluctuate significantly, records of both load and temperature data should be used to assess any effects temperature on the data (see section 6.8).

6.2 Portable Readouts

Geosense offer a range of readout and data logging options. Specific operation manuals are supplied with each readout device.

Below is a brief, step-by-step procedure for use with the **VW-2106** 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 -
BARE	=	Shield

2. Switch on the unit and, where necessary, select range B

3. The recorder displays the current VW reading (in Hz2/1000) and a temperature reading in degrees Centigrade.

Whilst it is not critical that the polarity be observed for most VW instruments, a stronger signal may be obtained if the correct polarity is adopted. Since the temperature sensor is a Thermistor, its connection polarity is not so important.

Geosense **VWLC-5000** load cells incorporate VW Strain Sensors mounted parallel to the longitudinal axis in a radial pattern. Depending on the size of the load cell, 3 or 6 sensors are used. Each sensor can be read individually “one by one” where a bare cable is supplied or all sensors read at the same time by means of an expansion plug fly lead which connects onto a special connector fitted to the load cell cable (to be requested at time of order).

Using a multi sensor configuration makes it possible:

- To obtain accurate readings under eccentric loading conditions
- To tension strands uniformly in multi strand anchors, by monitoring each sensor.

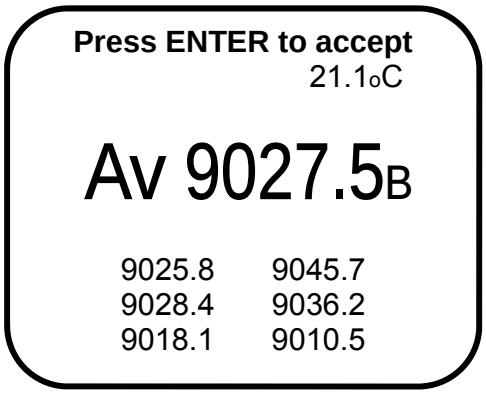
6.2 Portable Readouts contd...

Where individual sensors are read “one by one” the values will need to be manually manipulated to average them (see data reduction) whereas the expansion fly lead will enable this to be calculated within the VW-2106. A fly lead with five pin will be required for a three sensor and a fifteen pin for a 6 sensor load cell with a mating end for the load cell connector as below.

The VW-2106 contains an internal multiplexer allowing it to be connected to multi-channel instruments through its *Expansion* connector. Appendix B – Expansion Connector Pin-out provides the pin-out of this connector. Mating halves of the connectors are available from Geosense if your current sensors are not equipped with the appropriate connector.

The most common instrument with multiple channels is a Load Cell. Typical load cells have either 3 or 6 Vibrating Wire sensors with a common thermistor. During location setup, the number of sensors can be specified.

In the case where more than one sensor is specified for the location (i.e. load cells) the following screen will appear:



For full details please refer to the VW-2106 manual.

6.3 Data Loggers

A number of data loggers are available to automatically excite, interrogate and record the reading from Vibrating Wire instruments. These include single channel and multichannel GeoLoggers manufactured by Geosense.

GeoLoggers are primarily based around Campbell Scientific CR800 & CR1000 but can also be fitted with any data logger that is compatible with vibrating wire instruments. Specific configuration and programming advice can be obtained from Geosense.

6.4 Wiring details

Detailed wiring and operation details of individual data loggers are contained within their individual manuals but below are the wiring details for the three and six sensor **VWLC-5000** load cells.

4 PAIR CABLE	
Paired Wires	**Sensor**
RED / BLACK	**VW sensor 1**
GREEN / BLACK	**VW sensor 2**
BLUE / BLACK	**VW sensor 3**
WHITE / BLACK	**Thermistor**

7 PAIR CABLE	
Paired Wires	**Sensor**
RED / BLACK	**VW sensor 1**
GREEN / BLACK	**VW sensor 2**
BLUE / BLACK	**VW sensor 3**
WHITE / BLACK	**VW sensor 4**
YELLOW / BLACK	**VW sensor 5**
ORANGE / BLACK	**VW sensor 6**
BROWN / BLACK	**Thermistor**

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6.5 Data Reduction

6.5.1 Overview

The tension of a sensor wire can be measured by detecting the frequency (note) at which it naturally vibrates. The following is a description of the units commonly used by the instrumentation industry.

Frequency Units (Hz). If the wire is 'excited' electronically the frequency at which it vibrates can be measured. The units used to express frequency are Hertz (Hz) or Kilo□Hertz (kHz).

The disadvantage of these units is that there is no 'linear' conversion from 'change in Hertz' to 'change in wire tension'.

Linear Digits (B). In order to overcome the problem of a linear conversion described above, the frequency value can be squared, thereby rendering it linear, but quite large. To reduce its size, it is often divided by 1000 (or multiplied by 10^{-3}). The expression $Hz^2/1000$ (or $Hz^2 \times 10^{-3}$) is the most commonly adopted as a 'linear' digital output.

Period Units (P). Some readout devices utilise the 'counter' function available in many common integrated circuits.

Period Units represent the time taken for the wire to vibrate over one full oscillation, expressed in seconds. Due to the very small size of the number generated most equipment manufacturers display the unit multiplied by either 1000 (10^3) or 10000000 (10^7).

The relationship between Period units and Frequency units is expressed as

$$P = \frac{1}{\text{Frequency}}$$

Period units are convenient to measure but do not have a linear relationship to the 'change in wire tension'.

Calibration Factor. Each VWLC-5000 load cell is supplied with a Calibration certificate to enable conversion from the raw data (in the units described above) into engineering units such as kN.

The value of the calibration factor will vary depending upon the engineering units into which the raw data is to be converted.

6.5.1 Data Reduction overview contd...

Readings from VW sensors are typically in a form that is a function of frequency rather than in units of strain.

To convert the readings to units of load, a calibration factor must be applied to the recorded values. For Vibrating Wire load cells the calibration factors are unique to each unit.

If a readout display is in 'Period' units (e.g. 0.03612 or 3612 depending upon the readout used) a calculation must first be performed to convert the reading from 'Period' units to 'Linear Digits' ($Hz^2/1000$) units.

Two examples of this can be seen below. The first (1) where 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}**

(1) Linear $Hz^2/1000$ = $(1 / 0.03612 \times 10^{-2})^2 / 1000$
= 7664.8

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

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

Linear Digits ($Hz^2/1000$) = $(2768.5)^2 / 1000$
= 7664.6

Certain data loggers store their Vibrating Wire data in Linear Digits but divided by a further 1000. Obviously these data would have to be multiplied by another 1000 to maintain the standard data format for the conversion to engineering units.

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

6.6 LOAD CALCULATION

Each load cell is calibrated by loading in incremental steps and recording the data.

The following is a typical calibration routine:

The readings are then averaged, and a regression is done with Applied Load versus the averaged Readings to get the load cell constants for scale “B” and zero “A”. The constants are used in the formula below for calculating the current load.

$$F = (average - A)B$$

F = Load (in kN)

A = Averaged readings at zero load, B units (Obtained from calibration sheet)

average = average of current readings.

B = Calibration factor (kN/digit) - Obtained from calibration sheet

For example, values of **A = 8509**, and **B = - 1.627018719** are shown in the calibration sheet on next page.

Therefore if the following readings were obtained from the readout:

Sensor No.	Sensor Reading
1	7737
2	7980
3	7838
4	8048
5	7299
6	7849

then the **average** would be:

(7737 + 7980 + 7838 + 8048 + 7299 + 7849)/6 = **7792**

thus using the above formula, the result would be:

F = (7792 - 8509) * **- 1.627018719**

F = (-717)***- 1.627018719**

F = 1166.3 kN

6.7 CALIBRATION

MGS QUALITY FORM
Form No MGS QF/135
ISS: 3
DATE : JAN13
SIG: SKH

VIBRATING WIRE LOAD CELL CALIBRATION

Model / Series	VWLC-5000
Serial Number	509092
Readout Serial No	1000475284
Capacity	3000KN

Cal date	8-Feb-13
Frame Number	G64
Temp °C	19

Applied Load	Digits							Load	Error	Error % fso
kN	1	2	3	4	5	6	avg digit	kN	kN	linear
0	8460	8682	8568	8750	8016	8575	8509	16.8	16.8	0.56%
600	8093	8344	8192	8410	7660	8210	8152	597.7	-2.3	-0.08%
1200	7737	7980	7838	8048	7299	7849	7792	1183.1	-16.9	-0.56%
1800	7363	7599	7470	7672	6932	7483	7420	1788.6	-11.4	-0.38%
2400	6997	7215	7097	7293	6562	7112	7046	2396.7	-3.3	-0.11%
3000	6622	6823	6718	6906	6188	6736	6665	3015.7	15.7	0.52%

Calibration traceable to ACCREDIA
Traceable standard last calibrated 4th December 2012
Reference cell Serial No: 908565

CALIBRATION FACTOR

Linear factor (k)
KN per digit
-1.627018719

Calibrated By

Note: Digits are $Hz^2 \times 10^{-3}$ units.
(please consult the User Manuals for conversion of alternative reading units)
Polynomial calculation [kPa] = A * (Reading)2 + B * (Reading) + C
Linear calculation [kPa] = k (kPa) * (Current Reading - Site Zero Reading)
THIS CERTIFICATE IS VALID ONLY WHEN CARRYING THE OFFICIAL ORIGINAL STAMP OF MGS-GEOSENSE BELOW

Nova House, Geotechnical Centre, Rougham Industrial Estate, Rougham, Bury St. Edmunds, IP30 9ND, UK
T: +44 1359 270457 F: +44 1359 272860 E:info@mgs.co.uk www.mgsgeosense.co.uk
Geosense is a division of Marton Geotechnical Services Ltd

6.8 Temperature Considerations

Thermal influences are complex because it is not only the load cell that is affected but the element to which it is attached and whole structure that is affected. The rate of temperature change and the distribution of the thermal gradients also play a major part in influencing the actual strain (load) at any point and its effect on the load cell and its readings.

Consequently, in order to apply any correction for temperature it is necessary to first establish the effects of the temperature changes on the load cell and the medium in/on which it is installed.

A useful exercise to carry out on site to establish the in-situ effects of temperature changes is to observe the installed load cell readings, together with both ambient and cell temperatures, when no other factors are changing. This should be carried out prior to any loading or other structural changes / works are carried out.

An alternative, is to use a ‘No load”, load cell installed close to the monitoring cells. This will enable an assessment of temperature affects on the cell itself in the working environment for a particular location. For further discussion about ‘No load”, load cells please contact Geosense.

7.0 MAINTENANCE

VWLC-5000 anchor load cells are basically maintenance free device for most applications but the following should be considered during the service life:-

- Keep away from direct sunlight to avoid large thermal affects
- Keep the cable connection cap on when Readout not connected
- Avoid any impacts or significant vibration which can damage internal sensors
- Keep cables away from physical damage
- Keep cable ends waterproof

8.0 TROUBLESHOOTING

8.1 Unstable Readings

Readings can become unstable due to external influences or problems with the Readout. If unstable readings are experienced check the following:-

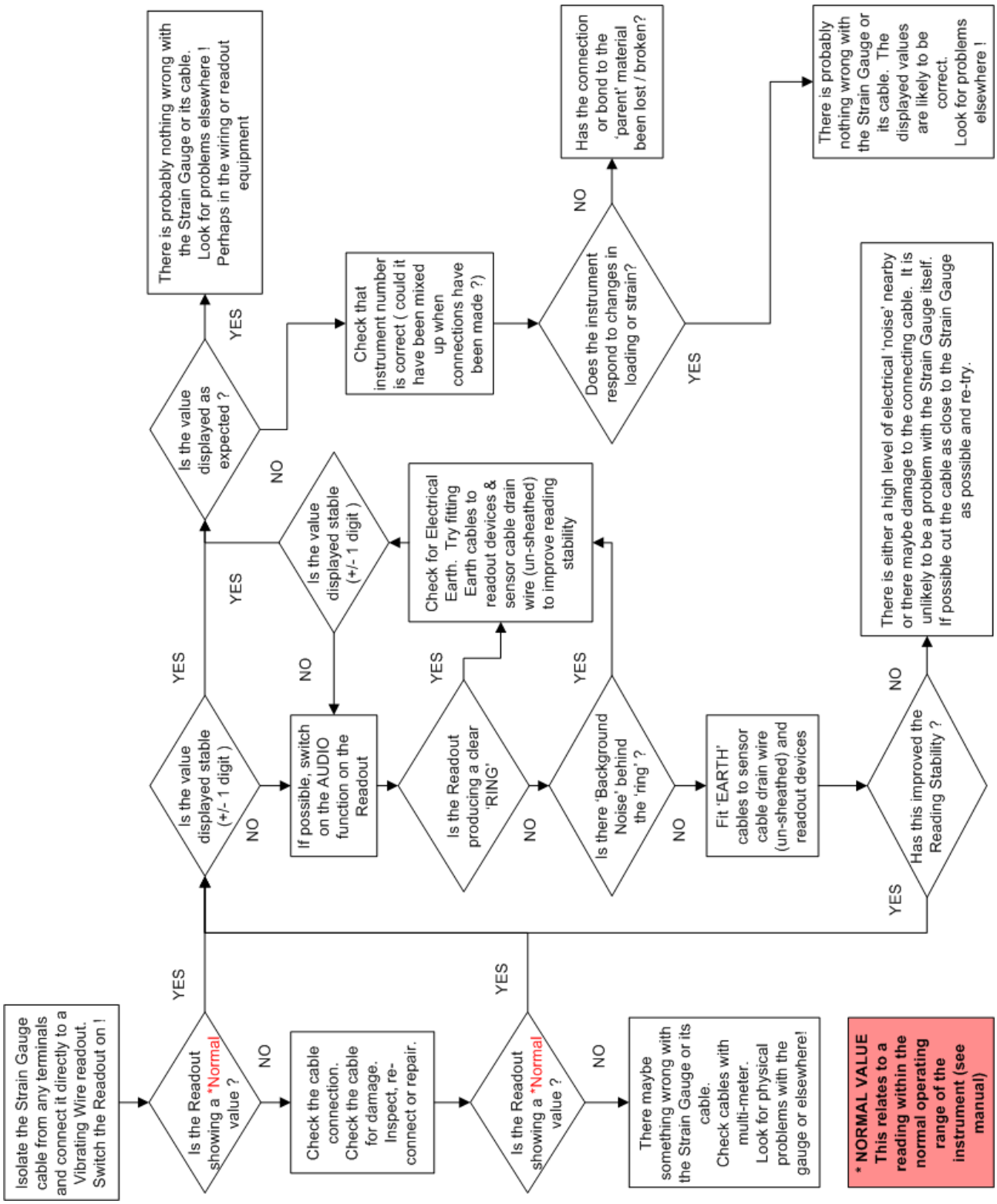
- Electrical interference can be emitted from heavy or generating equipment and can affect the readings.

Symptom	Possible cause	Possible remedy
Unstable readings	Electrical interference from Heavy or generating equipment Loose connections	Remove equipment Ground all cables Check connections
	Low Readout battery	Charge or replace battery
No signal	Cable damage	Check resistance of each cable core

8.0 TROUBLESHOOTING contd...

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.



9.0 SPECIFICATION

LOAD CELL

Description	Specification
Thermistor	3k Ohms at 25 °C
Over range capacity	150% FS
Resolution	0.05% FS
Accuracy[1]	0.5% FS*
Temperature range	-40°C to + 75°C
Material	High tensile, stress relieved steel
Hole size	16 to 280mm

[1]System accuracy depends on loading conditions
* 0.25% FS available on request

ANCHOR LOAD CELLS

Capacity (kN)	Sensors	Internal diameter (mm)	Outside Diameter (mm)	Height (mm)
250	3	40	60	100
500	3	50	80	100
750	3	77	108	100
1000	3	112	142	100
1250	3	144	174	100
1500	6	150	182	100
1750	6	190	222	100
2000	6	190	227	100
2500	6	225	264	100
3000	6	225	271	100

LOAD DISTRIBUTION PLATES

Capacity (kN)	Sensors	Internal diameter (mm)	Outside Diameter (mm)	Height (mm)
250	3	40	68	30
500	3	50	88	30
750	3	77	116	40
1000	3	112	150	40
1250	3	144	182	40
1500	6	150	190	50
1750	6	190	230	50
2000	6	190	235	50
2500	6	225	272	50
3000	6	225	279	60

10.0 SPARE PARTS

VWLC-5000 anchor load cells do not have 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:

- PE coated 4 & 7 core cable with foil shield and copper drain.
- Epoxy jointing kit for forming a waterproof cable joint.
- Quick connectors for end of load cell cable for use with fly lead to VW-2106.

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

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 **VWLC-5000** anchor load cells 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 Report 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 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.

12.0 LIMITED WARRANTY

The manufacturer, (**Marton Geotechnical Services Ltd - Geosense Division)**, warrants the **VWLC-5000** anchor load cells manufactured by it, under normal use and service, to be free from defects in material and workmanship under the following terms and conditions:-

The **VWLC-5000** anchor load cells 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 VWLC-5000 anchor load cells 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 **VWLC-5000** anchor load cells from the time of delivery to Purchaser.

13.0 INSTALLATION NOTES

VIBRATING WIRE ANCHOR LOAD

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