

GXM-300 SERIES

MAGNETIC SETTLEMENT SYSTEM

I N S T R U C T I O N M A N U A L



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1.0 INTRODUCTION

This manual is intended for all users of the GXM-300 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 GXM-300 Series READ and UNDERSTAND the manual, prior to working with the equipment.



1.1 General Description

The **GXM-300 Series**, is a magnetic extensometer that is installed into fills or unstable ground, to **monitor settlement or heave**, that may have occurred due to different civil/geotechnical engineering activities, such as:

- Embankment Construction
- Earth Dam Construction

Data obtained from this type of instrument will highlight the **settlement or heave** occurring in the ground, as well as highlighting the zones in which the highest settlement / heave is occurring. This aids in the design of structures, when construction is undertaken.

The primary use for the **GXM-300 Series** is :-

Soil settlement measurement.

Particular features of the Geosense **GXM-300 Series** are:-

Reliable long term performance.
Rugged; suitable for demanding environments.

The magnetic signals are particularly suited for the demanding environment found in civil and geotechnical engineering industries.

The Geosense range of **GXM-300 Series** can be supplied in various configurations to suit varying installation environments and techniques.

1.2 Theory of Operation

The **GXM300 Series** magnetic extensometers are installed in embankment fills or boreholes that are associated with different civil / geotechnical engineering applications. The **GXM300 Series** magnetic extensometers come in two different forms, as follows:-

Magnetic Settlement Systems GXM300.

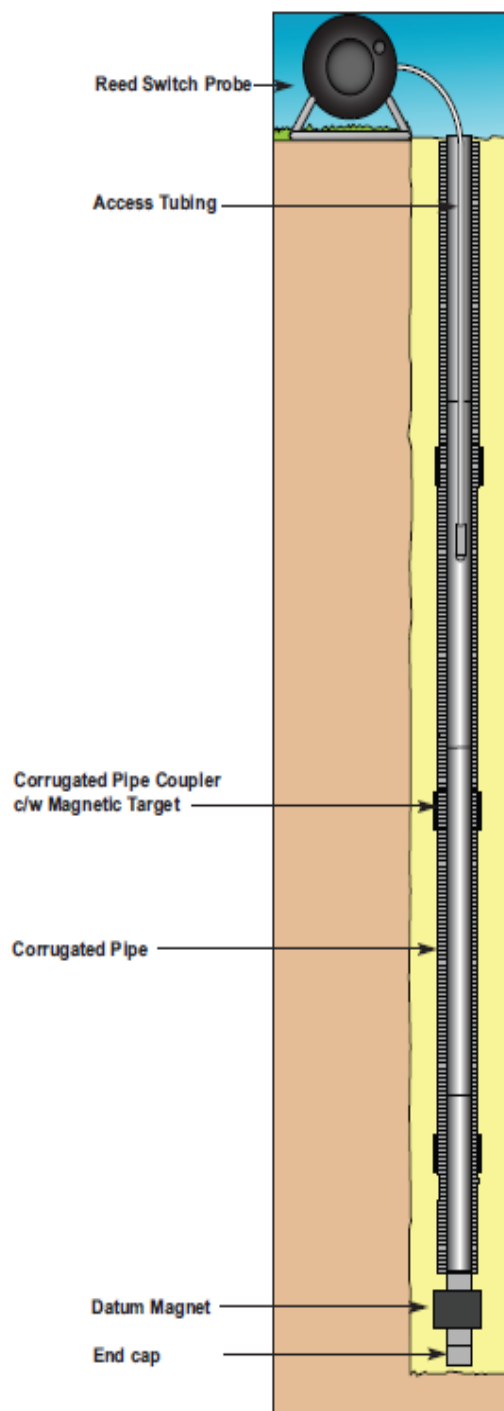
This magnet settlement system incorporates access tubing and corrugated piping. This corrugated piping is placed over the access casing in sections. These corrugated piping sections are then linked together with couplers or magnetic couplers. The corrugated piping is not attached to the access casing, so allowing the corrugated piping to movement with the ground as it settles or heaves.

Magnetic Settlement Systems GXM300i

This system operates and is installed, in the same manner as the **GXM300**. The only difference between the **GXM300** and **GXM300i** is that the **GXM300i** incorporates inclinometer casing into its installation.

Operation

The system comprises of a reed switch probe, a steel measuring tape, a tape reel with built-in buzzer and a series of magnetic targets located along the length of a access tube. As the probe passes through a magnetic field the internal reed switch closes, activating the audible buzzer and light, so that the location of the magnetic target can be identified by measuring to the nearest millimetre on the graduated tape.



1.3 Components

Access Tubing (GXM-300) : Allows the reed switch probe to be lowered so measurements of the magnetic target position can be taken.

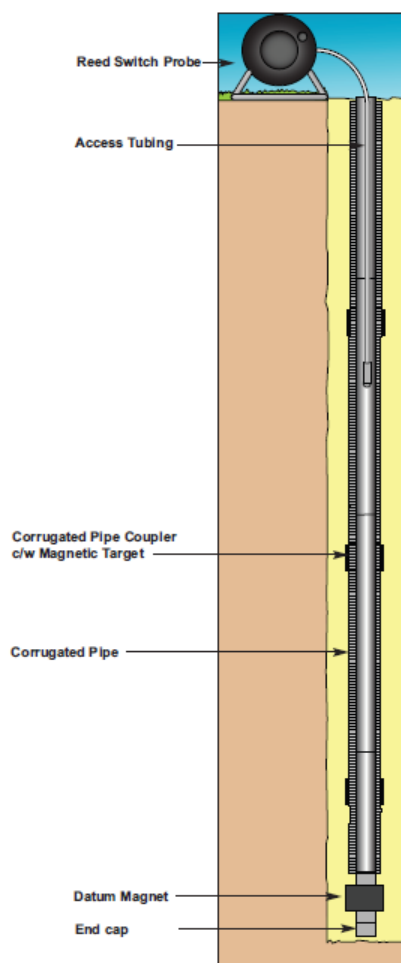
Inclinometer Casing (GXM-300I) : The casing allows the reed switch probe to be lowered so measurements of the magnetic target position can be taken. This casing also allows inclinometer probes to be inserted into the casing so lateral movements can be monitored.

Corrugated Piping: This piping is placed over the access tubing in sections. These corrugated piping sections are then attached together, with couplers or magnetic couplers, which are attached to the corrugated piping with screws. This casing is intended to de-bond the access tubing from the surrounding soil and move with the fill as it settles or heaves.

Couplers: These couplers are fixed to the corrugated pipe section in order to extend the section of corrugated piping to the elevation required to install the next magnetic couplers.

Magnetic Couplers: These are the magnetic targets that are used to trigger the reed switch probe. These are attached to the moving corrugated piping with screws. These can be positioned at different locations along that installation.

Datum Magnets: All readings made are taken in reference to the datum magnet, which is fixed in place on to the access tubing, is none moveable and located in stable ground.



2.0 DELIVERY

This section should be read by all users of **GXM-300 Series** manufactured by Geosense.

2.1 Packaging

GXM-300 Series 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.

2.2 Handling

Whilst they are a robust devices, **GXM-300 Series** are precision measuring instruments. They and their associated equipment should always be handled with care during transportation, storage and installation.

Once the shipment has been inspected, it is recommended that **GXM-300 Series** remain in their original packaging for storage or transportation.

2.3 Inspection

It is important 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.

2.4 Storage

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

No other special requirements are needed for medium or long-term storage.

3.0 INSTALLATION

This section of the manual is intended for all users of **GXM-300 Series** manufactured by Geosense and is intended to provide guidance with respect to their installation.

It must be remembered that no two installations will be the same and it is inevitable that some 'fine tuning' of the following procedures will be required to suit specific site conditions.



It is VITAL that personnel responsible for the installation and use of the GXM-300 Series 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

3.1 BASE Readings



IT IS ESSENTIAL TO TAKE BASE READINGS OF THE DATUM MAGNET WHEN INSTALLATION IS COMPLETE.



IT IS ALSO RECOMMENDED TO TAKE THREE SETS OF READINGS FROM DIFFERENT PASSES THROUGH THE ACCESS TUBING AND AVERAGE FOR EACH MAGNETIC TARGET.

3.2 Getting started

Ensure that all the equipment needed is laid out on clean ground and the number of items needed for installation are checked. Check that all equipment provided is not damaged and is clean.

Prior to installation of the **GXM-300** it is essential to confirm details of the installation to be carried out. Some of the main considerations are listed below :-

1. **Number of installation, datum magnet and magnetic targets.**

2. **Borehole Identification.**

Boreholes that require the **GXM-300 Series** to be installed in them should be clearly identified and a labelling/ marking scheme should be established with the client before installation is under taken.

3. **Tools.**

Obtain any tools necessary to carry out the installation. The following is a brief list of tools typically used during the installation of **GXM-300 Series**

- Tape Measure
- Cleaning Solvent
- Adhesive
- Star Screw Driver
- Permanent Marker Pen
- Allen Key
- Duct Tape

4. **Extensometer Components.**

- Access Tubing
- Corrugated Piping
- Couplers
- Magnetic Couplers
- Datum Magnet



3.3 Installation Procedures - GXM300I

1. Check the drill hole to ensure that the full depth is clear and free of obstructions. Ensure that the base of the borehole is in solid ground.

2. Lay out all the equipment that is supplied, ensuring that the quantity is correct for the installation.

3. Snap the end cap to the casing.

4. Insert the casing into the corrugated piping. Ensure the corrugated piping is taken above the end of the access tubing.

5. Place the datum magnet onto the end cap at the bottom of the access tube.



3.3 Installation - GXM300I contd...

6. Measure and mark the intended location of the datum magnet.



7. Place the magnet over the access tubing and screw the datum magnet in place with the provided Allen key.



8. Duct tape around the corrugated piping and the access tube.



9. Install the casing into the borehole, with the datum magnet end of the access tubing going in first.



3.3 Installation - GXM300I contd...

10. Ensure the access tube is firmly in place.



11. Ensure the access tube's verticality, with a spirit



12. Fill borehole with bentonite pellets.



13. Cover the borehole with fill marital.



3.3 Installation - GXM300I contd...

14. Insert the first coupling joint over the access tube and ensure that the corrugated piping is pushed into the coupling join firmly.



15. Attach coupling joint to corrugated piping with the screws provide.



16. Place top cap on access tubing. This is to ensure that no fill enters the access tube.



3.3 Installation - GXM300I contd...

17. Place fill around the installed access tube. Ensure that the fill is placed by hand around the access tubing.

18. Attach the next access tubing length to the just installed access tube.



19. Place the next corrugated piping over the access tubing and into the coupler, ensuring that the corrugated piping is firmly in the coupler.



20. Screw the corrugated piping in place with the screws provided. Ensure that this is done for all apertures that are provided for the screws in the coupler.

21. Place fill around the installed access tube. Ensure that the fill is placed by hand around the access tubing.



3.3 Installation - GXM300I contd...

22. Place the magnetic coupler over the just installed access tube and corrugated piping. Ensure that the corrugated piping is firmly pushed into the coupler.



23. Screw the corrugated piping in place with the screws provided.



24. Attach the next access tube length to the installed access tube.



25. Place the next corrugated piping over the access tube and into the magnetic coupler, ensuring that the corrugated piping is firmly in the magnetic coupler.



3.3 Installation - GXM300I contd...

26. Screw the corrugated tubing in place with the screws provided.

27. Repeat for the number of magnets required.

28. Proceed to place and compact fill around installation by hand.



Installation is complete.

5.4 Installation - GXM300

The installation for the GXM300 is exactly the same as the GXM-300I except the internal access tube is 33mm (1") with flush threads and the external corrugated pipe is 35mm external diameter. All connections & target fixing is identical to the GXM-300I

4.0 DATA

4.1 Taking Readings



TO ENSURE CONSISTENT READINGS MAINTAIN THE SAME PROCEDURES EVERY TIME READINGS ARE TAKEN.

WHEREVER POSSIBLE USE THE SAME REED SWITCH PROBE. IF DIFFERENT PROBES ARE USED ALWAYS TAKE BASE READINGS WITH EACH PROBE AND COMPARE DATA. APPLY ANY OFFSET TO LATER READINGS

1. Remove top cap.

2. Switch on reed probe.

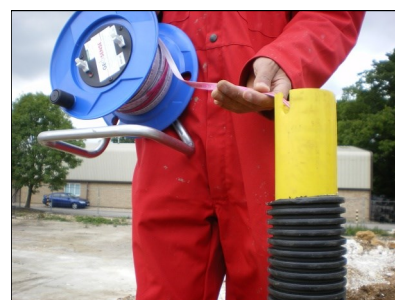
3. Lower probe to bottom of access tubing. As the probe passes past each magnetic target the buzzer will sound several times.

Readings should always be recorded from the base upwards.

4. Once the probe has reached the bottom of the access tube slowly raise it.

As the probe passes through the datum magnet TWO or more sounds will be heard. Lower the probe again to 'just below the first buzz', then raise it slowly and record the depth of the START OF THE FIRST BUZZ on the way UP.

5. Raise probe to next magnetic target and repeat the above reading process. Repeat for all targets.



4.1 Taking Readings contd...



Please RememberIt is ABSOLUTELY VITAL that the same procedure is adopted for ALL monitoring operations on the same instrument.

There are more than one methods that can be employed to gather data from Magnetic Extensometers. The aim is to accurately determine the distance between the targets and the top of the access tube (or other upper reference mark). Below is ONE tried and tested procedure....

The level of the target is defined as the reading on the Reed Switch Probe tape when the buzzer FIRST sounds as it enters a Targets magnetic field, FROM BELOW.

Once the probe is below the Datum Target, slowly raise it until a 'buzz' or 'bleep' is heard from the reel.

STOP !

Slowly lower the probe again to just below the point where the sound stops.

Slowly raise it until it sounds again.

STOP !

Repeat until the level at which the sound starts can be accurately read form the tape. This value should be recorded.

Repeat for ALL other Targets ... remembering to only use the FIRST sound as the probe RISES into the magnetic field of each Target.

4.2 Data Reduction

Readings taken from the **GXM300 Series** are taken from the top of the access tube, to indicate the depth of the probe. Therefore the site readings are referenced to the top of the access tubing and not the datum magnet.

The data in the table below show reading sets recorded from 1 instrument over 6 months:

Magnet Number	Collected Readings					
	01-Dec	01-Jan	01-Feb	01-Mar	01-Apr	01-May
5	19.244	19.245	19.245	19.246	19.245	19.244
4	21.785	21.791	21.793	21.797	21.796	21.796
3	23.990	24.000	24.003	24.009	24.010	24.011
2	30.698	30.711	30.714	30.721	30.723	30.726
1	35.430	35.445	35.449	35.457	35.459	35.462
Datum Magnet	40.755	40.772	40.777	40.786	40.789	40.792

Initially, the readings have to be inverted so that they show the distance between the individual targets and the datum magnet, not the top of the access tube. The data is inverted because the datum magnet is considered to be the fixed point, unlike the top of the access tube which may move as the sub-strata moves.

In order to calculate the Inverted Data the measured depth to each target is subtracted from the measured depth to the datum magnet as seen from the table below:-

Measured depth of the Datum Target - each month

Magnet Number	Collected & Inverted Readings											
	01-Dec	Inverted	01-Jan	Inverted	01-Feb	Inverted	01-Mar	Inverted	01-Apr	Inverted	01-May	Inverted
5	19.244	21.511	19.245	21.527	19.245	21.532	19.246	21.540	19.245	21.544	19.244	21.548
4	21.785	18.970	21.791	18.981	21.793	18.984	21.797	18.989	21.796	18.993	21.796	18.996
3	23.990	16.765	24.000	16.772	24.003	16.774	24.009	16.777	24.010	16.779	24.011	16.781
2	30.698	10.057	30.711	10.061	30.714	10.063	30.721	10.065	30.723	10.066	30.726	10.066
1	35.430	5.325	35.445	5.327	35.449	5.328	35.457	5.329	35.459	5.330	35.462	5.330
Datum Magnet	40.755	0.000	40.772	0.000	40.777	0.000	40.786	0.000	40.789	0.000	40.792	0.000



Measured depth of the Individual Targets - each month



If it is necessary to use the top of the access tubing as the reference because the datum magnet is not in stable ground, it is VITAL that the top of the access tube be surveyed each time the instrument is read.

4.2 Data Reduction contd..

Settlement Calculations

Once the inverted values have been obtained, as shown on the previous page, the calculation of settlement can be made. This calculation uses the first month's 'inverted' readings as the initial readings, subtracting the current month's 'inverted' values to determine the 'change'. This 'change' is the actual movement of the magnetic targets and is, therefore, the movement that has occurred in that particular strata. Where the elevation of the Datum Magnet is known, this can be added to the 'inverted' values to obtain the actual elevation of each target (see table below). Since the elevation of the datum magnet is a constant, the 'change' can be calculated either with or without its inclusion.

If the 'difference' is negative it indicates that the ground has experienced 'settlement', whereas a positive 'difference' indicated 'heave'.

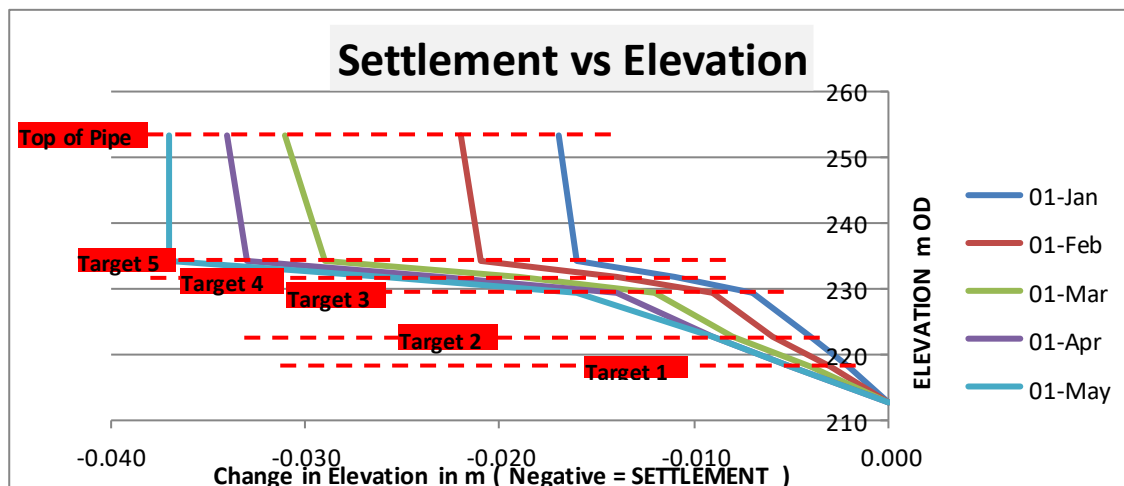
Datum elevation = 212.672 m OD (reading to datum minus the Survey EL. of the tube top)

Magnet Number	Calculated Movement											
	01-Dec		01-Jan		01-Feb		01-Mar		01-Apr		01-May	
	Initial		Current	Change	Current	Change	Current	Change	Current	Change	Current	Change
Top of pipe	253.427	0	253.444	-0.017	253.449	-0.022	253.458	-0.031	253.461	-0.034	253.464	-0.037
5	234.183	0	234.199	-0.016	234.204	-0.021	234.212	-0.029	234.216	-0.033	234.220	-0.037
4	231.642	0	231.653	-0.011	231.656	-0.014	231.661	-0.019	231.665	-0.023	231.668	-0.026
3	229.437	0	229.444	-0.007	229.446	-0.009	229.449	-0.012	229.451	-0.014	229.453	-0.016
2	222.729	0	222.733	-0.004	222.735	-0.006	222.737	-0.008	222.738	-0.009	222.738	-0.009
1	217.997	0	217.999	-0.002	218.000	-0.003	218.001	-0.004	218.002	-0.005	218.002	-0.005
Datum	212.672	0	212.672	0	212.672	0	212.672	0	212.672	0	212.672	0



'Change' in distance to the Datum Target (negative = settlement)
Actual elevation of each target with respect to fixed datum

The 'change' (Settlement or Heave) values can then be presented in graphical formats to suit particular requirements. There are many formats that can be adopted. The graph below is just one such format.

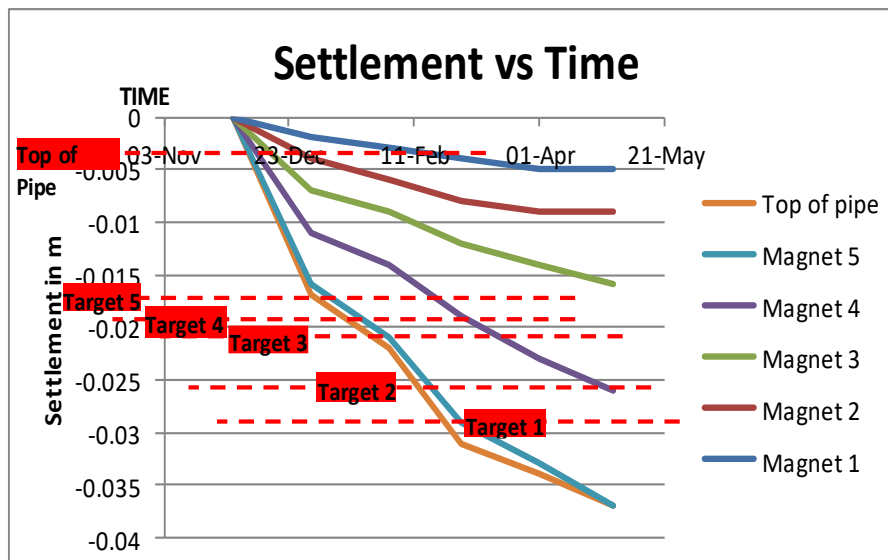


Settlement Calculations contd...

In the previous graph, the settlement profile for each months data is presented as a line which joins the change / elevation co-ordinates.

The negative 'change' values mean that the graph expands to the left as settlement increases. Some presentations change this value to positive to show the 'change' as an increase to the right.

In the graph below, the settlement of each target is plotted against time.



5.0 GROUTING



THERE IS OFTEN CONFUSION REGARDING THE PURPOSE OF THE SPIDER LEG SPRINGS. THEY ARE NOT AS MOST PEOPLE THINK TO KEY INTO THE SURROUNDING GROUND. ALTHOUGH SOME KEYING EFFECT MIGHT OCCUR THE LEGS ARE ONLY THERE TO KEEP THE TARGET IN PLACE UNTIL IT IS GROUTED. ONCE GROUTED THE LEGS BECOME REDUNDANT.

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.

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	0.33	15 Kg	0.33	20 Kg	0.4
Water	125 Lit	2.5	260 Lit	4.5	325 Lit	6.5

Other compounds can be added to the grout mixture to alter its characteristics:-

- Expanding agents are added to introduce small bubbles into a cement and water mix as it cures to prevent it from shrinking.
- Plasticisers can be added to a mixture to allow it to flow more freely through small bore pipe work.
- 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.

6.0 MAINTENANCE

As the **GXM300 Series** access tubing and magnetic targets are installed within a borehole and grouted or within embankments it is a non-retrievable system and therefore maintenance free.

However the reed switch probe will require some basic maintenance including the following:-

- Status of the battery - change as required
- Cleanliness - always clean the probe, tape & reel after use
- When lowering and raising the probe make sure that the tape does not run over any sharp edges on the access tubing reeling

9.0 TROUBLESHOOTING

If when lowering the reed switch probe down the access tube no sound is audible check the following:-

- That magnetic targets have been installed in the installation (check installation records)
- That the light is visible - if not then the battery should be checked

8.0 SPECIFICATION

GXM-300	
Access Casing OD	33mm
Access Casing ID	25mm
Casing Length	1.0 or 3m
Casing Weight	0.6kg/m
Bottom Cap OD	33mm
Material	PVC
CORRUGATED PIPE (compressibility 40%)	
Pipe OD	42mm
Pipe ID	35mm
Length	3m ,50m coil
Magnetic Target/Coupler	42 x 50mm
Material	PE
ACCESSORIES	
Bottom Cap	33mm
Magnetic Targets	3 & 6 leaf
Mastic Tape	10m
Reed Switch Probe	30,50,100,150,200m

GXM-300i		
QJ inclinometer casing		
Casing OD	70mm	83mm
Casing ID	59mm	71mm
Casing Length	1.5 or 3m	1.5 or 3m
Casing Weight	1.27kg	1.35kg
Bottom Cap OD	70mm	83mm
Material	ABS	ABS
Groove Spiral	<0.005 Rad/3m	<0.005 Rad/3m

GXM-300i contd...

CORRUGATED PIPE (compressibility 40%)	
Pipe OD	90mm
Pipe ID	75mm
Length	3m ,50m coil
Magnetic Target/Coupler	90 x 70mm
Material	PE
ACCESSORIES	ACCESSORIES
Mastic Tape	10m
Reed Switch Probe	30,50,100,150, 200m

9.0 SPARE PARTS

The access tubing of **GEO-XM Series** magnetic settlement system (GXM100, GXM100T, GXM100P and GXM100C) is installed within non-recoverable environments (below ground) it is not serviceable nor does it contain any replaceable parts.

The reed switch probe which is used to measure the location of the magnetic targets has the following spare parts:-

Qty	Description
1	Spare probe & tape
1	9 volt battery
1	Reel
1	LED
1	Buzzer
2	Probe clips

10.0 RETURN OF GOODS

10.1 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, 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 and a copy of the form should be faxed or emailed in advance to the factory.

10.2 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.

10.3 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 **GXM300 Series** 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.

10.4 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.

10.5 Transport & Storage

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



11.0 LIMITED WARRANTY

The manufacturer, warrants the **GXM300 Series** 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 to allow **Geosense** to select the correct type and range of **GXM300 Series** and other component parts.

The **GXM300 Series** equipment shall be installed in accordance with the manufacturer's recommendations.

The equipment is warranted for 2 years 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 GXM300 Series equipment 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 **GXM300 Series** equipment from the time of delivery to Purchaser.



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