REFLEX™

Manual

Reflex EZ-TRAC™ with Reflex EZ-COM

January 2009

Increase your drilling productivity with reliability & ease of use. Superior data and decision making made EZ.

Disclaimer and Limitation of Liability
Reflex Instrument AB assumes no responsibility for any damage or loss resulting from the use of this manual.

Reflex Instrument AB assumes no responsibility for any damage or loss caused by deletion of data as a result of malfunction, dead battery or repairs.

Reflex Instrument AB assumes no responsibility for any loss or claims by third parties which may arise through the use of this product.

Due to continuous research and development, the information contained in this manual is subject to change without notice.

Part no. 100009

Table of contents

1 Introduction

Thank you for purchasing **REFLEX EZ-TRAC™** provided by **REFLEX™**. We are committed to providing superior quality surveying instruments for the drilling industry. **REFLEX EZ-TRAC™** is a highly accurate instrument, which will provide you with accurate and reliable information about the borehole path.

In order to take full advantage of your new investment, we recommend that you carefully read this Manual.

REFLEX™ reserves the right to update the contents and correct any unintentional errors in this Manual without notice.

1.1 Contact REFLEX™

The headquarters of **REFLEX™** is located in Perth, Western Australia.

Phone	+61 8 9445 4020
Fax	+61 8 9445 4040
E-mail	info@reflexinstruments.com
Web	www.reflexinstruments.com

Contact information to your nearest distributor of **REFLEX™** products is available at www.reflexinstruments.com.

1.2 Manual conventions

Notes of caution, hints and pointers are items to which you should pay particular attention.

Notes of caution tell you to pay special attention to certain subjects.

Hints are suggestions that will help you with tasks.

2 General

This chapter provides an overall description of **REFLEX EZ-TRAC™**.

2.1 REFLEX EZ-TRAC™ at a glance

REFLEX EZ-TRAC™ is an accurate and reliable instrument for surveying of boreholes in all directions in non-magnetic environments.

Figure 1 REFLEX EZ-TRAC™

2.1.1 Survey types

REFLEX EZ-TRAC™ is a multifunctional surveying instrument, with single shot, multi shot and orientation capabilities.

Single shot survey A single shot survey is carried out to determine the azimuth and the dip at a certain point inside a borehole.

Multi shot survey A multi shot survey is used to determine the azimuth, dip and the regional and local coordinates along a borehole path.

Orientation survey An orientation survey is carried out to determine the orientation or rotation (tool face) of a downhole object. **REFLEX EZ-TRAC™** is capable of performing orientation surveys in boreholes of all angles, including vertical.

2.1.2 Magnetic and gravimetric

REFLEX EZ-TRAC™ provides survey data based on magnetic and gravimetric measurements.

Magnetometers Three fluxgate magnetometers aligned in orthogonal directions measure the Earth's magnetic field strength and dip. The magnetometers provide the horizontal component - the azimuth - and the magnetic tool face.

Accelerometers Three accelerometers aligned in orthogonal directions provide the vertical component - the dip - and the gravity tool face. The accelerometer readings are also used to compensate for the rotation of the instrument as it moves in the hole.

2.1.3 Survey accuracy

REFLEX EZ-TRAC™ is designed to provide accurate and reliable survey data. However, the survey accuracy depends on how the instrument is operated.

Magnetism **REFLEX EZ-TRAC™** is a magnetic instrument. Any interference from man-made or natural magnetism will disturb the magnetometers, which will result in incorrect measurements.

Station depth The exact depth of a survey station is not critical for **REFLEX EZ-TRAC™**, but the more precisely the instrument is positioned at the survey station the more accurate the survey.

2.1.4 Equipment

Instrument probe

The **REFLEX EZ-TRAC™** instrument probe is a robust tube that holds the electronic sensors, the onboard computer and the battery pack. In the upper end of the probe there is an IR port, which is used for communication with the control unit. The outer diameter of the probe is 35 mm.

Extension rods

Since **REFLEX EZ-TRAC™** is a magnetic instrument, it has to be placed at a distance from any magnetic interference. Aluminium extension rods are used for this purpose.

Control unit

The **REFLEX™ EZ-COM** unit is used to control the **REFLEX EZ-TRAC™** instrument. **REFLEX™ EZ-COM** is a robust handheld unit developed by **REFLEX™**. The user interface is menu driven and provides Single Shot and Orientation functionality as standard, with Multi Shot as a license key enabled option.

2.1.5 Post processing of data

The survey data can be downloaded to **REFLEX™ SProcess**, a Windows based processing software. In addition to the survey results presented on the **REFLEX™ EZ-COM** unit, regional and local coordinates of Multi Shot surveys are calculated and presented in **REFLEX™ SProcess**.

Reflex SProcess

REFLEX™ SProcess provides a single integrated project area for viewing, printing and exporting survey data generated by **REFLEX™** instruments. Survey data can be exported to other programs for further processing, such as exploration and mine planning systems.

2.2 Warranty

Worldwide warranty

The **REFLEX EZ-TRAC™** instrument and **REFLEX™** genuine parts are covered by a worldwide warranty of material and workmanship.

Registration slip

The warranty documentation is included in the delivery package. The warranty registration slip in the lower part of the document should be returned to **REFLEX™**, to ensure that you are correctly listed for the full terms of the warranty.

Misuse

REFLEX™ reserves the right to repair or replace defective component(s) as necessary. The warranty does not cover faults due to misuse, damage caused by unauthorized modification to the instrument or if instructions in the user documentation are not followed.

2.2.1 Shipping instructions for instrument return

If any malfunction should occur, please contact **REFLEX™** or your authorized **REFLEX™** distributor for instructions.

Transport case

Please use the original transport case for return shipment. Do not ship until you get shipping instructions.

3 About Surveying

This chapter is a general description of how underground information, such as the position of a borehole and the direction of an object inside the hole, may be obtained by surveying with magnetic instruments.

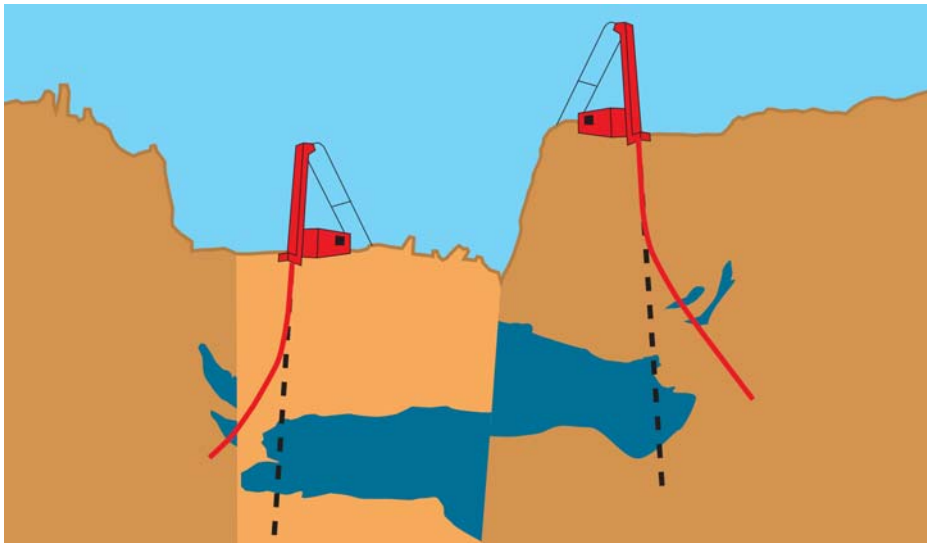
This chapter also presents different surveying options.

3.1 All boreholes deviate

In spite of technical developments in drilling equipment, it is difficult, if not impossible, to drill an accurate straight hole. For geological mapping, geophysical downhole surveys and for economical evaluation of mineralized rock formation, it is vital to know the exact position of the hole along its entire length.

Boreholes may deviate from the planned path in any direction. If you do not know the exact path of the borehole it becomes difficult to make accurate assessments, for example, ore volume and location assessments.

Figure 2 All boreholes deviate



3.1.1 Calculation of underground positions

With the technology of today we can determine positions on land and at sea with marvellous precision. We can make use of dependable methods like measuring distance and angles or we can use systems such as GPS. Below the surface things becomes slightly different.

Spatial coordinates The spatial coordinates of points along a borehole path cannot be measured directly. However, with mathematical algorithms the coordinates may be calculated based on a combination of measurable properties such as distance, curvature, direction of the Earth's magnetic field and gravitational field.

Field measurements Magnetic tool calculations are based on measurements in three directions of the gravitational and magnetic field at a particular depth.

3.2 Direction of downhole object

When conducting directional drilling, a metal wedge is applied in the borehole to force the drill bit to move out of the direction of the existing hole. The direction of the downhole wedge has to be determined in order to verify that the drilling will continue in the desired direction.

Directional information is also needed in core orientation, impressions of bore walls and for orientation of tools, such as downhole motors.

By combining a directional survey of the wedge with surveys of the tool orientation, the position of the tool can be adjusted correctly.

3.2.1 Measurement of direction

The direction of a downhole object can be determined by measuring the rotation of the survey instrument relative to gravity or magnetic north.

3.3 Single shot survey

A single shot survey is carried out to determine the azimuth (direction) and dip (inclination) at a certain point inside a borehole.

Single shot surveys are used at regular intervals as a hole is being drilled. Based on the survey information, decisions regarding further drilling can be made and corrections applied if needed. For example, wedge setting might be needed to change the direction of the borehole.

3.4 Multi shot survey

A multi shot survey is used to determine the regional and local coordinates along a borehole path, in addition to the azimuth (direction) and dip (inclination).

The multi shot survey data is used to calculate the position of a borehole along its entire path. It is also an efficient method to identify sharp changes in the borehole direction.

3.5 Orientation survey

An orientation survey is carried out to determine the orientation or direction of a wedge during directional drilling, or to measure the rotational position of a tool within the drill string or at the end of the drill string.

Reference angle The orientation survey consists of two measurements; registration of a reference at the surface and registration of the instrument rotation at the survey station inside the hole.

Angle of rotation The control unit software displays the rotation (tool face) of the object, compares it to the desired value, and gives the required angle of rotation if the object is not in the correct position.

4 Working Principles

This chapter describes the working principles of magnetic instruments from **REFLEX™**.

4.1 Introduction

REFLEX™ magnetic instruments provide survey results of azimuth, dip, magnetic field strength, magnetic dip, gravity, gravity tool face, magnetic tool face and temperature.

Azimuth is measured with magnetometers. Based on data from the magnetometers, the direction of the instrument relative to the Earth's magnetic field is calculated.

Dip and roll angle (gravity tool face) are measured with accelerometers. Based on data from the accelerometers, the direction of the instrument relative to the Earth's gravitational field is calculated.

Based on data from the magnetometers and the accelerometers, the total magnetic field strength and the magnetic dip are also calculated.

An electronic temperature sensor measures the temperature.

4.2 Magnetism

The Earth is surrounded by an invisible force – the geomagnetic field. The magnetic field originates deep within the Earth, and extends far out into space. The geomagnetic field is approximately directed from south to north, and changes constantly in direction and strength.

4.2.1 Magnetometers

The instrument probe contains three fluxgate magnetometers aligned in orthogonal directions. The magnetometers register the local geomagnetic field and provide the horizontal component (the azimuth) relative to the magnetic north.

A fluxgate magnetometer is based on the saturation of magnetic materials, and this is how it works:

A typical electromagnet has an iron core with a coil around it. The magnetic atoms of the iron substantially strengthen the magnetic field of the coil.

The magnetic axes of the atoms in ordinary iron point in random directions. The sum of their magnetic fields is close to zero. But, when an electric current flows in the coil, the magnetic field - which is generated by the current - forces the magnetic axes of the iron atoms to line up with and strengthen the magnetic field created by the current.

However, when all atoms are lined up, the iron core cannot contribute to the magnetic field any more. This state is called the saturation magnetisation of the iron. If the electric current is increased in the coil, the magnetic field only increases by the amount due to the current itself, without any help from the iron core.

There are materials where the saturation happens suddenly, completely and at a well defined level. If a core of such material is

used in an electromagnet, and an alternating current is run through the coil, the magnetic polarity of the coil changes directions back and forth. The saturation occurs symmetrically in each half of the cycle.

However, the saturation depends on the total magnetic intensity. If the electromagnet is placed in an existing magnetic field, the total magnetic intensity will vary. In one half of the cycle, the magnetisation due to the current in the coil will be added to the existing magnetic field. In the other half, the existing magnetic field strength will be reduced by the magnetisation. Hence, in half of the cycle the saturation will occur a bit earlier, in the other half it will happen somewhat later. This asymmetry is possible to register electronically.

Now, if a fluxgate magnetometer, which is based on the operation described above, is placed in the borehole, it will be capable of register the Earth's magnetic field. Three magnetometers placed at right angles are needed to fully determine the strength and direction of the field.

4.3 Gravity

Gravity is a force that attracts objects together. On Earth, gravity pulls objects towards the centre of the Earth.

4.3.1 Accelerometers

The instrument probe contains three MEMS capacitive accelerometers aligned in orthogonal directions. The accelerometers provide the vertical component (dip or inclination) and the rotation relative gravity. The accelerometer readings are also used to compensate for the rotation of the instrument as it moves in the borehole.

MEMS is an abbreviation for Micro-Electro-Mechanical Systems. MEMS technology allows the creation of small functional components via semiconductor-like manufacturing. A MEMS accelerometer is a fully self-contained sensor, with all electronics integrated into a component of small dimensions.

A capacitive accelerometer senses the change in electrical capacitance with respect to acceleration. The sensing element consists of two parallel plate capacitors, with a seismic mass in between. Under acceleration, the inertia makes the mass move between the plates, which changes the values of the capacitors. This differential variation is captured by a detecting circuit, which translates the signal into a calibrated voltage output.

4.4 Temperature

The instrument probe contains an electronic temperature senor. This sensor is used to measure the temperature for internal stabilization. The temperature values are also displayed in the control unit.

5 About Survey Accuracy

This chapter describes the survey accuracy of **REFLEX EZ-TRAC™** and explains the sources of errors.

5.1 Introduction

REFLEX™ surveying instruments are designed to provide accurate and reliable survey data.

The range and typical error of the parameters measured by **REFLEX EZ-TRAC™** are shown in the table below.

Figure 3 Range and typical error

Parameter	Range	Typical error
Azimuth	0º to 360º	± 0.35º
Dip	± 90º from horizontal	± 0.25º
Magnetic field strength	0 to 100,000 nT	± 50 nT
Magnetic dip	± 90º from horizontal	± 0.25º
Gravity tool face	0º to 360º	± 0.25º
Magnetic tool face	0º to 360º	± 0.35º

5.2 Magnetic interference

As for all magnetic instruments, any interference from man-made or natural magnetism will disturb the magnetometers, which will result in incorrect measurements.

Magnetic instruments try to measure their own heading relative to the direction of the magnetic north. If that field direction is distorted by e.g. a deposit of magnetite, the instrument will simply record a deviation of the hole. You will not know whether that is a real deviation or simply distortion of the magnetic vector.

Incorrect interpretation of azimuth data in mineral exploration may result in heavy costs. These may range from trying to straighten an apparently deviated hole to sinking shafts in the wrong position.

In construction projects, where anomalies are more often man-made, the results may be equally serious. The most common are voids in grout and freeze curtains, ground anchor interference and incorrect geotechnical data.

5.2.1 Man-made interference from within the hole

It is vital that the instrument does not come closer than three meters to rods, casing or other in-hole tools made from any form of ferrous, magnetic metal.

All measurements must always be made in an open section of the hole, unless it is lined with plastic or other non-ferrous casing or rod. If ferrous metal rod or wire is used to run the instrument into the hole, a minimum of three 1.5 meter long aluminium extension rods have to be used.

Occasionally drilling tools may wear and leave small traces of steel on the hole wall. You are unlikely to know about this, but it may upset your magnetic readings.

5.2.2 *Man-made interference from outside the hole*

Below is a selection of the more common causes of fabricated interference:

- The drill rig itself
- Rock bolts or reinforcement mesh
- Nearby mine or tunnel workings and plant
- Piles or ground anchors
- Underground services such as pipes, cables
- Tools or equipment in another borehole
- Electrical power lines

5.2.3 *Natural magnetism*

Magnetite, phyrrotite and titanium oxides are all naturally magnetic minerals. If you have cored through them, their presence should be obvious. It will be more difficult to detect them if you drill full hole and log cuttings. If cuttings or core are only analysed (assayed) after hole completion, you may not know about geomagnetism at the time of survey.

These minerals may still affect the survey if the hole has passed close to them without there being any evidence in core or cuttings.

The other natural danger is secondary remnant magnetisation. This takes place in rocks that are not naturally (primary) magnetic when they are formed; but at a later date, for a number of reasons, acquire an induced magnetisation. Some rocks are more “susceptible’ to this than others. Use of a borehole susceptibility meter will indicate which rocks are more, or less, susceptible; but it will not tell you which ones might have upset your magnetic readings.

Secondary magnetization can affect all lithologies including sedimentary materials.

5.3 Identify interference

The net result of any form of in-hole magnetic disturbance, natural or man-made, is azimuth error. As coordinate calculations are based on azimuth readings, these values will also be erroneous. You will not be able to tell whether it is your hole or magnetic north that has been deviated.

However, **REFLEX™** magnetic instruments provide you with information that will assist you to interpret the survey data. This, when combined with other geological, mineralogical and drilling data, enables you to make the best possible decisions about the true course of your holes.

5.3.1 *Earth's Magnetic Field*

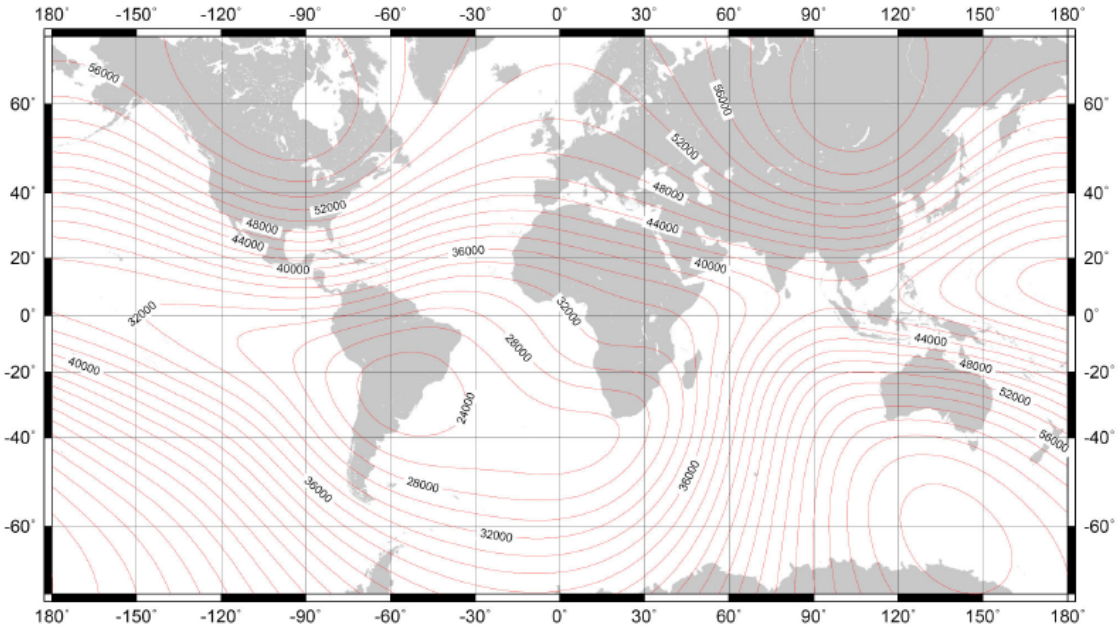
The Earth's magnetic field changes with location and over time. The maps below can be used as a general reference when verifying if the measured values are reasonable. For updated information about the magnetic field variation, please refer to for example http://www.geomag.bgs.ac.uk/mercator.html.

5.3.1.1 Total intensity

The total intensity (total magnetic field strength) year 2005 according to the British Geological Survey (Natural Environment Research Council) is presented in the figure below.

The contour interval is 2000 nT.

Figure 4 Total intensity 2005

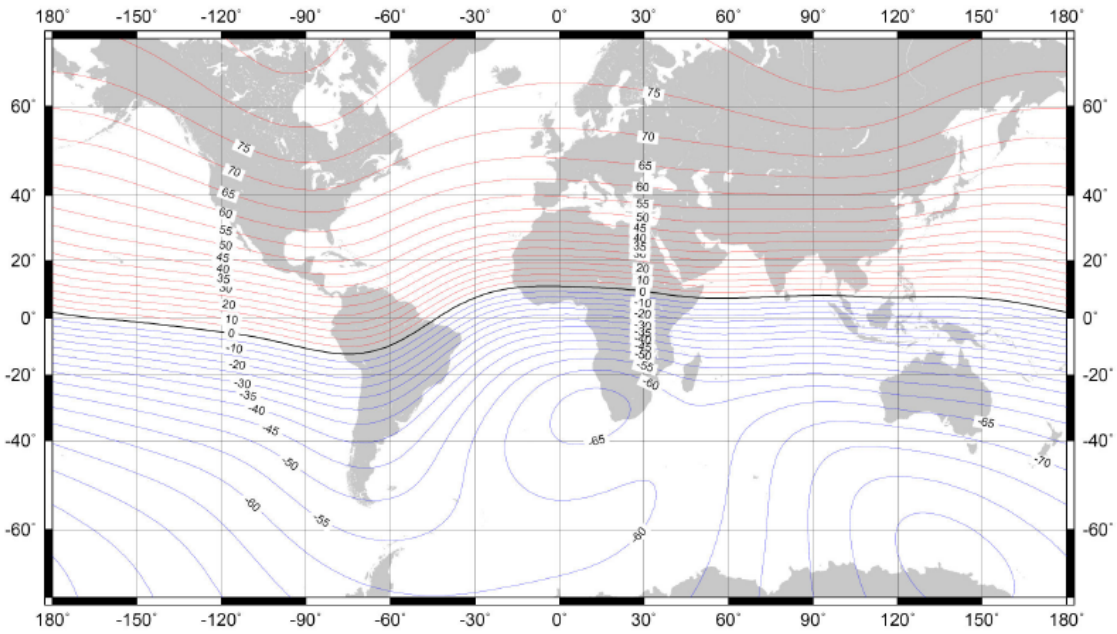


5.3.1.2 Inclination

The inclination (magnetic dip) year 2005 according to the British Geological Survey (Natural Environment Research Council) is presented in the figure below.

The contour interval is 5º.

Figure 5 Inclination 2005

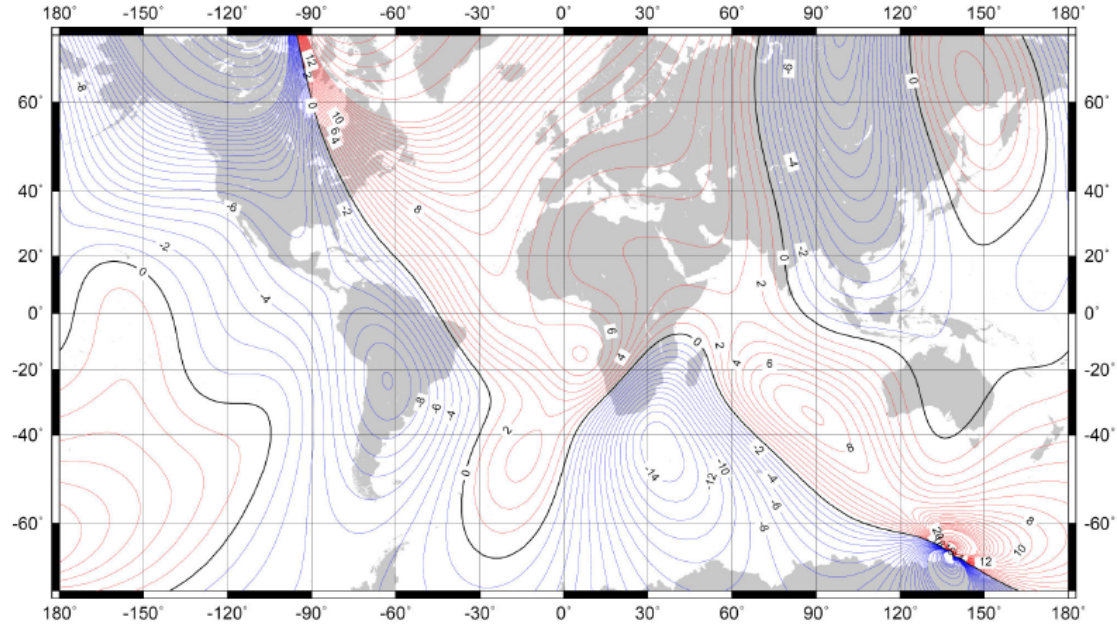


5.3.1.3 Annual rate of change

The annual rate of change of the declination for 2005 to 2010 according to the British Geological Survey (Natural Environment Research Council) is presented in the figure below.

The contour interval is 1'/year up to ±20'/year, thereafter 5'/year.

Figure 6 Annual rate of change



5.3.2 Background magnetic field

The local total magnetic field influences the measurements of magnetic instruments. To be able to compensate for the background magnetic field, a reference measurement made away from any magnetic disturbances is needed.

For a surface drill program, place the instrument in the location you plan to drill before the drill arrives. If that is not feasible, place the instrument as near the borehole as possible but away from any magnetic interference. Use the instrument to measure the background magnetic field strength and the magnetic dip and store this magnetic reference in the control unit.

As an alternative, you can compile both values from your on-going drill program along with the geology and magnetic susceptibility. This will give you a good idea of what the background magnetic field value is.

At the mine site the first option may not be possible due to all the man made disturbances. In this case, the determination of the background magnetic field value should be done by compiling the data from the actual boreholes to establish the baseline. The magnetic reference is possible to enter manually in **REFLEX™ SProcess**.

5.3.3 *Magnetic threshold*

A reasonable amount of natural variation of the magnetic field strength is ±1,000 nT and ±0.5 degrees for the magnetic dip.

In the **REFLEX™ EZ-COM** unit, the accepted range is ±1,000 nT from the magnetic field strength reference value, and ±0.5 deg from the magnetic dip reference value. For survey stations that are outside the accepted range, values which depend on input from the magnetic sensors will be highlighted.

5.3.4 *Quality control*

Using the quality checks on a daily basis will allow you to get familiar with your measurements, which will ensure quality interpretations of the survey data.

The measurements of the total magnetic field strength and magnetic dip are useful in determining the integrity of the data.

A magnetic anomaly may cause changes in either or both magnetic field values. It is therefore vital that you examine the magnetic field strength and magnetic dip at every station. Small changes in either parameter indicate a disturbance that may be upsetting the measured azimuth, and therefore the survey accuracy.

5.3.5 *Filter out bad data*

There is nothing you can do to change the measured azimuth because there is no way of calculating, or even estimating, the magnitude of the error. What you can do, is to filter out those measured stations you believe to have been upset by some sort of magnetic anomaly.

Filtering functionality, which automatically excludes erroneous data, is included in **REFLEX™ SProcess**.

Filtering must be used with care. A magnetic anomaly could be concealing or exaggerating a natural deviation of the hole. Even if these stations are excluded, it might not be possible to get an accurate survey.

If you have been using a rather long survey interval, it may be worth while rerunning the survey over the affected section of hole, using a shorter interval. You then use the merge facility to join the recalculated section into the original survey.

5.4 Survey station depth

The exact depth of a survey station is not critical, but the more precisely the instrument is positioned at the survey station the more accurate the survey.

If a hole deviates considerably, station accuracy may become more important.

Drill rods generally have the same known length. This makes it easy, simply by counting rods, to put the instrument where you want it in the hole.

Coiled running systems, such as wire, pipe or rod, should be fully calibrated or have a linear counter. However, it is possible, by measuring out a given length on the ground or up the rig mast, to mark equal intervals on the running system and count these as they are wound into or out of the hole.

5.5 Centralization

Centralization, or the likelihood of the instrument lying parallel to the hole, is also important for the survey accuracy.

If centralization – that is, hole inner diameter minus tool outer diameter – is within a few millimetres, the possibility of misalignment of the instrument is small. The accuracy of the survey will be unaffected.

If however you run the instrument in a hole with much larger diameter, the potential error could approach several degrees. If that is repeated throughout the hole then, for every 100 metres, the error will increase.

Generally, the problem is minimised on surveys taken while pulling out of downward inclined holes. This advantage is not available in upward holes.

In a horizontal or shallow inclined hole, gravity will try to pull the instrument parallel to the axis of the hole. In steeper holes this may not be valid.

5.6 Temperature

The temperature impacts the accuracy of the instrument. For full survey accuracy of all parameters, the ambient temperature must be within 0 ºC to +60 ºC.

5.7 Comparisons and Averaging

By performing a multi shot survey in both directions, repeatability comparisons and averaging of results are possible. By averaging the survey data, a more accurate result will be obtained.

6 About Survey Data

This chapter describes the survey data provided by magnetic instruments from **REFLEX™**.

6.1 Introduction

REFLEX™ magnetic instruments measure and displays the following basic survey data:

Azimuth	0º to 360º
Dip	±90º
Magnetic field strength	0 to 100,000 nT
Magnetic dip	±90º
Gravity tool face	0º to 360º
Magnetic tool face	0º to 360º

6.2 Dip and azimuth

Dip, or inclination, is the angle from the horizontal plane to the borehole. Azimuth, or the direction of the dip, is the angle from north to the horizontal projection of the borehole.

The readings of dip and azimuth are absolute measurements, at a particular depth, of the direction of the instrument relative to the gravitational and magnetic vectors.

The dip and azimuth angles, along with the depth of the survey station, are used to calculate the regional and local coordinates of the survey station.

The mathematic algorithms needed for the calculations of the coordinates are included in **REFLEX™ SProcess**.

6.3 Magnetic components

Based on data from the magnetometers and the accelerometers, two types of magnetic data are calculated; total magnetic field strength and magnetic dip.

6.3.1 Total magnetic field strength

The Earth's total magnetic field strength is reported in nanoTesla (nT). This is the unit in which magnetic survey maps are often contoured. This is the force exerted by the Earth's magnetic field at any particular point. The magnetic field increases in strength towards the poles, but have minimal change down the borehole.

Several items will distort the Earth's magnetic field, such as solar wind from the sun, rocks (wide range of magnetic influences) and man made ferrous objects.

6.3.2 Magnetic dip

The Earth's magnetic field does not run parallel to the Earth's surface. The magnetic dip is the angle from the horizontal plane to the magnetic lines of force.

The magnetic dip can vary depending on ones position on the surface of the Earth. Near the equator it approaches horizontal (0 degrees), but steeper towards vertical (90 degrees) at the poles.

The general convention is that the magnetic dip is positive (downwards) in the northern hemisphere and negative (upwards) in the southern.

6.3.3 *Magnetic integrity*

Since two types of magnetic data are provided – the total magnetic field strength and the magnetic dip – it is possible to check if the magnetic results are plausible.

Both values should remain constant in any given location, with some natural variation, unless altered by some form of natural or man-made disturbance.

In order to determine if discrepancies are present, the background field (magnetic reference) has to be established.

6.3.4 *Magnetic declination*

The direction in which the compass needle points is referred to as magnetic north. The angle between magnetic north (horizontal component of the magnetic field) and true north is called magnetic declination. It can also be referred to as magnetic variation or compass variation.

The magnetic declination varies from place to place and with time, due to the complex fluid motion in the Earth's core. This causes the magnetic field to change with time. This change is known as secular variation.

*Note, **REFLEX™** magnetic instruments measure the azimuth relative to magnetic north. To obtain the true north, magnetic declination rules must be applied. As a general rule, you must subtract if the declination is west and add if the declination is east.*

The value for the geomagnetic declination may be obtained from regional geomagnetic declination and inclination maps or from geomagnetic reference field models. This magnetic declination value may be entered in and applied to surveys in **REFLEX™ SProcess**.

6.4 Rotation

REFLEX™ magnetic instruments are capable of measuring rotation relative to both gravity, using the gravity tool face angle, and to magnetic north, using the magnetic tool face angle.

Rotation relative to gravity is used for inclinations from -85 to +85 degrees. Rotation relative to magnetic north is used for holes that are within 5 degrees from vertical.

The rotation information is used to determine the orientation of a downhole object, for example a wedge or a tool.

6.5 Temperature

REFLEX™ magnetic instruments have electronic temperature sensors that measure the temperature of the instrument itself.

For full survey accuracy of all parameters, the ambient temperature of the instrument must be within 0 ºC to +60 ºC.

The temperature is an indirect indicator of water flows in the borehole, which could indicate faults and bad rock formations.

7 About the REFLEX EZ-TRAC™ equipment

This chapter describes the equipment for **REFLEX EZ-TRAC™**.

7.1 Instrument

1. Instrument probe

The instrument probe is a robust tube that holds the electronic sensors, the onboard computer and the battery pack. In the upper end of the probe there is an IR port, which is used for communication with the control unit. The outer diameter of the probe is 35 mm.

2. Top coupling

The top coupling is used to seal the upper end of the instrument probe, to protect the IR port. The top coupling is sealed with sealing rings to avoid drilling fluid ingress and to maintain proper pressure sealing.

3. Bottom nose

The bottom nose is removed when orientation equipment is to be attached.

4. Battery pack

The lithium battery pack is designed to give several years of life under normal conditions. The battery pack can be replaced in the field, please refer to chapter *Battery Replacement*.

7.2 Control unit

5. REFLEX™ EZ-COM unit

REFLEX™ EZ-COM, which is a robust handheld unit developed by **REFLEX™**, is used to control the **REFLEX EZ-TRAC™** instrument.

6. Multi Shot license key

The Multi Shot license key is needed to enable the Multi Shot functionality in the **REFLEX™ EZ-COM** unit. The license key is linked to the serial number of the unit.

7. USB cable, Type A-A

The USB cable is used to connect the **REFLEX™ EZ-COM** unit to a PC, to allow transfer of survey files. The USB cable has a Male Type A connector in both ends.

7.3 Utilities

10. Silicon grease

Silicon grease is applied to the sealing rings to ensure that they stay moist, in order to keep the instrument probe water tight.

11. Sealing rings

The sealing rings keep the instrument probe clean and water tight. Use of clean, undamaged and correctly sized sealing rings is vital. The sealing ring dimensions are 24mm x 3mm.

12. Open end wrench

Open end wrenches are used to tighten subs and extension rods. The wrenches should only be placed in the designated machined slots.

7.4 Running gear

13. Aluminium extension rods

The non-magnetic aluminium extension rods are used to extend the instrument a safe distance from any magnetic interference, such as the drill rig or other man made or natural disturbances. The extension rods are 1.5 meters long and a minimum of three must be used when extending past the bit. The extension rods also assist the assembly to lay flat in the hole, giving more accurate readings opposed to a short rod. The extension rods have a box end and pin end.

14. Pin spear landing collar assembly

The pin spear landing collar assembly consists of a steel body, nylon landing collar and a spring. The nylons are size specific to the bit

diameter and designed to stop the assembly in the bit extending the instrument past the drill string. The landing collar has an adjustable steel spear point end which latches to the overshot. The opposite end is threaded into the aluminium extension rod. The most common application is wireline drilling with negative inclinations of –90 to –45. The pin spear landing collar assembly is available in standard drilling sizes.

15. Pin spear coupling

A pin spear coupling assembled with a landing collar is an alternative to the pin spear landing collar assembly.

16. Landing collar

The landing collar is used together with a pin spear coupling. The landing collar consists of a steel body with nylon landing collars and spring. The nylons are size specific to the bit diameter, can be interchanged with the steel body and are available for all current drill diameters. The nylons are designed to stop the assembly in the bit extending the instrument past the drill string. The spring absorbs the impact shock as the collar lands in the bit.

17. Landing collar box type

The landing collar box type consists of a steel body with nylon landing collars and spring. The nylons are size specific to the bit diameter, as they are designed to stop the assembly in the bit extending the instrument past the drill string. The landing collars have a box type configuration which is threaded onto the overshot. The size of this box thread is dependent on the overshot size (this could be a BQ or NQ box coupling). Nylon can be interchanged with the steel body and are available for all current drill diameters. The most common application is wireline drilling with negative inclinations of –90 to –45 and for those who do not feel comfortable with latch type applications.

18. Brass Wireline Swivel

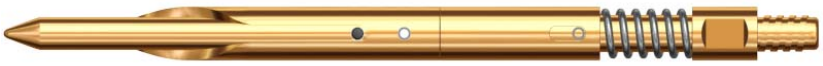
The swivel is made of brass. It must be non-magnetic as sometimes the swivel is attached directly to the top coupling without any aluminium extension rods, most commonly in open hole surveying applications. The swivel has ball bearings, which prevents the wireline from becoming tangled and twisted due to the ability to rotate freely. Wireline is threaded through the eyelet and the cable is crimped with special adapters to form a strong loop and knot. The

threaded end is attached to the top coupling or aluminium extension rod. The most common application is open hole surveying in single or multi shot mode.

7.5 Orientation equipment

The orientation equipment is needed for Orientation Surveys.

19. Orientation mule shoe



The orientation mule shoe orientates the instrument with the steel pin in the mule shoe sleeve.

20. Orientation bull plug

The orientation bull plug allows the instrument to be correctly aligned with the orientation mule shoe. Inside the bull plug there is a shock absorbing spring.

21. Lead tell tale

A lead tell tale is placed in the orientation mule shoe. The tell tale is used to verify that the instrument has been correctly positioned during the measurement.

22. Mule shoe sleeve

The mule shoe sleeve is assembled with the device to orientate, e.g. a wedge. The mule shoe sleeve is used to ensure that the survey system is positioned in line with the device down in the borehole. The diameter and threads of the mule shoe sleeve should be exactly the same as the drill rods being used. The mule shoe sleeve is available in 0.6 m/2 ft sections in different sizes; BQ, NQ and HQ.

7.6 Part Numbers

Should you need to buy additional parts, please contact your authorised **REFLEX™** distributor or **REFLEX™**. For contact information, please refer to www.reflexinstruments.com.

For fast supply of the part, please use the part numbers in the lists below. The item numbers are the same as in the previous sections and figures.

7.6.1 Instrument

Part numbers for the **REFLEX EZ-TRAC™** instrument:

Item no.	Item	Part no.
1.	Instrument probe (including top coupling and bottom nose)	2200050
2.	Top coupling	2210001

3.	Bottom nose	2210002
4.	Battery pack	2212001

7.6.2 Control unit

Part numbers for the **REFLEX™ EZ-COM** control unit:

Item no.	Item	Part no.
5.	REFLEX™ EZ-COM unit	2221001
6.	Multi Shot license key	2222201
7.	USB cable, Type A-A	2221021
8.	REFLEX™ EZ-COM battery	2221101

7.6.3 Utilities

Part numbers for utilities:

Item no.	Item	Part no.
9.	Transport case	2251001
10.	Silicon grease	1100021
11.	Sealing rings (set of 30)	2261001
12.	Open end wrench	3100034

7.6.4 Running gear equipment

Part numbers for the running gear equipment:

Item no.	Item	Part no.
13.	Aluminium extension rod	3100032
14.	Pin spear landing collar assembly	
	BQ size	4100070
	NQ size	4100071
	HQ size	4100072
15.	Pin spear coupling	3100028
16.	Landing collar	
	BQ size	3100024
	NQ size	3100025
	HQ size	3100026
	PQ size	3100027
17.	Landing collar box type	
	BQ size	4100073
	NQ size	4100074
	HQ size	4100075
18.	Brass Wireline Swivel	4100076

7.6.5 *Orientation equipment*

Part numbers for the orientation equipment.

Item no.	Item	Part no.
19.	Orientation mule shoe	3100030
20.	Orientation bull plug for Reflex EZ-Trac	2210003
21.	Lead tell tale, set of 6	3100043
22.	Mule shoe sleeve	
	BQ box – pin	3100044
	NQ box – pin	3100045
	HQ box – pin	3100047

7.7 Equipment overview

An overview of all **REFLEX EZ-TRAC™** equipment is shown in the figures below.

The item numbers are the same as in the previous sections and figures.

Figure 7 Instrument

1.

2.

3.

4.

Figure 8 Control unit

5.

Figure 9 Utilities

10.

11.

12.

Figure 10 Running gear equipment

13.

14. **15.** **16.** **17.**

18.

Figure 11 Orientation equipment

19. **21.**

20.

22.

8 About the REFLEX™ EZ-COM control unit

This chapter describes the **REFLEX™ EZ-COM** control unit.

8.1 Control unit

REFLEX™ EZ-COM is a robust handheld unit developed by **REFLEX™**. The user interface is menu driven and provides Single Shot and Orientation functionality as standard, with Multi Shot as a license key enabled option.

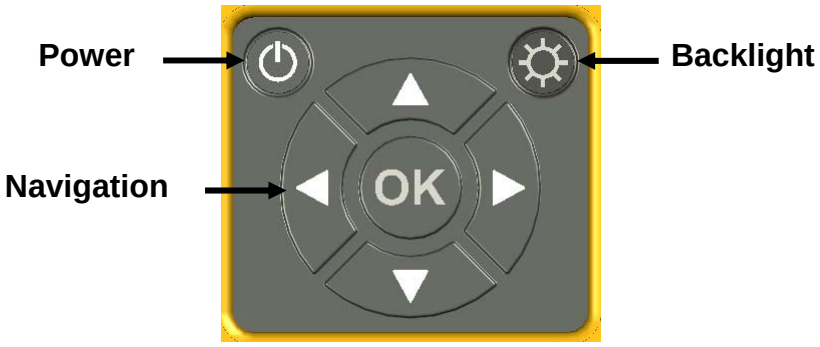
REFLEX™ EZ-COM has an integrated infrared (IR) port for communication with the instrument. The control unit is equipped with a long-life battery pack.

Figure 12 Reflex EZ-Com

8.1.1 Keypad

The **REFLEX™ EZ-COM** keypad has a power key, a backlight key and five keys for navigation control.

Figure 13 Keypad



Power key

The power key is used to turn on/off the **REFLEX™ EZ-COM** unit. To turn on the unit, the power key is pressed once. To turn off the unit, the power key has to be pressed until ‘Shutting down…’ is displayed.

Auto Power Off If keys have not been pressed for 5 minutes, the power is automatically turned off to save battery. When the power key is pressed again, the unit resumes where it was before turned off.

Manual Power Off If the unit is manually powered off, it starts from the MAIN menu when powered on again. However, if the unit is powered off during survey execution, the execution is resumed when the unit is powered on again.

Backlight key The backlight key is used to turn on/off the backlight.

Auto Backlight Off If keys have not been pressed for 30 seconds, the backlight is automatically turned off to save battery.

Navigation control The menu driven user interface is controlled with the four arrow keys (UP, DOWN, LEFT and RIGHT) and the OK key.

UP/DOWN The UP/DOWN keys are normally used to navigate upwards/downwards on the display.

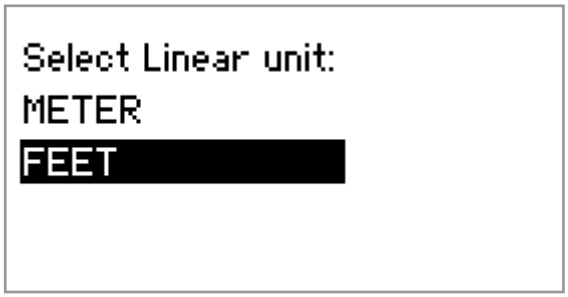
LEFT/RIGHT The LEFT/RIGHT keys are normally used to navigate to the left/right on the display.

Navigate back The LEFT key is sometimes, for examples in the menus, used to navigate back to the previous screen.

Fast navigation Fast navigation is available when entering characters and in the result lists. If the UP/DOWN or LEFT/RIGHT key is held down, you navigate directly to the top/bottom or to the far left/right.

Active option The active option is inversed on the display. The figure below shows the active option FEET.

Figure 14 Active option

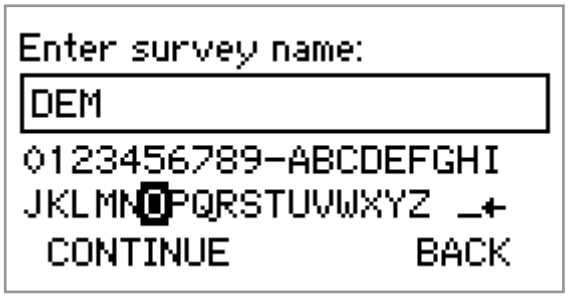


OK The OK key is used to select the active option.

8.1.2 Enter characters

When Survey Name, Survey Depth, Survey Interval etc are to be entered, a list with the available characters is displayed.

Figure 15 Enter characters



Select character The UP/DOWN and LEFT/RIGHT keys are used to navigate to the desired character. The OK key is used to select the active character.

Fast navigation If the LEFT/RIGHT key is held down, you navigate directly to the far left/right.

Delete If the arrow to the right in the line of characters is active when the OK key is pressed, the last character is deleted.

Continue When the first character has been entered, the **CONTINUE** option is displayed. To continue to the next screen, use the DOWN key to go to **CONTINUE** and then the OK key to select **CONTINUE**.

8.1.3 *IR communication*

REFLEX™ EZ-COM communicates with the instrument via an infrared (IR) communication connection. The IR port of the **REFLEX™ EZ-COM** is placed in the top of the unit, and it has to be directed towards the IR port of the instrument for communication.

Figure 16 IR port

8.1.4 *USB connector*

In the bottom of the **REFLEX™ EZ-COM** unit there is a USB connector, which allows transfer of survey files to a USB Memory stick or directly to a PC.

For detailed instructions on how to transfer survey files, please refer to the chapter *Transfer survey files.*

Figure 17 USB connector

8.1.5 Software version

When the **REFLEX™ EZ-COM** unit is turned on, the software version is displayed under the **REFLEX™** logo.

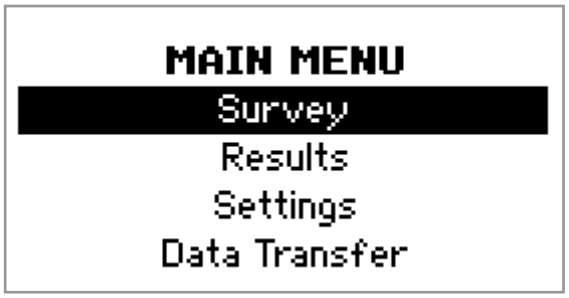
In the figure below, the software version is 1.2.0.

Figure 18 Version number

8.2 Main Menu

The MAIN menu is displayed at start up a short while after the **REFLEX™** logo is shown. The MAIN menu gives access to the SURVEY, RESULTS, SETTINGS and DATA TRANSFER menus.

Figure 19 MAIN menu



Survey The SURVEY menu gives access to the Single Shot, Multi Shot and Orientation surveying functions.

Results The RESULTS menu gives access to all stored Single Shot, Multi Shot and Orientation surveys.

Settings The SETTINGS menu gives access to the settings functionality; Units, Magnetic Reference, Time & Date, Language and License Key.

Data Transfer The DATA TRANSFER menu gives access to the data transfer functionality, which allows transfer of survey data to a USB Memory stick or directly to a PC.

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

8.2.1 *Multi Shot enabler*

Multi Shot functionality is available as a license key enabled option.

If you have lost your license key, or if you would like to upgrade your **REFLEX™ EZ-COM** unit to include Multi Shot functionality, please contact **REFLEX™** or your authorized **REFLEX™** distributor.

Note, the serial number of the **REFLEX™ EZ-COM** unit is needed to obtain the license key. Please refer to the following section.

8.2.1.1 Serial number

The serial number of the **REFLEX™ EZ-COM** unit is displayed in the License Key function.

Display serial number

1. From the MAIN menu, select **Settings**.
2. From the SETTINGS menu, select **Device**.
3. From the DEVICE menu, select **License Key**.
4. The serial number of the unit is displayed to the right.
5. Select **CANCEL** to return to the DEVICE menu.
6. Use the LEFT key to return to the MAIN menu.

In the figure below, the serial number is 0004.

Figure 20 Serial number

8.2.1.2 Enable Multi Shot

In order to enable the Multi Shot functionality, you need a license key assigned to your particular **REFLEX™ EZ-COM** unit.

Figure 21 Enable Multi Shot

Enable Multi Shot

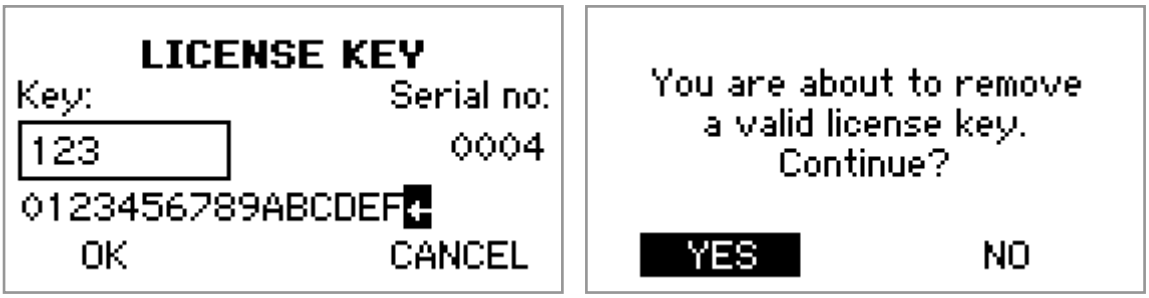
1. From the MAIN menu, select **Settings**.
2. From the SETTINGS menu, select **Device**.
3. From the DEVICE menu, select **License Key**.
4. Enter the license key.
5. Use the DOWN key to go to **OK** on the display.
6. Use the OK key to select **OK** on the display.
7. Use the LEFT key to return to the MAIN menu.

8.2.1.3 Disable Multi Shot

It is possible to disable the Multi Shot functionality.

Make a note of the license key before the Multi Shot functionality is disabled, as it would be needed to enable the function again.

Figure 22 Disable Multi Shot



Disable Multi Shot

1. From the MAIN menu, select **Settings**.
2. From the SETTINGS menu, select **Device**.
3. From the DEVICE menu, select **License Key**.
4. Delete the license key, by selecting the small arrow character to the far right.
5. Use the OK key to select **OK** on the display.
6. A warning message will be displayed.
7. Select **YES** to disable the Multi Shot functionality and return to the DEVICE menu.
8. Select **NO** to return to the previous screen, where the correct license key will be displayed. Select **OK** to return to the DEVICE menu.

8.2.2 Survey Menu

The SURVEY menu gives access to the Single Shot, Multi Shot and Orientation surveying functions.

Note, Multi Shot is only displayed if the Multi Shot function has been enabled. Please refer to the section *Multi Shot enabler* above.

For instructions on how to perform surveys, please refer to the chapters *Single Shot and Multi Shot surveys* and *Orientation Survey*.

Figure 23 SURVEY menu

Single Shot The *Single Shot* function is used to survey one single station. It is also possible to add a Single Shot measurement to an existing survey.

Multi Shot The *Multi Shot* function is used to survey multiple stations, while surveying into and/or out of the borehole.

Orientation The *Orientation* function is used to determine the orientation of a downhole object.

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

LEFT Use the LEFT key to return to the MAIN menu.

8.2.3 Results Menu

All surveys are stored automatically in the **REFLEX™ EZ-COM** unit. The RESULTS menu gives access to all stored Single Shot, Multi Shot and Orientation surveys.

All types of Single Shot surveys, including the ones where Single Shot measurements have been added to an existing survey, are accessed by selecting the Single Shot option.

Note, Multi Shot is only displayed if the Multi Shot function has been enabled. Please refer to the section *Multi Shot enabler* above.

Figure 24 RESULTS menu

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

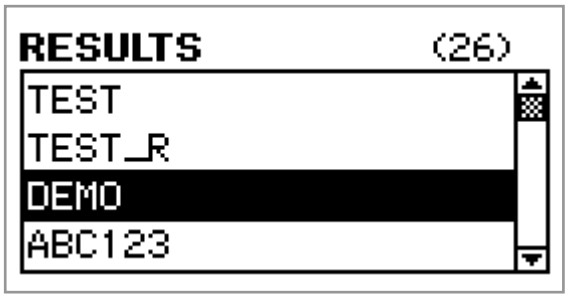
LEFT Use the LEFT key to return to the MAIN menu.

8.2.3.1 Stored surveys

For Multi Shot surveys that have been performed in both directions, the into hole survey has the name as entered when starting up the survey, and the out of hole survey has the same name with '_R' at the end. Example: Test and Test_R, as shown in the figure below.

When one of these twin surveys (e.g. Test or Test_R) is opened, the corresponding twin survey is also opened.

Figure 25 Stored surveys



UP/DOWN Use the UP/DOWN keys to navigate between the stored surveys.

OK Use the OK key to open the active survey.

LEFT Use the LEFT key to return to the RESULTS menu.

8.2.3.2 Survey results

It is possible to register a Magnetic Reference, to be used for quality verification in the **REFLEX™ EZ-COM** unit.

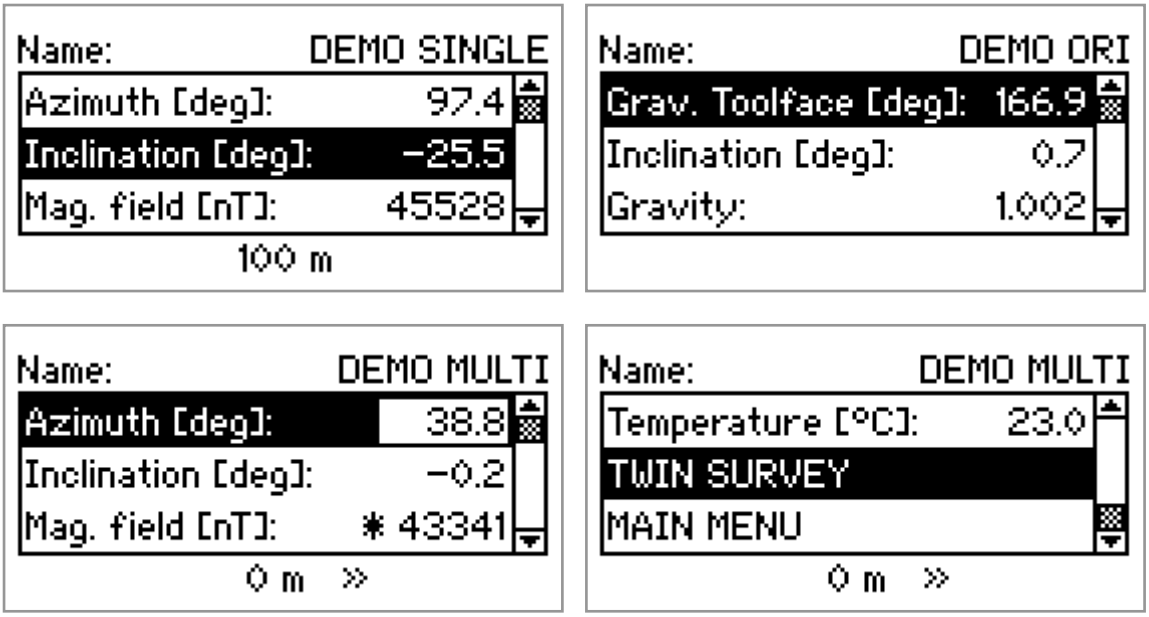
When the results of a Single Shot or a Multi Shot survey are displayed, the Azimuth value is blinking if the station is out of the magnetic reference range (±1,000 nT and ±0.5 deg). A star (*) in front of the Mag. Field and/or the Mag. Dip values indicates that the value is out of range.

When the results of an Orientation survey are displayed, the Magnetic Toolface value is blinking if the station is out of the magnetic reference range. A star (*) in front of the Mag. Field and/or the Mag. Dip values indicates that the value is out of range.

Note, if 'No Reference' has been set in the Magnetic Reference function, magnetic interference verification will not be performed. In this case, there will be no blinking value even if there is a magnetic disturbance.

Note, the Magnetic Reference that is set when a survey is performed, is saved in the data file of that survey. The saved reference applies when that survey is opened via the RESULTS menu, even if another reference has been set in the Magnetic Reference function. The Magnetic Reference of a stored survey can be viewed and edited in **REFLEX™ SProcess**.

Figure 26 Survey results



UP/DOWN Use the UP/DOWN keys to scroll in the result list.

LEFT/RIGHT Use the LEFT/RIGHT keys to scroll between survey stations in Multi Shot surveys and in surveys where Single Shot measurements have been added to an existing survey.

Fast navigation Hold down the UP/DOWN key to navigate directly to the top/bottom of the results. In surveys with more than one survey station, the LEFT/RIGHT key can be used in the same manner to navigate directly to the first/last survey station.

TWIN SURVEY If a Multi Shot survey has been performed in both directions, the **TWIN SURVEY** option is used to toggle between the into and out of hole surveys. The **TWIN SURVEY** option is available in the bottom of the results list, just above **MAIN MENU**.

Return to MAIN Select **MAIN MENU**, which is available in the bottom of the results list, to return to the MAIN menu.

8.2.4 Settings Menu

The SETTINGS menu gives access to the settings functionality.

Figure 27 SETTINGS menu

Units The *Units* function is used to set the linear and temperature units.

Magnetic Reference The *Magnetic Reference* function is used to manage the magnetic reference settings.

Date and Time The *Date and Time* function is used to set date and time.

Device The *Device* option gives access to the *Language* and *License Key* functions.

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

LEFT Use the LEFT key to return to the MAIN menu.

8.2.4.1 Units

The unit setting defines the linear and temperature units to be used when presenting the survey results on the **REFLEX™ EZ-COM** display.

The units that are set when a survey is started, are saved in the data file of the survey. These settings will apply when the survey is opened in **REFLEX™ SProcess**. However, the current settings in the **REFLEX™ EZ-COM** unit take precedence over the settings in the data file when the results are displayed on the unit.

The angular unit used in **REFLEX™ EZ-COM** is *Degrees*. In **REFLEX™ SProcess** it is possible to change the angular unit to *Grad* if desired.

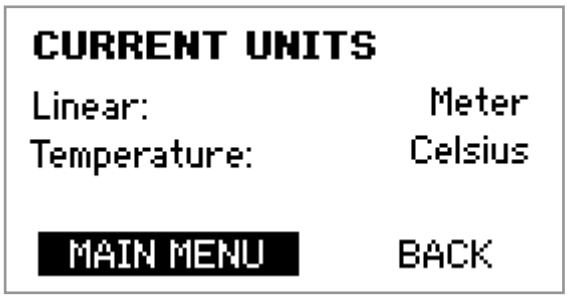
Figure 28 Units menu

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

LEFT Use the LEFT key to return to the SETTINGS menu.

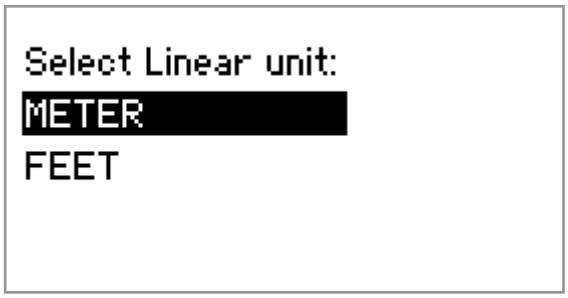
Figure 29 Current unit setting



View current units

1. From the SETTINGS menu, select **Units**.
2. From the UNITS menu, select **View current settings**.
3. The current unit settings are displayed.
4. Select **MAIN MENU** to return to the MAIN menu or **BACK** to return to the UNITS menu.

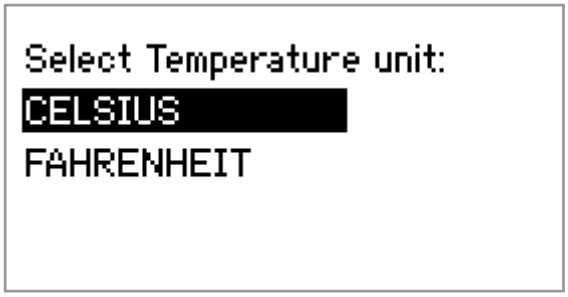
Figure 30 Select linear unit



Set linear unit

1. From the UNITS menu, select **Set Linear unit**.
2. Use the UP/DOWN keys to navigate between the **METER** and **FEET** options.
3. Use the OK key to select the active option.

Figure 31 Select temperature unit



Set temperature unit

1. From the UNITS menu, select **Set Temperature unit**.
2. Use the UP/DOWN keys to navigate between the **CELSIUS** and **FAHRENHEIT** options.
3. Use the OK key to select the active option.

8.2.4.2 Magnetic Reference

REFLEX EZ-TRAC™ is a magnetic instrument. Any magnetic interference will disturb the magnetic sensors, which will result in incorrect survey data. To be able to identify survey data that might have been destroyed by magnetic interference, a Magnetic Reference should be registered.

The Magnetic Reference is registered via the SETTINGS menu. The current Magnetic Reference setting applies to all new surveys, and is

saved in the data file of the surveys. A new Magnetic Reference setting has no effect on stored surveys.

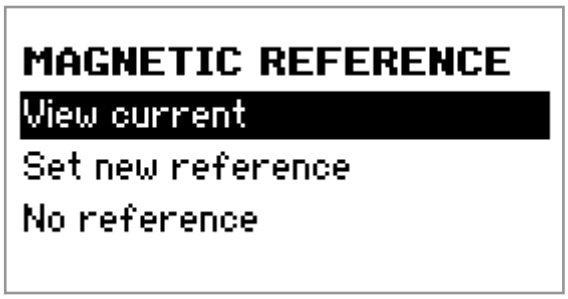
If a Magnetic Reference has been registered, the **REFLEX™ EZ-COM** unit compares the measured magnetic field strength and magnetic dip of every survey station with the reference values. The accepted range is ±1,000 nT from the magnetic field strength reference value, and ±0.5 deg from the magnetic dip reference value.

For survey stations that are out of the magnetic reference range, the Azimuth and Magnetic Toolface values (which both depend on input from the magnetic sensors) will have blinking values in the survey results list.

If 'No Reference' is selected, magnetic interference verification will not be performed.

The Magnetic Reference of a stored survey can be viewed and edited in **REFLEX™ SProcess**.

Figure 32 Magnetic Reference menu



UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

LEFT Use the LEFT key to return to the SETTINGS menu.

Figure 33 View current magnetic reference

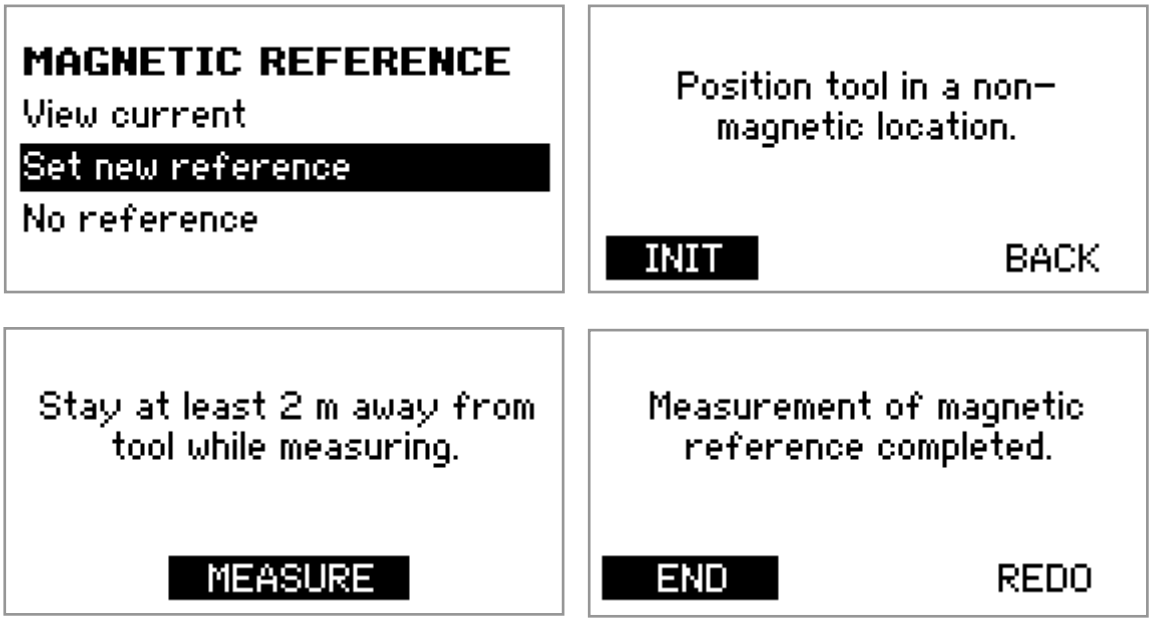
View current magnetic reference

1. From the SETTINGS menu, select **Magnetic Reference**.
2. From the MAGNETIC REFERENCE menu, select **View current**.
3. The current magnetic reference is displayed.
4. Select **MAIN MENU** to return to the MAIN menu or **BACK** to return to the MAGNETIC REFERENCE menu.

The **REFLEX EZ-TRAC™** instrument is used to register a new magnetic reference.

Note, the instrument must be placed away from any magnetic interference when the magnetic reference is registered. Also, no person should be closer than two meters from the tool during the measurement.

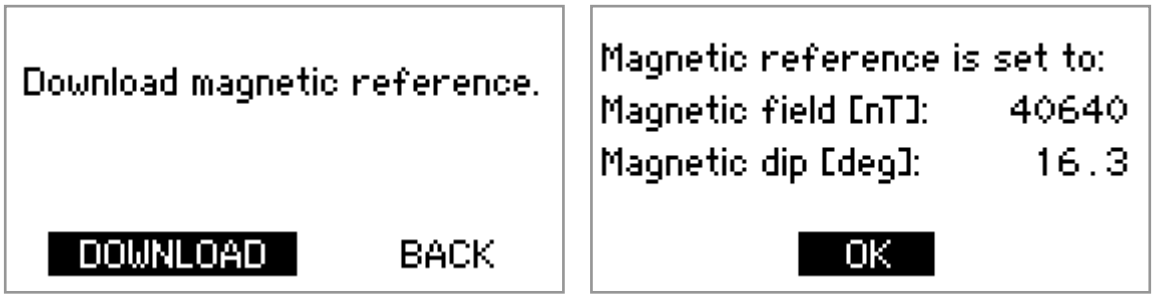
Figure 34 Register magnetic reference



Measure magnetic reference

1. Position **REFLEX EZ-TRAC™** away from any magnetic interference, such as constructions or machines.
2. From the SETTINGS menu, select **Magnetic Reference**.
3. From the MAGNETIC REFERENCE menu, select **Set new reference**.
4. Direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the instrument and select **INIT**.
5. Maintain at least 2 metres from the instrument.
6. Select **MEASURE**.
7. The tool must be kept stationary and nobody shall be near the tool while ‘Measuring reference’ is displayed.
8. When the measurement is completed, select **END**.

Figure 35 Download magnetic reference



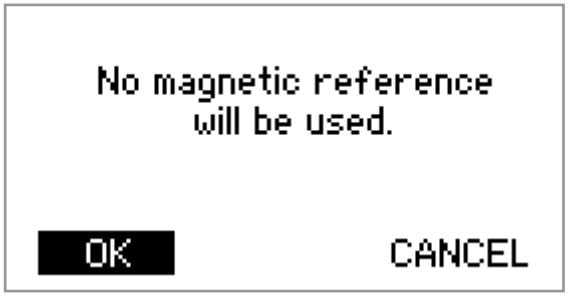
Download magnetic reference

1. Direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the instrument and select **DOWNLOAD**.
2. The values of the measured magnetic reference are displayed on the screen.
3. Select **OK** to return to the MAGNETIC REFERENCE menu.
4. Use the LEFT key to return to the SETTINGS menu.

The measured total magnetic field value should be compared with information from the national Land Surveyor about the local total magnetic field. If there is a major difference, there might be magnetic rock under the surface. Another reference point should be selected, and a new magnetic reference should be registered.

If a reasonable magnetic reference cannot be registered, the magnetic verification function can be disabled by setting the magnetic reference to ‘No Reference’.

Figure 36 No reference



No reference

1. From the MAGNETIC REFERENCE menu, select **No reference**.
2. Select **OK** to remove the magnetic reference.
3. Use the LEFT key to return to the SETTINGS menu.

If ‘No Reference’ is selected, magnetic interference verification will not be performed.

8.2.4.3 Date and Time

The date and time of the survey start is stored in the survey file. The date and time setting is used to set the local time and date.

Figure 37 Date and Time menu

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

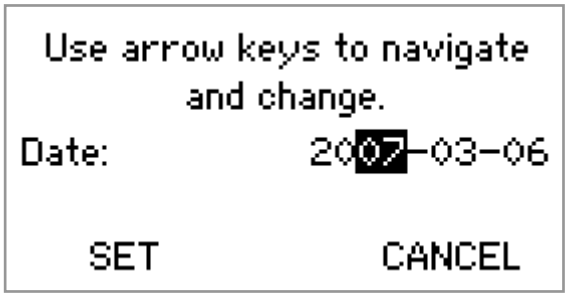
LEFT Use the LEFT key to return to the SETTINGS menu.

Figure 38 View current date and time

View current date and time

1. From the SETTINGS menu, select **Date and Time**.
2. From the DATE AND TIME menu, select **View current**.
3. The current date and time settings are displayed.
4. Select **MAIN MENU** to return to the MAIN menu or **BACK** to return to the DATE AND TIME menu.

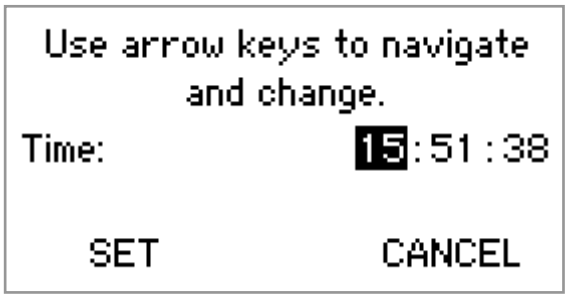
Figure 39 Set Date



Set Date

1. From the SETTINGS menu, select **Date and Time**.
2. From the DATE AND TIME menu, select **Set Date**.
3. Use the UP/DOWN keys to increase/decrease values.
4. Use the LEFT/RIGHT keys to navigate between Year, Month and Date.
5. When Month is active, use the RIGHT key to go to the **SET** option.
6. If needed, use the UP key to navigate back to the Date row.
7. Select **SET** to set the displayed date.
8. Use the LEFT key to return to the SETTINGS menu.

Figure 40 Set Time



Set Time

1. From the SETTINGS menu, select **Date and Time**.
2. From the DATE AND TIME menu, select **Set Time**.
3. Use the UP/DOWN keys to increase/decrease values.
4. Use the LEFT/RIGHT keys to navigate between Hour, Minutes and Seconds.
5. When Seconds is active, use the RIGHT key to go to the **SET** option.
6. If needed, use the UP key to navigate back to the Time row.
7. Select **SET** to set the displayed time.
8. Use the LEFT key to return to the SETTINGS menu.

8.2.4.4 Device menu

The Device option in the SETTINGS menu opens the DEVICE menu, which gives access to the *Language* and *License Key* functions.

Figure 41 DEVICE menu

Language The *Language* function is used to set the language.

License Key The *License Key* function is used to enable/disable the Multi Shot functionality, see section *Multi Shot enabler* above.

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

LEFT Use the LEFT key to return to the SETTINGS menu.

With the *Language* function, it is possible to select which language to use in the **REFLEX™ EZ-COM** unit.

Figure 42 Set Language

Set Language

1. From the DEVICE menu, select **Language**.
2. Use the UP/DOWN keys to select the desired language.
3. Use the OK key to confirm the language setting.
4. Use the LEFT key to return to the DEVICE menu.

8.2.5 Data Transfer Menu

The DATA TRANSFER menu gives access to the data transfer functionality.

For instructions on how to transfer survey files, please refer to the chapter *Transfer survey files*.

Figure 43 DATA TRANSFER menu

Transfer to USB Stick The *Transfer to USB Stick* function is used to transfer survey files to a USB Memory stick.

Transfer to PC The *Transfer directly to PC* function is used to transfer survey files directly to a PC.

UP/DOWN Use the UP/DOWN keys to navigate between the menu options.

OK Use the OK key to select the active option.

LEFT Use the LEFT key to return to the MAIN menu.

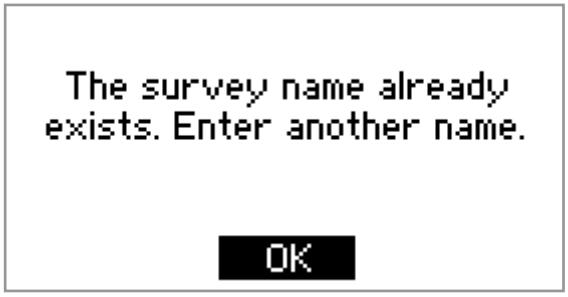
8.3 Messages and Warnings

As a result of different events, messages and warnings may be displayed on the **REFLEX™ EZ-COM** unit.

8.3.1 General

The messages described in this section may appear in all types of surveys.

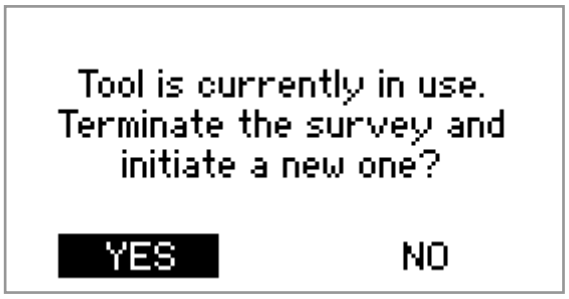
Figure 44 Name exists



The *Name Exists* message appears if a survey of the same type (Single Shot, Multi Shot or Orientation) with the same survey name already exists in the **REFLEX™ EZ-COM** unit. A unique name is needed to distinguish surveys from each other.

Select **OK** and enter another name.

Figure 45 Tool in use

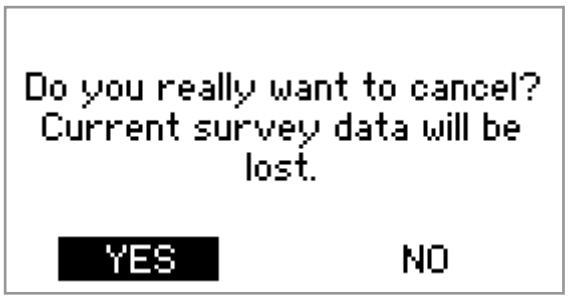


If the instrument is executing a survey when the **REFLEX™ EZ-COM** unit tries to connect to it, the *Tool in use* message appears.

Select **YES** to end the on-going survey and initiate the new survey. Note, survey data from the on-going survey will be lost.

Select **NO** to return to the previous screen.

Figure 46 Cancel



The *Cancel* message appears if **CANCEL** is selected during a survey.

Select **YES** to continue to the MAIN menu. Note, the survey data will be lost.

Select **NO** to return to the previous screen.

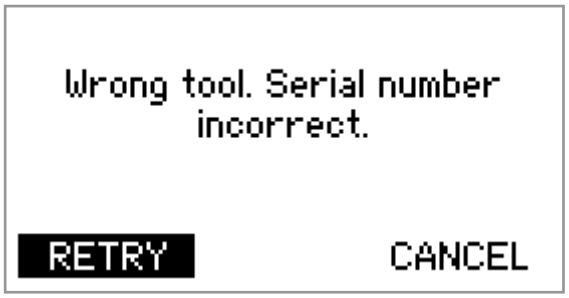
Figure 47 No Connection

The *No Connection* message appears if the **REFLEX™ EZ-COM** unit cannot establish a connection with the **REFLEX EZ-TRAC™**.

Be sure to direct the IR port of the **REFLEX™ EZ-COM** unit to the IR port of the **REFLEX EZ-TRAC™**. Select **RETRY** to retry to connect to the instrument.

Select **CANCEL** to cancel. The *Cancel* message as described above will be displayed.

Figure 48 Serial Number Incorrect

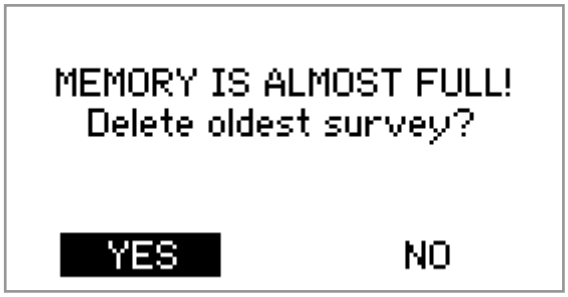


Before downloading data, the **REFLEX™ EZ-COM** unit verifies that the serial number of the instrument is the same as the serial number of the instrument that was initiated for the survey. If there is a mismatch, the *Serial number incorrect* message appears.

Align the **REFLEX™ EZ-COM** unit with the correct instrument and select **RETRY**.

Select **CANCEL** to cancel. The *Cancel* message as described above will be displayed.

Figure 49 Memory Full

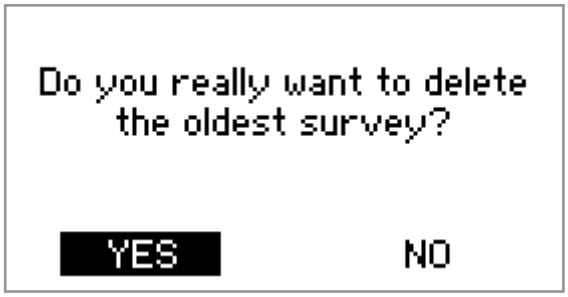


The *Memory Full* message appears at the start of a new survey if there is not enough memory left in the **REFLEX™ EZ-COM** unit to store the new survey.

Select **YES** to delete the oldest survey of that survey type (Single Shot, Multi Shot or Orientation). The *Delete Oldest* message below is displayed.

Select **NO** to return to the MAIN menu without deleting any surveys. For instructions on how to transfer survey files to a PC or to a USB Memory stick before surveys are deleted, please refer to the chapter *Transfer Survey Files.*

Figure 50 Delete Oldest

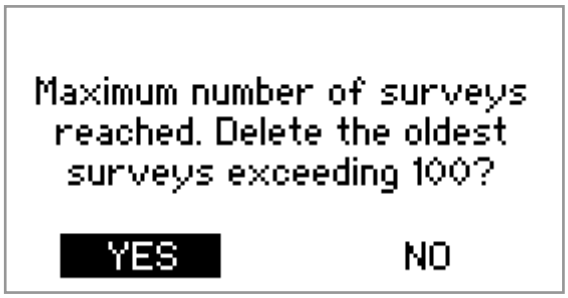


The *Delete Oldest* message appears if **YES** is selected in the *Memory Full* message.

Select **YES** to delete the oldest survey of that type (Single Shot, Multi Shot or Orientation). If sufficient memory is not made available, the *Memory Full* message will appear again. Otherwise the next screen in the survey procedure will be displayed.

The most effective way to free memory is to transfer all survey files to a PC or a USB Memory stick and then delete the surveys from the **REFLEX™ EZ-COM** unit. Select **NO**; the *Free Memory* message below will appear.

Figure 51 Maximum Number

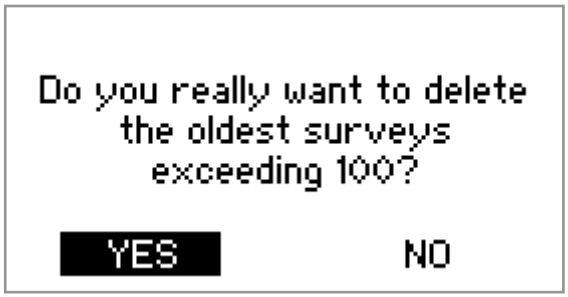


The *Maximum Number* message appears at start up of a new survey, if the maximum number (100) of surveys of that type (Single Shot, Multi Shot or Orientation) has been exceeded.

Select **YES** to delete the oldest surveys of that type, exceeding the maximum of 100. The *Delete Exceeding* message below is displayed.

The most effective way to free memory is to transfer all survey files to a PC or a USB Memory stick and then delete the surveys from the **REFLEX™ EZ-COM** unit. Select **NO**; the *Free Memory* message below will appear.

Figure 52 Delete Exceeding

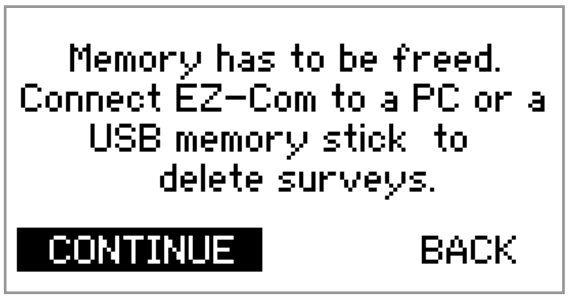


The *Delete Exceeding* message appears if **YES** is selected in the *Maximum Number* message.

Select **YES** to delete the oldest surveys of that type, exceeding the maximum of 100. On completion, the next screen in the survey procedure will be displayed.

The most effective way to free memory is to transfer all survey files to a PC or a USB Memory stick and then delete the surveys from the **REFLEX™ EZ-COM** unit.. Select **NO**; the *Free Memory* message below will appear.

Figure 53 Free Memory



The *Free Memory* message appears if **NO** is selected in the *Delete Oldest, Maximum Number* or *Delete Exceeding* messages.

Select **Continue** to return to the MAIN menu. For instructions on how to transfer and then delete surveys, please refer to the chapter *Transfer Survey Files.*

Select **BACK** to return to the previous screen.

Figure 54 Tool Battery Low

The *Tool Battery Low* message appears if the **REFLEX EZ-TRAC™** reports battery low during initialisation.

A battery replacement is needed immediately. Please refer to the chapter *Battery Replacement*.

Figure 55 Control unit Battery Low

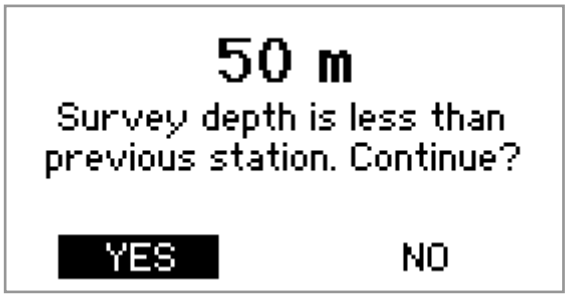
The *Control unit Battery Low* message appears at start-up if the battery level of the **REFLEX™ EZ-COM** is not sufficient.

A battery replacement is needed. Please refer to the chapter *Battery Replacement*.

8.3.2 Single Shot

The messages described in this section may appear in Single Shot surveys.

Figure 56 Depth is less

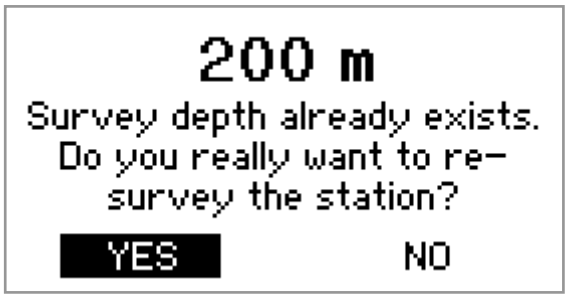


The *Depth Is Less* message appears if the entered Survey Depth of a Single Shot measurement to be added to an existing survey is less than the previous stations in the existing survey.

Select **YES** to keep the entered Survey Depth.

Select **NO** to enter another Survey Depth.

Figure 57 Depth exists



The *Depth Exists* message appears if the entered Survey Depth of a Single Shot measurement to be added to an existing survey already exists in the survey.

Select **YES** to keep the entered Survey Depth. The survey station will appear twice in the data record.

Select **NO** to enter another Survey Depth.

8.3.3 Multi Shot

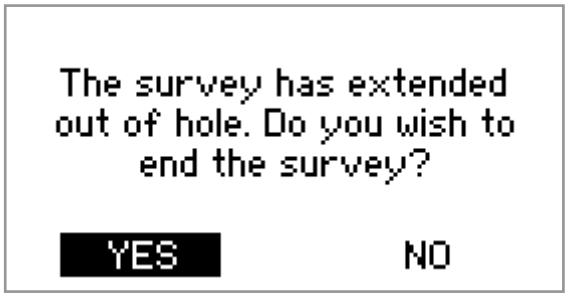
The messages described in this section may appear in Multi Shot surveys.

Figure 58 Reverse survey completed

The *Reverse survey completed* message appears when the last station in the reverse survey has been measured.

Select **OK** and end the survey normally.

Figure 59 End of hole

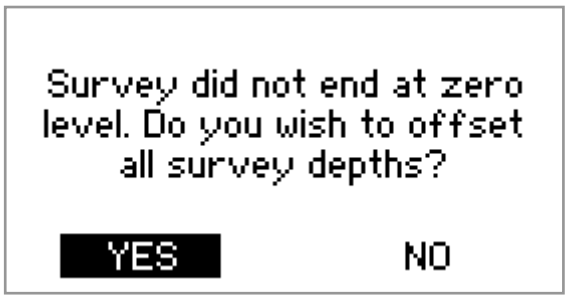


The *End of Hole* message appears when a survey in the out of hole direction has passed the zero level.

Select **YES** to end the survey and continue to the download procedure.

If the ground level is in effect not reached and you want to continue the survey, select **NO**. There will be a minus sign in front of the survey depths for the following survey stations.

Figure 60 Offset



The *Offset* message appears at download if there are survey stations with negative depths.

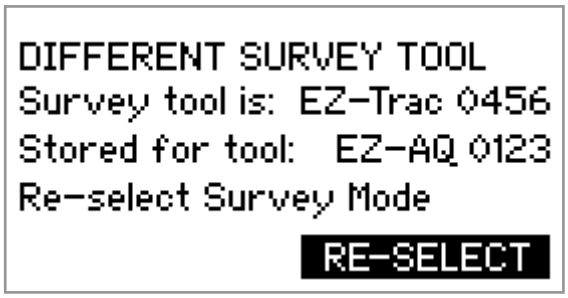
Select **YES** to offset all stations depths; that is, to adjust the survey station depths to end the survey at 0 m/ft.

Select **NO** to keep the stations depths as they are.

8.3.4 *Orientation*

The messages described in this section may appear in Orientation surveys.

Figure 61 Different tool

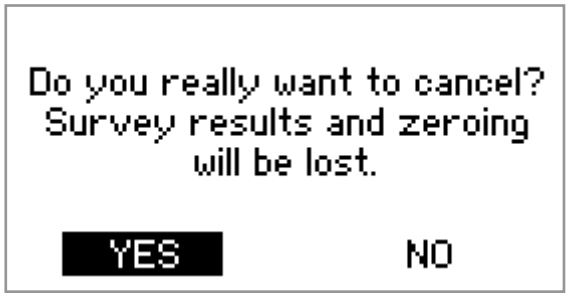


The *Different Tool* message appears if a stored zeroing value is about to be used, and if the serial number of the tool is not the same as the serial number of the tool used to register the zeroing.

Change to the correct tool and re-select **STORED ZEROING** from the *Select survey mode* screen.

Use the current tool, but select either **GRAVITY TOOLFACE (NEW)** or **MAGNETIC TOOLFACE (NEW)** from the *Select survey mode* screen. Follow the instructions in section 10.5.1 *Register new zeroing*.

Figure 62 Lose results and zeroing

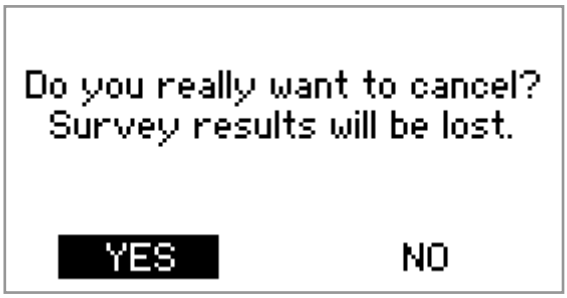


The *Lose results and zeroing* message appears if **CANCEL** is selected during an Orientation survey (with a new zeroing value registered).

Select **YES** to proceed with the cancellation. The survey results and the new zeroing value will be lost.

Select **NO** to return to the previous screen.

Figure 63 Lose results



The *Lose results* message appears if **CANCEL** is selected during an Orientation survey (with a stored zeroing value).

Select **YES** to proceed with the cancellation. The survey results will be lost.

Select **NO** to return to the previous screen.

Figure 64 Close to vertical

The *Close to vertical* message appears after download if the Gravity Tool Face mode has been used and the measured inclination of the borehole is less than 5 degrees from vertical.

For inclinations within 5 degrees from vertical, the Gravity Tool Face mode is not reliable and the survey should be re-run using the Magnetic Tool Face mode.

Figure 65 Magnetic warning

The *Magnetic warning* message may appear after download if the Magnetic Tool Face mode has been used. This happens if a Magnetic Reference has been registered and if the measured magnetic field strength and/or magnetic dip are out of the accepted range (±1,000 nT and ±0.5 deg).

To avoid the risk for magnetic interference, the Orientation survey should be re-run using the Gravity Tool Face mode. However, the Gravity Tool Face mode can only be used in boreholes with inclinations that are more than 5 degrees from vertical.

If the borehole is less than 5 degrees from vertical, the Gravity Tool Face mode is less accurate. In that case you have to take actions to protect the instrument from magnetic interference and re-run the survey using the Magnetic Tool Face mode.

8.3.5 Data transfer

The messages described in this section may appear when survey data is transferred to a USB Memory stick.

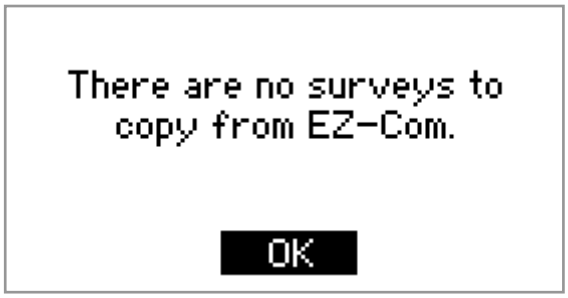
Figure 66 No USB stick

The *No USB stick* message appears if the **REFLEX™ EZ-COM** unit cannot establish contact with a USB Memory stick.

Be sure to connect the USB Memory stick correctly or test with another USB Memory stick. Select **RETRY** to retry to establish contact with the USB Memory stick.

Select **CANCEL** to return to the DATA TRANSFER menu.

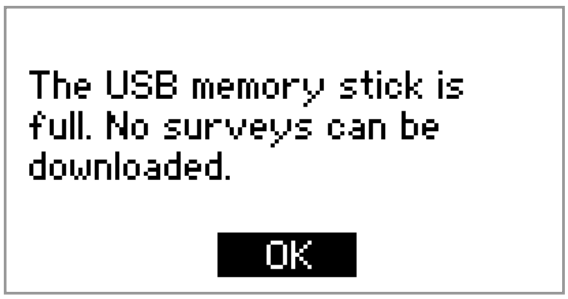
Figure 67 No surveys



The *No surveys* message appears if there are no surveys to copy from the **REFLEX™ EZ-COM** unit.

Press **OK** to confirm and return to the USB MEMORY STICK menu.

Figure 68 USB stick full



The *USB stick full* message appears if there is not memory enough on the USB stick to copy all the survey files on the **REFLEX™ EZ-COM** unit.

Press **OK** to confirm and return to the USB MEMORY STICK menu.

Figure 69 Folder exists

The *Folder exists* message appears if a folder with the same name as the entered one already exists on the USB Memory stick. A unique name is needed to avoid survey name conflicts.

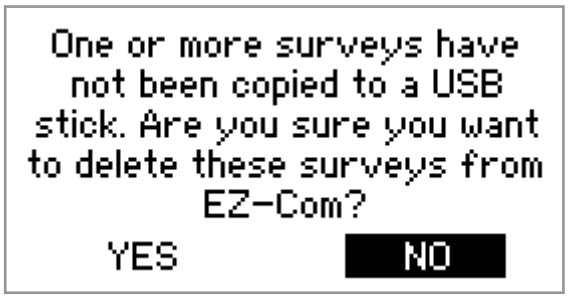
Select **OK** and enter another name.

Figure 70 Transfer error

The *Transfer error* message appears for example if the USB Memory stick is removed before all files have been copied.

Select **OK** to confirm and return to the DATA TRANSFER menu. To ensure that no surveys are missed, the data transfer procedure has to be restarted from the beginning.

Figure 71 All not copied

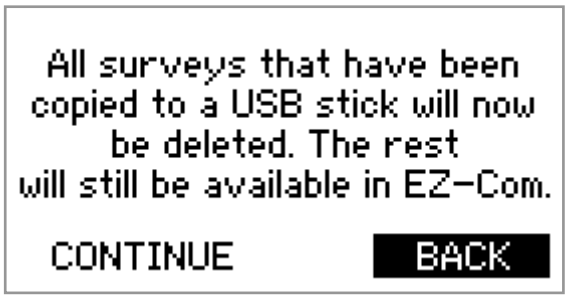


The **REFLEX™ EZ-COM** unit keeps a record of the surveys that have been copied to a USB Memory stick. However, there is no such record for surveys that have been transferred directly to a PC. The *All not copied* message appears when surveys are to be deleted from **REFLEX™ EZ-COM**, if there are surveys in the unit that have not been copied to a USB Memory stick. These surveys may have been transferred to a PC or they may not need to be saved, but you should not delete the un-copied surveys unless you are sure.

If you are sure that the surveys that have not been copied to a USB Memory stick either have been copied directly to a PC or do not need to be saved, select **YES**. All surveys will now be deleted from the **REFLEX™ EZ-COM** unit.

If you only want to delete the surveys that have been copied to a USB Memory stick, select **No**. The *Delete copied only* message will be displayed, see below.

Figure 72 Delete copied only



The *Delete copied only* message appears if **NO** is selected in the *All not copied* message.

Select **CONTINUE** to delete the surveys that have been copied to a USB Memory stick. The un-copied surveys will still be available in the **REFLEX™ EZ-COM** unit.

Select **BACK** to return to the USB STICK MENU without deleting any surveys.

9 Single Shot and Multi Shot surveys

This chapter provides instructions on how to perform Single Shot and Multi Shot surveys.

Note, Multi Shot is only available if the functionality has been enabled, which requires a license key. For instructions on how to enable Multi Shot functionality, please refer to section 8.2.1 *Multi Shot Enabler*.

9.1 Preparation

Before the survey is started, you need to decide on what surveying method to use. Your choice will impact on the equipment you need, and some of the methods require further preparations before you can get started.

Surveying methods are described in the chapter *Surveying Methods*.

9.2 Register magnetic reference

To be able to identify survey data that might have been destroyed by magnetic interference, a magnetic reference should be registered.

Instructions for how to register a magnetic reference are provided in section 8.2.4.2 *Magnetic Reference.*

9.3 Set up Single Shot

It is possible to run a new Single Shot survey, or add a Single Shot measurement to an existing survey. The survey setup is slightly different, which is described in separate sections below.

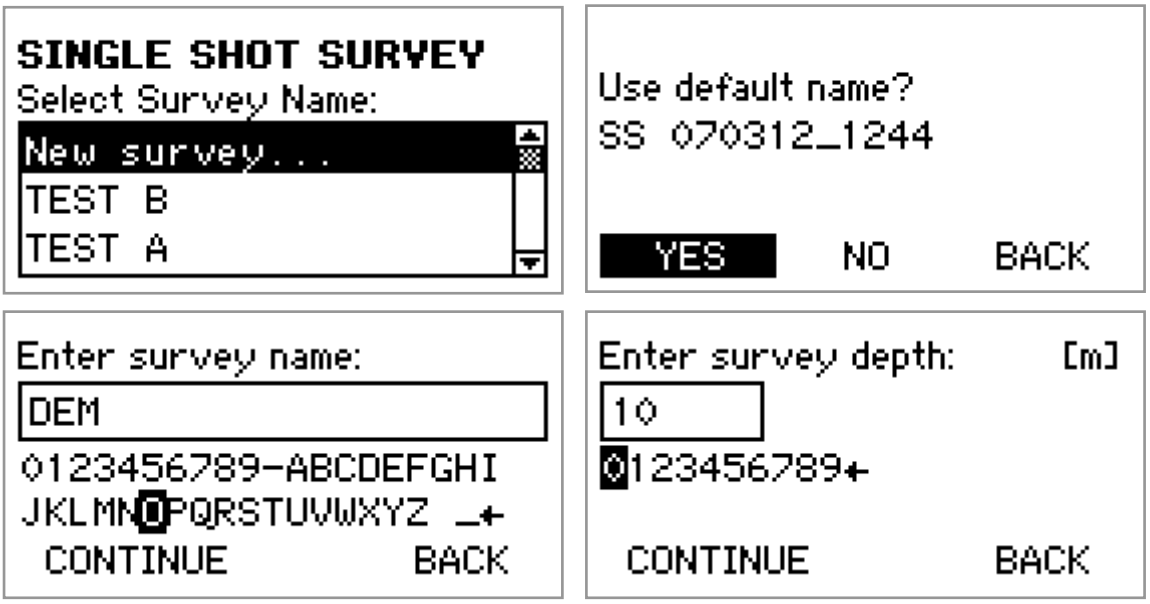
Set up Single Shot

1. From the MAIN menu, select **Survey**.
2. From the SURVEY menu, select **Single Shot**.

9.3.1 New Single Shot

Name and depth of the new Single Shot survey is entered.

Figure 73 New Single Shot



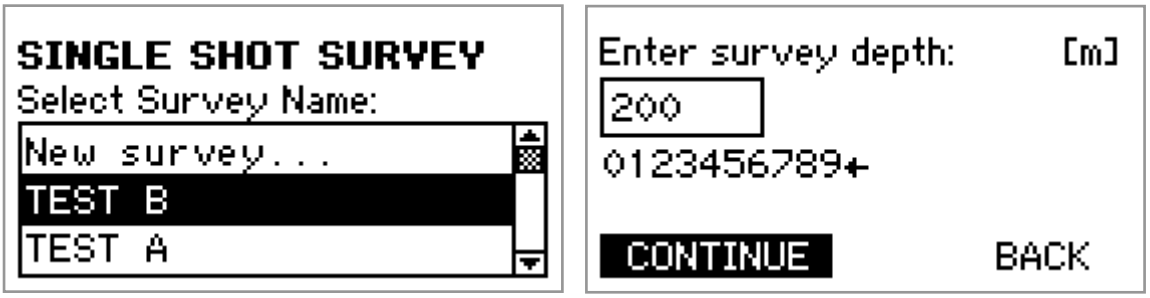
New Single Shot

1. From the SINGLE SHOT SURVEY menu, select **New survey…**.
2. To use the default name, select **YES**. Continue to step 5 below.
3. To enter a survey name, select **NO**.
4. Use the navigation keys to enter the Survey Name. Select **CONTINUE** when finished.
5. Use the navigation keys to enter the Survey Depth. Select **CONTINUE** when finished.
6. Continue to the section *Initialise instrument*.

9.3.2 Add to existing survey

The name of the existing survey to add a Single Shot measurement to is selected, and the survey depth is entered.

Figure 74 Add to existing survey



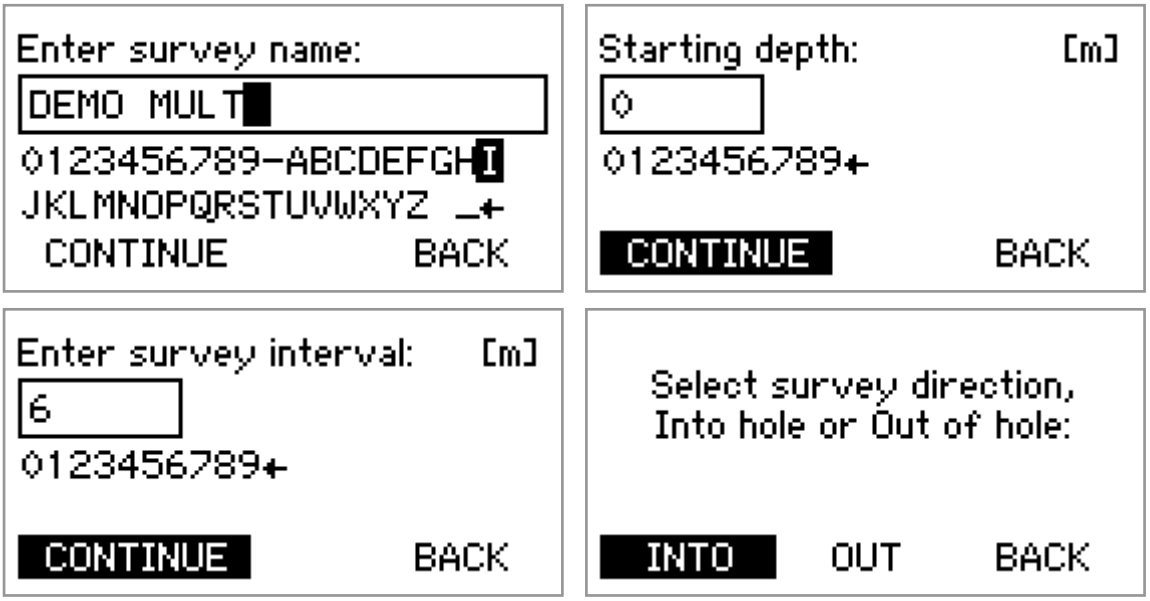
Add to existing survey

1. From the SINGLE SHOT SURVEY menu, select the name of the survey to add the Single Shot measurement to.
2. Use the navigation keys to enter the Survey Depth. Select **CONTINUE** when finished.
3. Continue to the section *Initialise instrument*.

9.4 Set up Multi Shot

Starting parameters of the Multi Shot survey are entered.

Figure 75 Set up Multi Shot



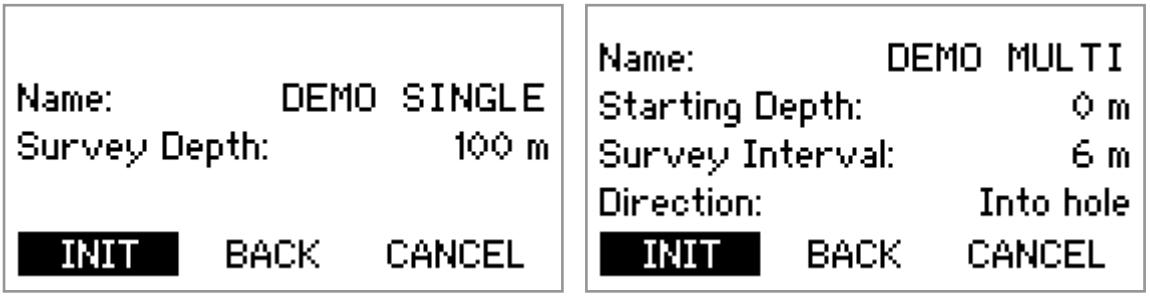
Set up Multi Shot

1. From the MAIN menu, select **Survey**.
2. From the SURVEY menu, select **Multi Shot**.
3. To use the default name, select **YES**. Continue to step 6 below.
4. To enter a survey name, select **NO**.
5. Use the navigation keys to enter the Survey Name. Select **CONTINUE** when finished.
6. Use the navigation keys to enter the Starting Depth. Select **CONTINUE** when finished.
7. Use the navigation keys to enter the Survey Interval. Select **CONTINUE** when finished.
8. Use the navigation keys to select Survey Direction. Select **INTO** for into hole and **OUT** for out of hole.
9. Continue to the section *Initialise instrument*.

9.5 Initialise instrument

The **REFLEX EZ-TRAC™** is initialised for the survey, which includes synchronisation of the clocks in the instrument and the control unit and that the instrument memory is cleared.

Figure 76 Initialise instrument



Initialise instrument

1. Remove the top coupling from the **REFLEX EZ-TRAC™** and direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the instrument.
2. Select **INIT** to initialise the instrument.
3. Do not break the IR connection until 'Ready to survey' is displayed.
4. Thread the top coupling onto the instrument.

9.6 Assemble survey system

Assemble the survey system with running gear appropriate for the chosen surveying method.

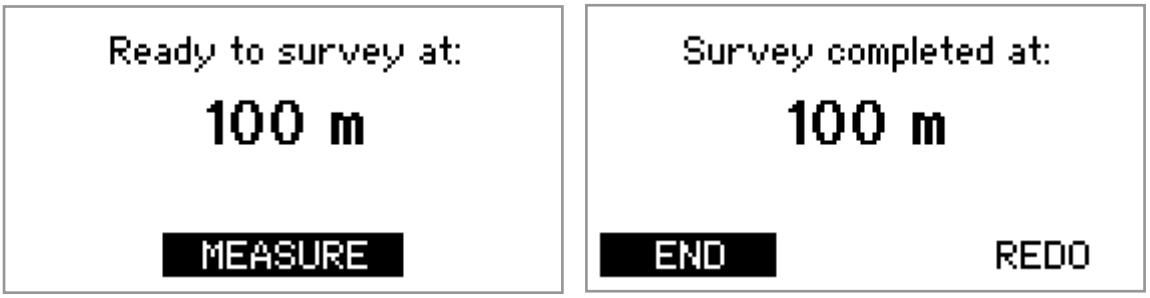
Instructions for how to assemble the survey system are provided in the chapter *Surveying Methods*.

9.7 Execute survey

Position the instrument at the survey station and register the measurement.

9.7.1 Single Shot execution

Figure 77 Single Shot execution



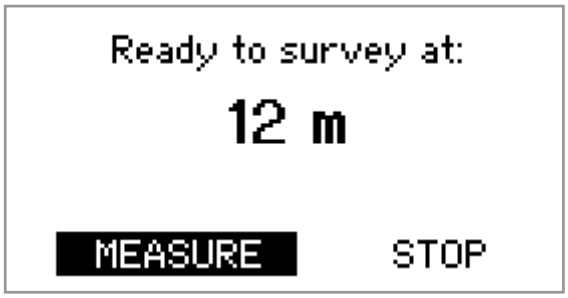
Execute Single Shot survey

1. Position the survey system at the survey station, using one of the methods described in chapter *Surveying Methods*.
2. When the instrument is stationary at the survey station, select **MEASURE** on the **REFLEX™ EZ-COM** unit.
3. Do not move the instrument while 'Measuring' is displayed.

4. To redo the measurement, select **REDO**. Note, previous measurement will be replaced.
5. To end the survey, select **END**.
6. Retrieve the survey system from the borehole.
7. Continue to the section *Download data*.

9.7.2 *Multi Shot execution*

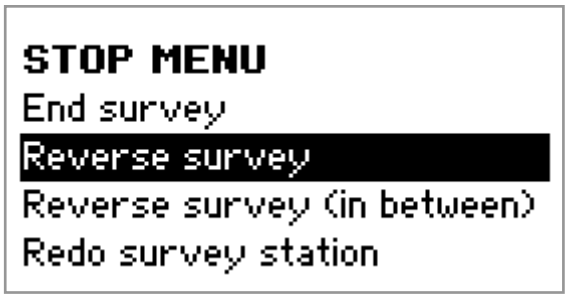
Figure 78 Multi Shot execution



Execute Multi Shot survey

1. Position the survey system at the survey station, using one of the methods described in chapter *Surveying Methods*.
2. When the instrument is stationary at the survey station, select **MEASURE** on the **REFLEX™ EZ-COM** unit.
3. Do not move the instrument while ‘Measuring’ is displayed.
4. When ‘Ready to survey’ is displayed, move the instrument to next survey station.
5. Repeat steps 2-4 until the survey has been completed.
6. Select **STOP** to stop the survey execution.
7. The STOP menu is displayed.

Figure 79 STOP menu



The STOP menu offers four options.

a) Select **End survey** to end the survey execution and download the survey data. Continue to the section *Download data*.

b) Select **Reverse Survey** to continue the survey execution in reverse direction, at the same survey stations. This option is only available when surveying into the hole. Continue with step 2 in the *Execute Multi Shot survey* procedure above.

c) Select **Reverse Survey (in between)** to continue the survey execution in reverse direction, at survey stations in between the previous stations. This option is only available when surveying into the hole. Continue with step 2 in the *Execute Multi Shot survey* procedure above.

d) Select **Redo survey station** to redo the measurement at the current survey station. Note, the previous measurement will be replaced. Continue with step 2 in the *Execute Multi Shot survey* procedure above.

9.8 Download data

When the instrument has been retrieved from the borehole, survey data is downloaded to the **REFLEX™ EZ-COM** unit.

For Multi Shot surveys that have been performed in both directions, two surveys are generated. The into hole survey has the name as entered when starting up the survey, and the out of hole survey has the same name with '_R' at the end. Example: DEMO MULTI and DEMO MULTI_R, as shown in the figure below.

Figure 80 Download data

Download data

1. Remove the top coupling from the **REFLEX EZ-TRAC™** and direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the instrument.
2. Select **DOWNLOAD**. Survey data is downloaded and automatically stored in the control unit.
3. Do not break the IR connection while 'Downloading' is displayed.

9.9 Survey results

When the survey data has been downloaded, the results are displayed on the **REFLEX™ EZ-COM** unit.

If a Magnetic Reference has been registered and if the survey station is out of the accepted reference range (±1,000 nT and ±0.5 deg), the Azimuth value is blinking. A star (*) in front of the Mag. Field and/or the Mag. Dip values indicates that the value is out of range.

Figure 81 Single Shot results

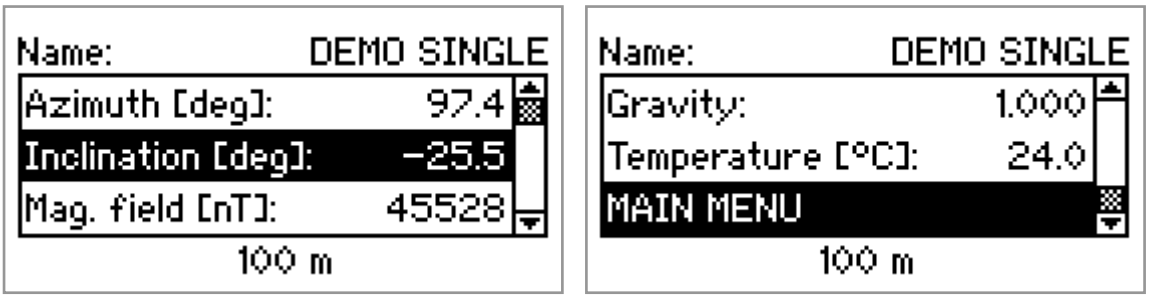
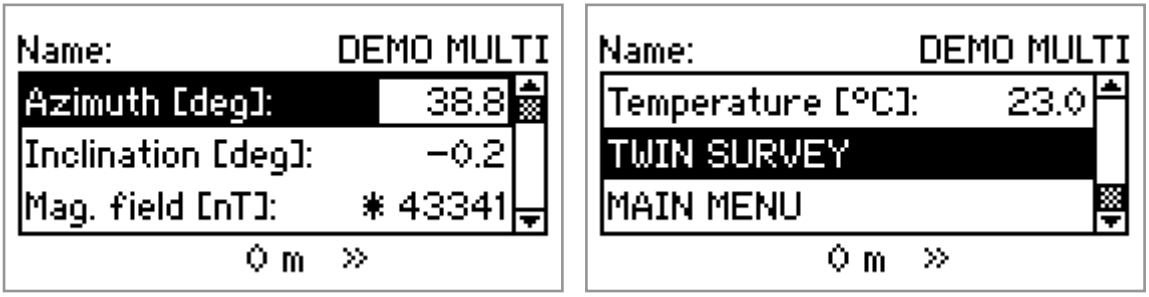


Figure 82 Multi Shot results



View survey data

1. Use the UP/DOWN keys to scroll in the result list.
2. For Multi Shot surveys and if a Single Shot measurement has been added to an existing survey, the LEFT/RIGHT keys are used to scroll between the survey stations.
3. If a Multi Shot survey has been performed in both directions, select **TWIN SURVEY** to toggle between the into and out of hole surveys. The **TWIN SURVEY** option is available in the bottom of the results list.
4. To exit, use select **MAIN MENU** in the bottom of the results list.

Hold down the UP/DOWN key for about a second to navigate directly to the top/bottom of the results. In surveys with more than one survey station, the LEFT/RIGHT key can be used in the same manner to navigate directly to the first/last survey station.

10 Orientation survey

This chapter provides instructions on how to perform an Orientation survey.

10.1 Introduction

An Orientation survey is performed to establish the orientation or direction of an object inside the borehole, for example a wedge, a directional tool or a downhole motor.

The Orientation survey consists of two main parts, zeroing and downhole measurement. The zeroing part is performed to register a reference value. The downhole measurement is made to register how much the downhole object is rotated relative to that reference value.

A wedge is used as example in the description of the orientation equipment in this chapter. The procedure would be similar for a directional tool or a downhole motor.

10.2 Measuring modes

Orientation surveys may be performed in two different modes; relative to Gravity Tool Face or Magnetic Tool Face.

10.2.1 Gravity Tool Face

Measuring relative to gravity is the recommended method, since it is not affected by magnetic disturbances.

However, in boreholes close to vertical, the measurements of tool face based on gravity recordings are less accurate. Hence, the gravity measuring mode is used in boreholes with inclinations from -85 to +85 degrees. In holes close to vertical, the magnetic method shall be used.

10.2.2 Magnetic Tool Face

Magnetic measurements could easily be disturbed by magnetic influences. For that reason, measurements relative to magnetic north should only be used for boreholes that are within 5 degrees from vertical (where the gravity measurements cannot be used).

10.3 Set magnetic reference

For the Magnetic Tool Face mode, a magnetic reference should be set to be able to identify survey data that might have been destroyed by magnetic interference.

Instructions for how to register a magnetic reference are provided in section 8.2.4.2 *Magnetic Reference.*

10.4 Orientation equipment

The survey system for Orientation surveys consists of the **REFLEX EZ-TRAC™** instrument, a bull plug, a mule shoe and a mule shoe sleeve.

The mule shoe sleeve (or corresponding equipment) is assembled with the wedge, to ensure that the survey system is positioned in line

with the wedge down in the borehole. The diameter and threads of the mule shoe sleeve should be exactly the same as the drill rods being used. The mule shoe sleeve is provided in 0.6 m/2 ft sections.

When surveying relative to Magnetic Tool Face, six aluminium extension rods and nine meters of non-magnetic drill rods are also required.

Figure 83 Orientation equipment

Orientation bull plug

Orientation mule shoe

Figure 84 Additional equipment for Magnetic Tool Face mode

6 aluminium extension rods

9 meters of non-magnetic drill rods

10.4.1 Mule shoe sleeve

The direction indicator (pin) on the mule shoe sleeve shall be aligned with the kick direction of the wedge.

Figure 85 Mule shoe sleeve

Align mule shoe sleeve

1. Set out the wedge horizontally on the rod rack or the ground, with its required kick direction pointing vertically upwards.
2. Thread the mule shoe sleeve onto the wedge.
3. The mule shoe sleeve is now ready for zeroing, as described in the section *Zeroing* below.

10.5 Zeroing

An applicable reference value (zeroing) is needed to correctly calculate the orientation of the wedge.

The zeroing value is automatically stored in **REFLEX™ EZ-COM** at the end of the Orientation survey. A stored zeroing may be used instead of registering a new reference value, when starting up a survey.

Registering a new zeroing value eliminates the risk of using a reference that is not applicable to the survey. Follow the instructions in the section *Register new zeroing* below.

If you are sure the stored zeroing value is applicable, continue to the section *Use stored zeroing* below.

10.5.1 Register new zeroing

Register a new zeroing value to be used as reference when calculating the orientation of the wedge.

Note, if a new zeroing value is registered, the stored zeroing value is replaced.

With the mule shoe sleeve attached to the wedge, you align the tool face by setting the reference position to zero.

Note, the positioning of the instrument during the zeroing depends on the survey mode; Gravity Tool Face or Magnetic Tool Face.

10.5.1.1 Position for zeroing – Gravity Tool Face

The gravity method shall be used for boreholes with inclinations from -85 to +85 degrees. The instrument should be positioned as close to horizontal as possible when the zeroing is performed.

If the wedge with the mule shoe sleeve is already in the borehole, the zeroing measurement can be made with the mule shoe slot directed vertically upwards. With this method however, the results will be slightly less accurate.

Position for zeroing – Gravity Tool Face

1. Ensure that the mule shoe is clean and free from roughness.
2. Thread the bull plug onto the mule shoe.
3. Remove the bottom nose from the instrument.
4. Thread the bull plug, with the mule shoe attached, onto the bottom of the instrument. Ensure that the locking nut located on the bull plug is tight so the shaft does not rotate.
5. Slide the mule shoe into the mule shoe sleeve (see section *Mule shoe sleeve* above).
6. Verify that the mule shoe rotates as necessary and that it slides in correctly over the pin in the mule shoe sleeve.
7. Ensure that the kick direction of the wedge is still pointing upwards and level.

8. Remove the top coupling of the **REFLEX EZ-TRAC™**.
9. The instrument is now ready for the registration of the zero position. Continue to the section *Register zero position*.

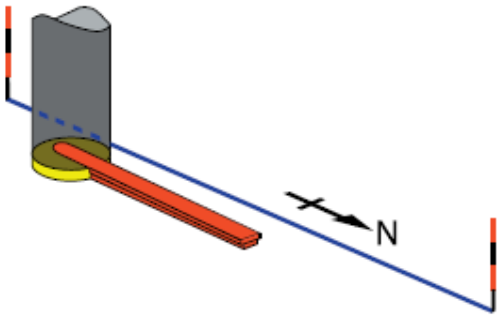
10.5.1.2 Position for zeroing – Magnetic Tool Face

The magnetic method shall be used for boreholes that are within 5 degrees from vertical. The instrument should be positioned in a north-south direction when the zeroing is performed.

The instrument has to be positioned away from any magnetic disturbance when the zeroing measurement is performed. It is also very important that the operator does not wear anything that can interfere magnetically with the measurement.

A reference mark on the outside of the **REFLEX EZ-TRAC™** instrument has to be defined. When the zero position has been established, this reference mark on the instrument shall be orientated in line with the mule shoe slot. Since three aluminium extension rods – which make up a quite long distance – are to be placed between the **REFLEX EZ-TRAC™** and the mule shoe, you will need a method of aligning the two items.

Figure 86 Position for zeroing – Magnetic Tool Face



Position for zeroing – Magnetic Tool Face

1. Use a compass to set out a string pulled tight between two points, so that it lies exactly in a north-south direction.
2. Thread the bull plug onto the mule shoe.
3. Remove the bottom nose from the instrument.
4. Thread the bull plug, with the mule shoe attached, onto the bottom of the instrument.
5. Remove the top coupling of the instrument.
6. Stand the instrument assembly vertically upright, close to the string.
7. Rotate the instrument so that the open face of the mule shoe is parallel with the string and the north direction. A wooden stick or measuring ruler in the slot of the mule shoe may help with this alignment.
8. Make a mark, which is in line with the mule shoe slot, on the outside of the **REFLEX EZ-TRAC™**. This mark is required as a

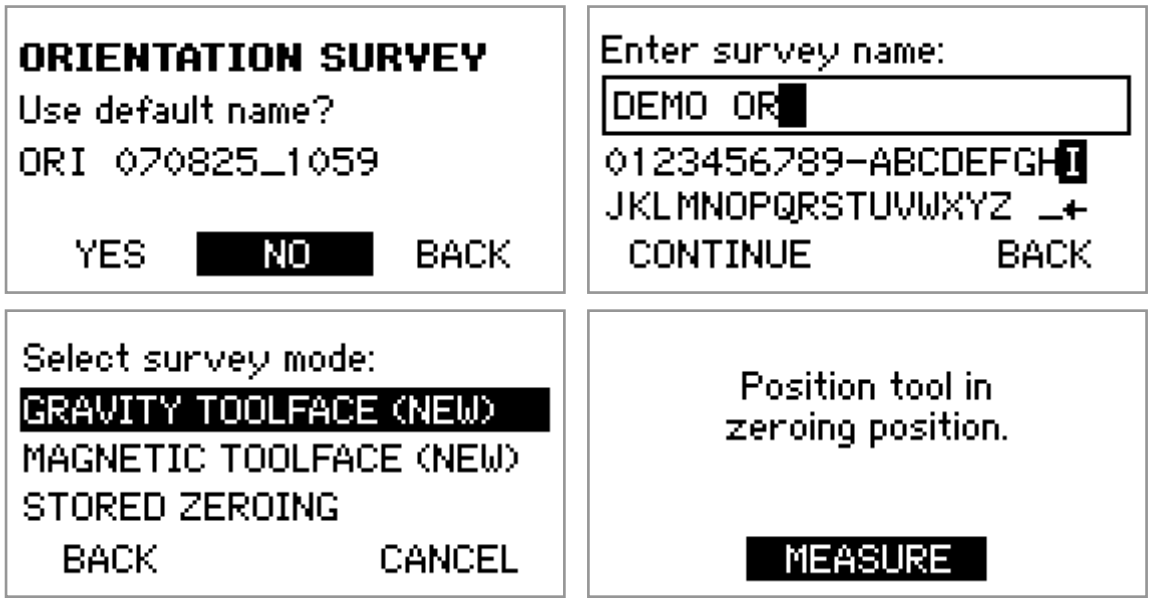
reference when assembling the survey system with aluminium extension rods.

9. The instrument is now ready for the registration of the zero position. Continue to the section *Register zero position*.

10.5.1.3 Register zero position

It is important that the correct survey mode – Gravity Toolface or Magnetic Toolface – is selected; otherwise the tool face calculation will be based on incorrect input.

Figure 87 Register zero position



Register zero position

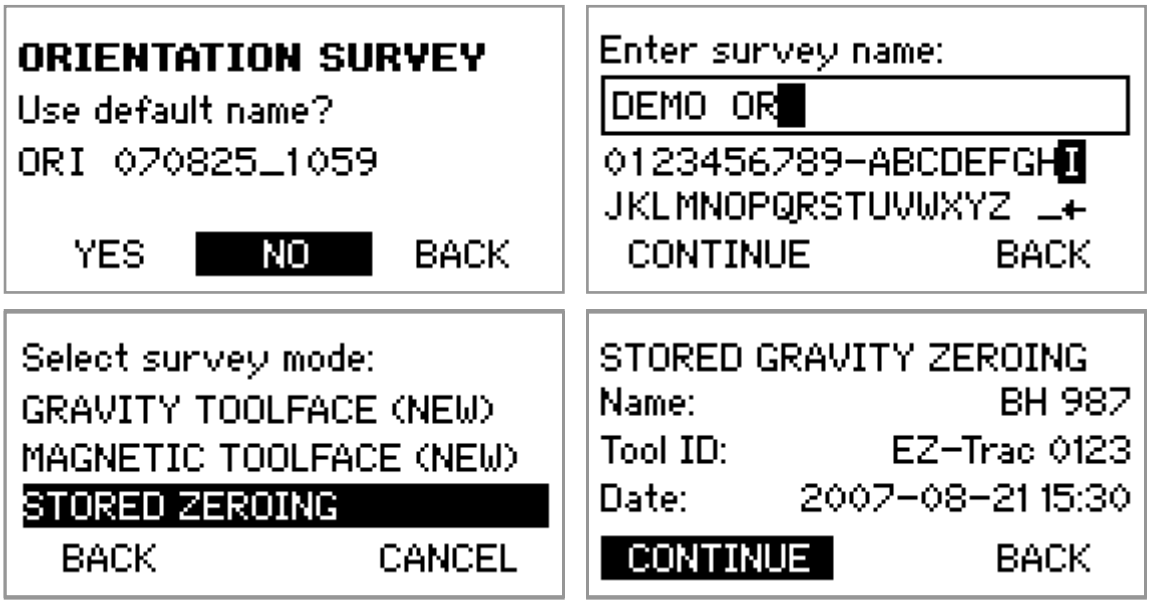
1. From the MAIN menu, select **Survey**.
2. From the SURVEY menu, select **Orientation**.
3. To use the default name, select **YES**. Continue to step 6 below.
4. To enter a survey name, select **NO**.
5. Use the navigation keys to enter the Survey Name. Select **CONTINUE** when finished.
6. Select survey mode, **GRAVITY TOOLFACE** or **MAGNETIC TOOLFACE**.
7. Position the instrument in correct zeroing position and keep it stationary. For the Magnetic Toolface mode, be sure to avoid any magnetic interference.
8. Direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the **REFLEX EZ-TRAC™**.
9. Select **MEASURE** to register the measurement.
10. Keep the control unit aligned with the instrument until ‘Tool is now set to zero’ is displayed. Continue to the section *Downhole survey* below.

10.5.2 Use stored zeroing

The following criteria have to be fulfilled to use the stored zeroing value:

- the survey mode (Gravity or Magnetic) of the stored zeroing must be applicable to the new survey
- the stored Tool ID must be the same as the serial number of the tool to be used for the new survey
- for Gravity Tool Face mode, the instrument must not have been disassembled since the zeroing was registered
- for Magnetic Tool Face mode, the reference mark made when the zeroing was registered must still be visible (or the survey system must still be assembled, with the mule shoe aligned with the reference mark)

Figure 88 Stored Zeroing



Use stored zeroing

1. From the MAIN menu, select **Survey**.
2. From the SURVEY menu, select **Orientation**.
3. To use the default name, select **YES**. Continue to step 6 below.
4. To enter a survey name, select **NO**.
5. Use the navigation keys to enter the Survey Name. Select **CONTINUE** when finished.
6. Select **STORED ZEROING**. Information about the stored zeroing is displayed.

7. If the stored zeroing is not applicable for the present survey, select **BACK** to return to the previous screen. Follow the instructions in section *Register new zeroing* above to register a new zeroing.
8. If the stored zeroing is applicable for the present survey, select **CONTINUE**.
9. 'Tool is now set to zero' is displayed. Continue to the section *Downhole survey* below.

10.6 Downhole survey

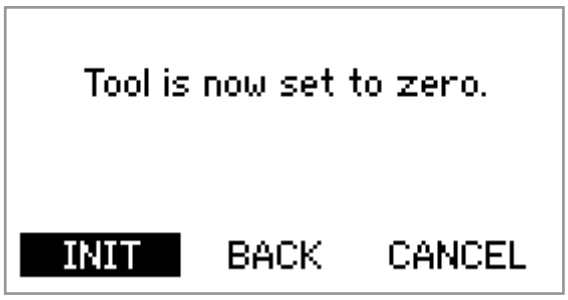
The downhole survey is performed to establish the orientation of the wedge.

10.6.1 Initialise instrument

The **REFLEX EZ-TRAC™** is initialised for the downhole survey, which includes synchronisation of the clocks in the instrument and the control unit and that the instrument memory is cleared.

If a stored zeroing is used, a serial number check is performed to ensure that the present instrument is the same as the one used to register the stored zeroing.

Figure 89 Initialise instrument



Initialise instrument

1. Direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the instrument.
2. Select **INIT** to initialise the instrument for the downhole measurement.
3. Do not break the IR connection until 'Ready for downhole measurement' is displayed.
4. Thread the top coupling onto the instrument.

10.6.2 Assemble survey system – Gravity Tool Face

For the Gravity Tool Face mode, the survey system with the **REFLEX EZ-TRAC™** instrument, the bull plug and the mule shoe is already assembled at this point. Continue to the section *Load tell tale* below.

10.6.3 Assemble survey system – Magnetic Tool Face

For the Magnetic Tool Face mode, in total six aluminium extension rods have to be assembled with the survey system to avoid magnetic interference from the wedge.

When the extension rods are in place, the reference that was marked on the **REFLEX EZ-TRAC™** while doing the zeroing has to be aligned with the mule shoe and the mule shoe sleeve.

If the wedge with the mule shoe sleeve is already in the borehole, the alignment can be made with the mule shoe slot directed vertically upwards. With this method however, the results will be slightly less accurate.

Align survey system

1. Make sure that a reference mark on the outside of the instrument was established when the zeroing procedure was performed. If not, the zeroing has to be redone.
2. Using open end wrenches, join three aluminium extension rods together. Use the machined slots to position the wrenches. The total assembled length should be 4.5 m/15 feet.
3. Unthread the mule shoe from the bull plug and ensure that it is clean and free from roughness.
4. Thread the mule shoe onto the box end of the three assembled aluminium extension rods and tighten.
5. Thread the bull plug, with the **REFLEX EZ-TRAC®** attached, onto the pin end of the three aluminium extension rods and tighten.
6. Slide the instrument assembly into the mule shoe sleeve (see section *Mule shoe sleeve* above).
7. Verify that the mule shoe rotates as necessary and that it slides in correctly over the pin in the mule shoe sleeve.
8. Ensure that the locking nut of the bull plug is loose.
9. Rotate the instrument assembly until the reference mark on the outside of the **REFLEX EZ-TRAC®** is aligned with the kick direction of the wedge.
10. Tighten the locking nut of the bull plug. Ensure that the alignment remains.
11. Remove the survey system from the mule shoe sleeve assembly.

In order to avoid magnetic interference from the drill rods, another three aluminium extension rods are attached to the upper end of the instrument.

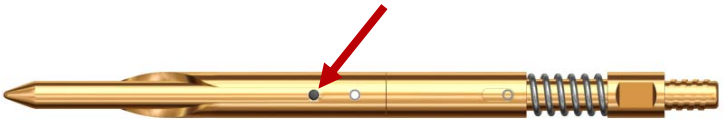
Assemble survey system

1. Using open end wrenches, join the three aluminium extension rods together. Use the machined slots to position the wrenches. The total assembled length should be 4.5 m/15 feet.
2. Thread the aluminium extension rod package into the top coupling of the instrument.

10.6.4 Load tell tale

A lead tell tale is loaded in the mule shoe, allowing confirmation that the mule shoe has been correctly positioned in the mule shoe sleeve during the downhole survey. The internal pin of the mule shoe sleeve leaves an impression on the tell tale if the mule shoe has positioned accurately.

Figure 90 Load lead tell tale



Load tell tale

1. Put the lead tell tale (or other suitable material) into the hole in the upper end of the slits on the mule shoe.

10.6.5 Run into hole

When the wedge has been positioned in the borehole, the survey system is run into and recollected from the borehole using one of the surveying methods described in the chapter *Surveying methods*.

Depending on surveying method, the survey system may also need to be equipped with a pin spear assembly, a landing collar box type, a core adapter and/or a swivel.

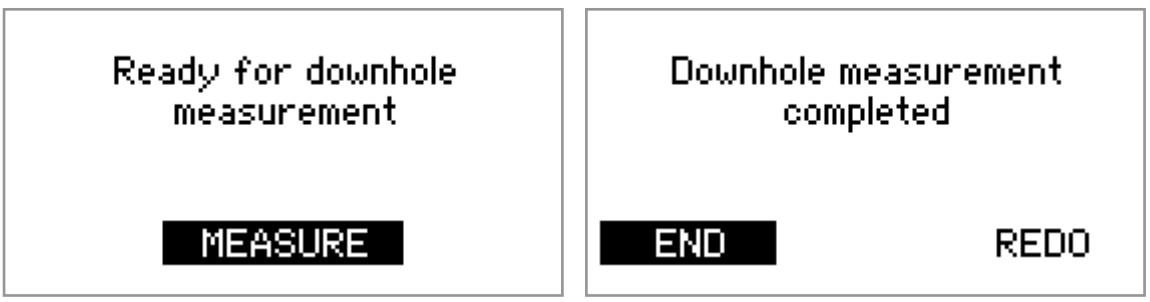
For the Magnetic Tool Face mode, 9 meters of non-magnetic drill rods are also needed to avoid magnetic interference. These rods shall go into the rod string behind the bit or hammer and the survey system shall sit in the middle of the non-magnetic rods.

Note, the **REFLEX EZ-TRAC™** has to be initialised before the instrument is run into the hole. Please refer to the section *Initialise instrument* above.

10.6.6 Execute downhole survey

The downhole survey is performed when the survey system has landed and is stationary in the mule shoe sleeve.

Figure 91 Execute downhole survey



Execute downhole survey

1. When the survey system is stationary at the survey station, select **MEASURE** on the **REFLEX™ EZ-COM** unit.
2. Do not move the instrument while ‘Measuring’ is displayed.

3. To redo the measurement, select **REDO**. Note, previous measurement will be replaced.
4. To end the survey, select **END**.
5. Retrieve the survey system from the borehole.

10.6.7 Verify lead tell tale

When the survey system has been retrieved from the borehole, verify that the lead tell tale indicates a successful landing in the mule shoe sleeve. If not, you must redo the downhole survey.

10.7 Download data

Survey data is downloaded to the **REFLEX™ EZ-COM** unit.

Figure 92 Download

Download data

1. Remove the top coupling from the **REFLEX EZ-TRAC™** and direct the IR port of the **REFLEX™ EZ-COM** unit towards the IR port of the instrument.
2. Select **DOWNLOAD**. Survey data is downloaded and automatically stored in the control unit.
3. Do not break the IR connection while ‘Downloading’ is displayed.

10.8 Survey results

When the survey data has been downloaded, the tool face - that is, the orientation of the wedge - is displayed on the **REFLEX™ EZ-COM** unit.

Figure 93 Toolface

When **CONTINUE** is selected, the *Orientation Menu* screen is displayed.

Figure 94 Orientation Menu

Select *Enter desired Toolface* to continue the orientation procedure with the current zeroing.

Select *End survey and Save results* to save the survey results to file. The zeroing value is automatically stored.

Select *Cancel* to end the survey without saving. The zeroing value is lost (unless a stored value is being used).

10.8.1 Enter desired Toolface

If the orientation of the wedge is not as wanted, the desired tool face can be entered. The **REFLEX™ EZ-COM** unit tells you how much you need to rotate the rods to obtain the correct orientation. The entered value is stored until the survey is ended.

Figure 95 Enter desired toolface

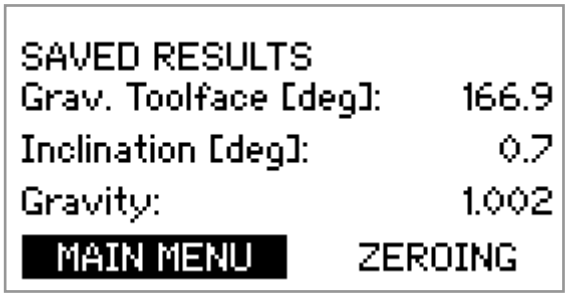
Enter desired Toolface

1. In the *Orientation Menu* screen, select **Enter desired Toolface**.
2. Enter the desired toolface value. Select **CONTINUE** when finished.
3. The required rotation of the drill rods is displayed. Rotate the drill rods accordingly.
4. Select **RE-MEASURE** on the **REFLEX™ EZ-COM** unit.
5. Continue to the section *Downhole survey* above.

10.8.2 End survey and Save results

In addition to the toolface (orientation) of the wedge, **REFLEX EZ-TRAC™** also registers the Inclination and Gravity at the survey station. These values are saved to file in the **REFLEX™ EZ-COM** unit, and can be viewed at a later stage from the RESULTS menu.

Figure 96 End survey and Save results



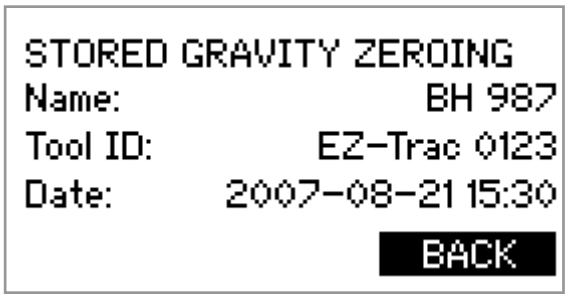
End survey and Save results

1. In the *Orientation Menu* screen, select **End survey and Save results**.
2. The stored survey results are displayed.
3. Select **MAIN MENU** to return to the MAIN menu.

10.8.2.1 Stored Zeroing

The zeroing value is automatically stored for future use when the *End survey and Save results* option is selected. Information about the stored zeroing can be displayed before returning to the MAIN menu.

Figure 97 Stored Zeroing



Stored Zeroing

1. In the *Saved Results* screen, select **ZEROING**.
2. Information about the stored zeroing is displayed.
3. Select **BACK** to return to the previous screen.

10.8.3 Cancel

If there is no need to save the results, the survey can be ended by selecting Cancel.

Note, the zeroing value is lost when cancelling the survey (unless a stored zeroing value is being used).

11 Surveying methods

This chapter describes a number of different surveying methods for **REFLEX EZ-TRAC™**. Instructions for assembling the corresponding running gear are also provided.

Running gear for Orientation surveys is described in the chapter *Orientation Survey*.

11.1 Running gear

Since **REFLEX EZ-TRAC™** is a magnetic instrument, it has to be placed at a distance from any magnetic interference, such as the drill string or wireline. Aluminium extension rods are used for this purpose. The total length may vary depending of type of drill string, but normally 4.5 m/15 ft of extension rods is enough.

Depending on surveying method, you may also need a pin spear assembly, a landing collar box type, a core adapter or a swivel.

11.1.1 Important assembling tips

When assembling the running gear, please keep the following in mind:

- Only use sealing rings that have been provided by **REFLEX™** and ensure that they are correctly placed at all times.
- Always keep sealing rings lubricated with a sufficient amount of silicone grease, but not excessive amounts.
- Always inspect the aluminium extension rods for tightness. Due to the constant shock, they can sometimes slowly back off coming loose, and possibly unscrewing down the hole.
- Inspect the nylon landing sub for wear on a regular basis. This can make the difference between the landing sub stopping or passing right through the bit.
- Ensure that the spring of the landing collar is facing in the upwards direction. Otherwise it will not be able to absorb the shock when the landing collar lands in the bit.

11.1.2 Maintenance

Before starting to assemble the running gear, check the condition of all sealing rings. Clean, replace or lubricate if needed.

After the survey, clean and place all equipment back in the transport case.

Please also refer to the chapter *Maintenance*.

11.1.3 Extension rods

Aluminium extension rods at a total length of 4.5 m/15 ft have to be used at all times to avoid magnetic interference.

Figure 98 Aluminium extension rods

Assemble extension rods

1. Using open end wrenches, join the three aluminium extension rods together. Use the machined slots to position the wrenches. The total assembled length should be 4.5 m/15 feet.
2. Initiate the instrument using the **REFLEX™ EZ-COM** unit before the top coupling is threaded onto the instrument probe.
3. Thread the pin end of the aluminium extension rod into the top coupling of the instrument.

11.1.4 Landing collars

Landing collars are needed when the survey system is run down the drill string and through the drill bit, to prevent the system from passing out of the drill string completely.

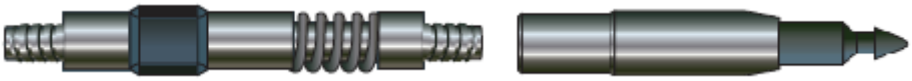
Some operators use a landing collar with pin spear head, which is latched to the overshot assembly. Some operators prefer to thread the landing collar to the overshot assembly, using a box type of landing collar.

Figure 99 Pin spear landing collar assembly

Pin spear landing collar assembly

1. Thread the pin spear landing collar assembly into the box end of the aluminium extension rod and tighten with pipe wrenches.
2. Latch the pin spear onto the overshot assembly.

Figure 100 Pin spear coupling and landing collar



Pin spear coupling and landing collar

1. Thread the spring end of the landing collar into the pin spear coupling. Note, it is important that the spring is facing in the upwards direction.
2. Thread the landing collar assembly into the box end of the aluminium extension rod and tighten with pipe wrenches.
3. Latch the pin spear onto the overshot assembly.

Ensure that the spring of the landing collar is facing in the upwards direction. Otherwise it will not be able to absorb the shock when the landing collar lands in the bit.

Figure 101 Landing collar box type

Landing collar box type

1. Thread the pin end of the landing collar into the box end of the aluminium extension rod and tighten with pipe wrenches.
2. Thread the box end of the landing collar onto the overshot assembly and tighten with pipe wrenches.

11.2 Surveying methods

The survey system may be run into and recollected from the borehole using one of the surveying methods below.

11.2.1 Through drill string - wireline

Surveying with wireline through the drill string is most commonly used for Single Shot surveys. This method allows surveying to be performed without interrupting the drilling activity.

The instrument is run down the drill string, through the drill bit and into the open hole. A landing collar is needed to prevent the survey system from passing out of the drill string completely. There has to be an opening at the drill bit, large enough for the instrument to pass through, but small enough for the landing collar to stop.

When surveying with wireline through the drill string, gravity is used to lower the instrument down the hole. Hence, the method is best suited for inclined boreholes, with inclinations up to 45 degrees from vertical.

The survey system for surveying with wireline through the drill string consists of the **REFLEX EZ-TRAC™** instrument, three aluminium extension rods and a landing collar. This configuration allows the instrument to extend 4.5 m/15 ft past the drill string, to avoid any magnetic interference that the string may cause.

Through drill string - wireline

1. Before lowering the survey system down the drill string, ensure that the drill rods are raised from the bottom a minimum of seven meters.
2. With the survey system – including a landing collar of appropriate size – attached to the overshot assembly, raise the system up the drill slide.
3. Slowly lower the survey system down the drill string.
4. When the survey system reaches the bit, the landing collar will rest in the bit – with the instrument extending 4.5 m/15 ft past the bit – and the wireline should become slack.
5. Keep the survey system stationary at the survey station until the measurement has been taken.
6. Using the wireline, slowly raise the survey system until it reaches the collar of the hole.

7. Gently lift the survey system from the hole.
8. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.2 Through drill string - tripping out

Surveying through the drill string while tripping out is most commonly used for Multi Shot surveys.

The instrument is run down the drill string, through the drill bit and into the open hole. A landing collar is needed to prevent the survey system from passing out of the drill string completely. There has to be an opening at the drill bit, large enough for the instrument to pass through, but small enough for the landing collar to stop.

For boreholes with inclinations up to 45 degrees from vertical, gravity is used to lower the survey system down the drill string. Wireline may be used for extra safety. For boreholes that are not inclined enough or are directed upwards, the survey system must be pumped in while attached to the core tube.

The survey is performed while tripping out. This is best done when the drill string has to be recovered for a change of drill bit, for example. Surveys may also be performed on subsequent drill bit changes. In that case, survey coverage would extend back to the start of the previous survey. All these survey sections may be merged together. Alternatively, the hole is completed and the drill rig is to be moved on. The survey should then be performed while recovering the rods.

The survey system for surveying through the drill string while tripping out consists of the **REFLEX EZ-TRAC™** instrument, three aluminium extension rods and a landing collar or core adapter.

11.2.2.1 Gravity

Gravity may be used to lower the survey system down the hole. Naturally, this is only possible for inclined boreholes, with inclinations up to 45 degrees from vertical.

When lowering the survey system using gravity, a pin spear type or a box type of landing collar can be used. Note, the landing collar box type must not be threaded onto the overshot assembly as it is impossible to release it at the bottom of the hole.

Lower with gravity

1. Before lowering the survey system down the drill string, ensure that the drill rods are raised from the bottom a minimum of seven meters.
2. Gently place the survey system – including a landing collar of appropriate size – at the collar of the hole and let it go. Gravity will lower the system to the bottom. If the borehole is filled with water, allow sufficient time to reach the bottom.
3. When the survey system has reached the drill bit, the landing collar will rest in the bit with the instrument extending 4.5 m/15 ft past the bit.
4. Continue to the section *Tripping out* below.

11.2.2.2 Wireline

For extra safety, wireline may be used when using gravity to lower the survey system.

When wireline is used, it must be released at the bottom of the hole and recovered before the rod tripping begins. A pin spear type of landing collar should be used and a special adapter is needed to release the dogs on the overshot assembly to recover the wireline.

Lower with gravity - wireline

1. Before lowering the survey system down the drill string, ensure that the drill rods are raised from the bottom a minimum of seven meters.
2. With the survey system – including a landing collar of appropriate size – attached to the overshot assembly, raise the system up the drill slide.
3. Slowly lower the survey system down the drill string.
4. When the survey system reaches the bit, the landing collar will rest in the bit – with the instrument extending 4.5 m/15 ft past the bit – and the wireline should become slack.
5. Release the dogs on the overshot assembly and recover the wireline.
6. Continue to the section *Tripping out* below.

11.2.2.3 Pump into hole

If the survey system is pumped into the hole, a core adapter attached to the core tube is used instead of landing collar. A water swivel or stuffing box may also be required.

Pumping

1. Follow step 1-6 in the procedure instructions in section *Pumping* below.
2. Continue to the section *Tripping out* below.

11.2.2.4 Tripping out

When the survey system is located at the bottom of the hole, the surveying while tripping out can start.

Survey while tripping out

1. Keep the survey system stationary at the survey station until the measurement has been taken.
2. While tripping out the rods, keep track of the number. Remove the correct amount of rods until the next survey station has been reached.
3. Continue the process and repeat step 1 and 2 until the collar of the hole is reached.
4. Gently lift the survey system from the hole.
5. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.3 *In front of drill string*

Surveying with the instrument pushed in front of the drill string is most commonly used for Multi Shot surveys. With this method it is possible to survey both in and out of the borehole, which allows for repeatability and averaging of survey results.

Using an adapter, the survey system is attached to the drill string. The survey system is pushed in front of the drill string as it is being run into the hole.

To recollect the instrument, the drill string has to be tripped out. The survey system will come with the drill string as it is being removed from the hole.

The survey system for surveying in front of the drill string consists of the **REFLEX EZ-TRAC™** instrument, a minimum of three aluminium extension rods and an adapter.

Do not rotate the drill string counter-clockwise when advancing the survey system into or out of the borehole. In that case, the survey system might be un-threaded.

In front of drill string

1. Thread the adapter into the box end of the aluminium extension rod and tighten with pipe wrenches.
2. Gently place the survey system in the collar of the hole. Be careful to secure the survey system to prevent it from falling into the hole.
3. Thread the survey system onto the drill string. Tighten with pipe wrenches.
4. Slowly move the survey system forward to the first survey station.
5. Keep the survey system stationary at the survey station until the measurement has been taken.
6. Continue adding drill rods to advance to next survey station and repeat the measuring process.
7. Repeat step 5 and 6 until the last station is measured or the bottom of the hole is reached. Caution, always stop short of bottom depth to prevent damaging of the survey system - the system extends 4.5 m/15 ft beyond the drill string, and build up of sledge and loose material can be located at the bottom.
8. Begin removing the rods. If surveying out of hole is required, remove the correct amount of rods until the next survey station has been reached.
9. Keep the survey system stationary at the survey station until the measurement has been taken.
10. Continue removing rods and repeat step 8 and 9 until the adapter reaches the collar of the hole.
11. Gently lift the survey system from the hole.
12. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.4 Pumping

The pumping method is used for boreholes with inclinations up to 45 degrees from horizontal and for boreholes directed upwards, where gravity is not an advantage.

This method is commonly used for underground programs were the inclinations vary from positive to negative.

By using the core tube and locking in the core barrel, the system is allowed to safely lock in place while the survey is being performed.

The survey system for the pumping method consists of the **REFLEX EZ-TRAC™** instrument, three aluminium extension rods and a core adapter. A water swivel or stuffing box may also be required depending on the inclination of the hole.

Pumping

1. Before lowering the survey system down the drill string, ensure that the drill rods are raised from the bottom a minimum of seven meters.
2. Thread the box end of the core adapter to the pin end of the core tube. Tighten with pipe wrenches.
3. Gently place the survey system (instrument with three aluminium extension rods) in the collar of the hole. Be careful to secure the survey system to prevent it from falling into the hole.
4. Thread the pin end of the core adapter into the box end of the aluminium extension rod and tighten with pipe wrenches.
5. Attach the water swivel or stuffing box and slowly pump the core tube with the attached survey system into the borehole.
6. When the core tube and the back end reach the landing ring, the back end will lock in the landing ring while the instrument extends 4.5 m/15 ft past the drill string.
7. Keep the survey system stationary at the survey station until the measurement has been taken.
8. Slowly retrieve the core tube and the survey system. Alternatively, continue surveying while tripping out (see the section *Tripping out* above).
9. Gently lift the survey system from the hole.
10. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.5 Open hole surveying

Open hole surveying is used when the drill rods have been removed from the hole. If the hole is uncased, or cased with PVC tubing or other non-magnetic material, these holes may be surveyed.

Note, open hole surveying is high risk. Due to the existence of cavities, irregularities and fractures as a result of bad rock formation, the survey system risks to get struck and remain in the hole.

Should it be necessary to perform open hole surveying, check the borehole with a dummy probe first. This will give you information about the hole condition and if the recorded hole depth is correct. Taking this step can avoid the possible loss or excess damage to the equipment.

11.2.5.1 Downwards direction

For boreholes that are directed downwards, gravity can be used to lower the survey system. A swivel with a wireline and a winch is normally used to recollect the system. For short holes, a marked rope or wire can be used.

The survey system for surveying downwards in an open hole consists of the **REFLEX EZ-TRAC™** instrument, three aluminium extension rods and a swivel.

Open hole downwards

1. Thread the swivel into the box end of the aluminium extension rod and tighten with pipe wrenches.
2. Make sure that the wireline cable goes through the swivel eyelet and that it is secured.
3. Gently place the survey system at the collar of the hole.
4. Using the wireline winch and a counter or marked wireline, slowly lower the survey system to the survey station.
5. Keep the survey system stationary at the survey station until the measurement has been taken.
6. Using the wireline, slowly raise the survey system until it reaches the collar of the hole.
7. Gently lift the survey system from the hole.
8. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.5.2 Upwards direction

For boreholes that are directed upwards, a set of rods must be attached to the survey system to allow the instrument to be pushed in and pulled out of the hole.

Drill rods, wood rods, coiled plastic hose, coiled tendon or any other suitable push rods may be used. If any of these are of ferrous steel, non-magnetic aluminium extension rods have to be used.

The survey system for surveying upwards in an open hole consists of the **REFLEX EZ-TRAC™** instrument, three aluminium extension rods (if the push rods are of magnetic material) and an adapter that will allow the system to be threaded to the push rods.

Open hole upwards

1. Thread the adapter into the box end of the aluminium extension rod and tighten with pipe wrenches. If the push rods are of non-magnetic material, the adapter can be threaded directly into the top coupling of the instrument.
2. Gently place the survey system at the collar of the hole.

3. Thread a push rod into the survey system.
4. Continue to add rods until the survey station is reached.
5. Keep the survey system stationary at the survey station until the measurement has been taken.
6. Pull the rods from the hole until the survey system has reached the collar of the hole.
7. Gently lift the survey system from the hole.
8. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.6 Reverse Circulation

This surveying method is used in Reverse Circulation drilling only.

Since the survey system cannot pass the drill bit, the survey has to be performed inside the RC drill rods. Inclination measurements can always be performed, as these are not affected by magnetism. However, if azimuth readings are required, a minimum of nine meters of non-magnetic rods directly behind the RC hammer must be included. The instrument also has to be placed in the middle of these non-magnetic drill rods.

11.2.6.1 Azimuth and inclination

This method is used to achieve Single Shot or Multi Shot readings of azimuth and inclination in an RC environment.

Wireline is used to run the survey system into and out of the borehole, with the instrument placed in the middle of in total nine meters of non-magnetic aluminium extension rods.

The survey system consists of the **REFLEX EZ-TRAC™** instrument, six aluminium extension rods, an orientation bull plug and a brass wireline swivel.

In addition to that, nine meters of non-magnetic RC drill rods are required. These shall be placed directly behind the RC hammer to prevent magnetic interference.

Assemble survey system

1. Remove the bottom nose from the **REFLEX EZ-TRAC™**.
2. Thread the orientation bull plug onto the lower end of the instrument.
3. Using open end wrenches, join the three aluminium extension rods together. Use the machined slots to position the wrenches. The total assembled length should be 4.5 m/15 feet.
4. Thread the box end of the aluminium extension rods into the orientation bull plug.
5. Initiate the instrument using the **REFLEX™ EZ-COM** unit before the top coupling is threaded onto the instrument probe.
6. Join another three aluminium extension rods together (see step 5 above).

7. Thread the pin end of the aluminium extension rods into the top coupling of the instrument.
8. Thread the brass wireline swivel into the upper aluminium extension rod.

Before starting the survey, ensure that nine meters of non-magnetic RC drill rods are placed directly behind the RC hammer.

RC environment – azimuth and inclination

1. Mark the wireline cable or use a wireline counter, to prevent the survey system from being damaged by hitting the top of the RC hammer.
2. Make sure that the wireline cable goes through the swivel eyelet and that it is secured.
3. Gently place the survey system at the collar of the hole.
4. Using the wireline, slowly lower the survey system to the survey station.
5. Keep the survey system stationary at the survey station until the measurement has been taken.
6. Should you wish to perform a Multi Shot survey, you must now release the survey system from the wireline as it will rest above the hammer, and perform the survey while tripping the rods out of the hole. Continue to the section *Tripping out* above.
7. Using the wireline, slowly raise the survey system until it reaches the collar of the hole.
8. Gently lift the survey system from the hole.
9. Place the survey system in a safe position away from the borehole and unthread the running gear.

11.2.6.2 Inclination

This method is used to achieve Single Shot or Multi Shot readings of inclination in an RC environment.

In this case, the instrument can be run inside the normal RC drill rods, since the inclination measurements are not affected by magnetism.

Wireline is used to run the survey system into and out of the borehole.

The survey system consists of the **REFLEX EZ-TRAC™** instrument and brass wireline swivel.

Assemble survey system

1. Initiate the instrument using the **REFLEX™ EZ-COM** unit before the top coupling is threaded onto the instrument probe.
2. Thread the brass wireline swivel into the top coupling.

Note, since inclination measurements are not affected by magnetism, the recording can be taken at any position in the RC drill rods.

RC environment – inclination only

1. Mark the wireline cable or use a wireline counter, to prevent the survey system from being damaged by hitting the top of the RC hammer.
2. Make sure that the wireline cable goes through the swivel eyelet and that it is secured.
3. Gently place the survey system at the collar of the hole.
4. Using the wireline, slowly lower the survey system to the survey station.
5. Keep the survey system stationary at the survey station until the measurement has been taken.
6. Should you wish to perform a Multi Shot survey, you must now release the survey system from the wireline as it will rest above the hammer, and perform the survey while tripping the rods out of the hole. Continue to the section *Tripping out* above.
7. Using the wireline, slowly raise the survey system until it reaches the collar of the hole.
8. Gently lift the survey system from the hole.
9. Place the survey system in a safe position away from the borehole and unthread the running gear.

12 Transfer Survey Files

This chapter describes the contents of survey files and how to transfer them to a USB Memory stick or directly to a PC. Import of survey files via **REFLEX™ SProcess** is also described.

12.1 Survey files

Survey data files are automatically saved in the **REFLEX™ EZ-COM** unit.

The Survey Name entered when starting the survey is stored in the header file. That name is used to identify the survey in the **REFLEX™ EZ-COM** unit and in **REFLEX™ SProcess**.

In the file system (as viewed when connecting to a PC), the name of the survey data file is the Survey Name entered when the survey was created; provided that the name is maximum 7 characters long, for example DEMO_1.

If the Survey Name is more than 7 characters long, the name of the survey file is a prefix (indicating the type of survey; SS, MS or ORI) and a serial number, for example MS_0001.

The reason for the file name difference is that **REFLEX™ EZ-COM** has a basic operating system, which has a limitation when it comes to the length of the file name.

Note, survey files that are imported via **REFLEX™ SProcess** (version 2.0) are automatically renamed to the Survey Name stored in the header file.

12.1.1 Single Shot

Single Shot surveys generate two data files:

SS_xxxx.MLH
SS_xxxx.MLR

The .MLH file is a text file that contains header information about the survey. The .MLR file is a binary file that contains the raw data for each survey station.

A Single Shot survey with added single shot measurements has the name of the original survey.

12.1.2 Multi Shot

Multi Shot surveys generate two data files:

MS_xxxx.MLH
MS_xxxx.MLR

Reversed Multi Shot surveys generate two additional data files:

MS_xxxxR.MLH
MS_xxxxR.MLR

The .MLH file is a text file that contains header information about the survey. The .MLR file is a binary file that contains the raw data for each survey station.

12.1.3 *Orientation*

Orientation surveys generate two data files:

ORI_xxxx.ORH
ORI_xxxx.ORR

The .ORH file is a text file that contains header information about the survey. The .ORR file is a binary file that contains the raw data.

Note, Orientation surveys are not recognised by **REFLEX™ SProcess**.

12.2 REFLEX™ SProcess

REFLEX™ SProcess is a Windows based application used to view, print and export survey data generated by the **REFLEX™** surveying instruments.

In addition to the survey results displayed on the **REFLEX™ EZ-COM** unit, **REFLEX™ SProcess** also calculates and presents the regional and local coordinates of Multi Shot surveys, based on the survey data collected by the **REFLEX™ EZ-COM** unit.

In **REFLEX™ SProcess** versions higher than 1.75, the Magnetic Reference of Single Shot and Multi Shot surveys is possible to view and edit.

Please refer to the **REFLEX™ SProcess** on-line Help document for detailed information.

12.2.1 *Limitations*

Orientation files generated by the **REFLEX™ EZ-COM** unit are not recognized by **REFLEX™ SProcess**.

Single Shot files generated by the **REFLEX™ EZ-COM** unit can be opened in **REFLEX™ SProcess**, but in version 1.70 and earlier versions no survey results are displayed.

12.3 Transfer survey files

There are three ways of transferring survey files from the **REFLEX™ EZ-COM** unit:

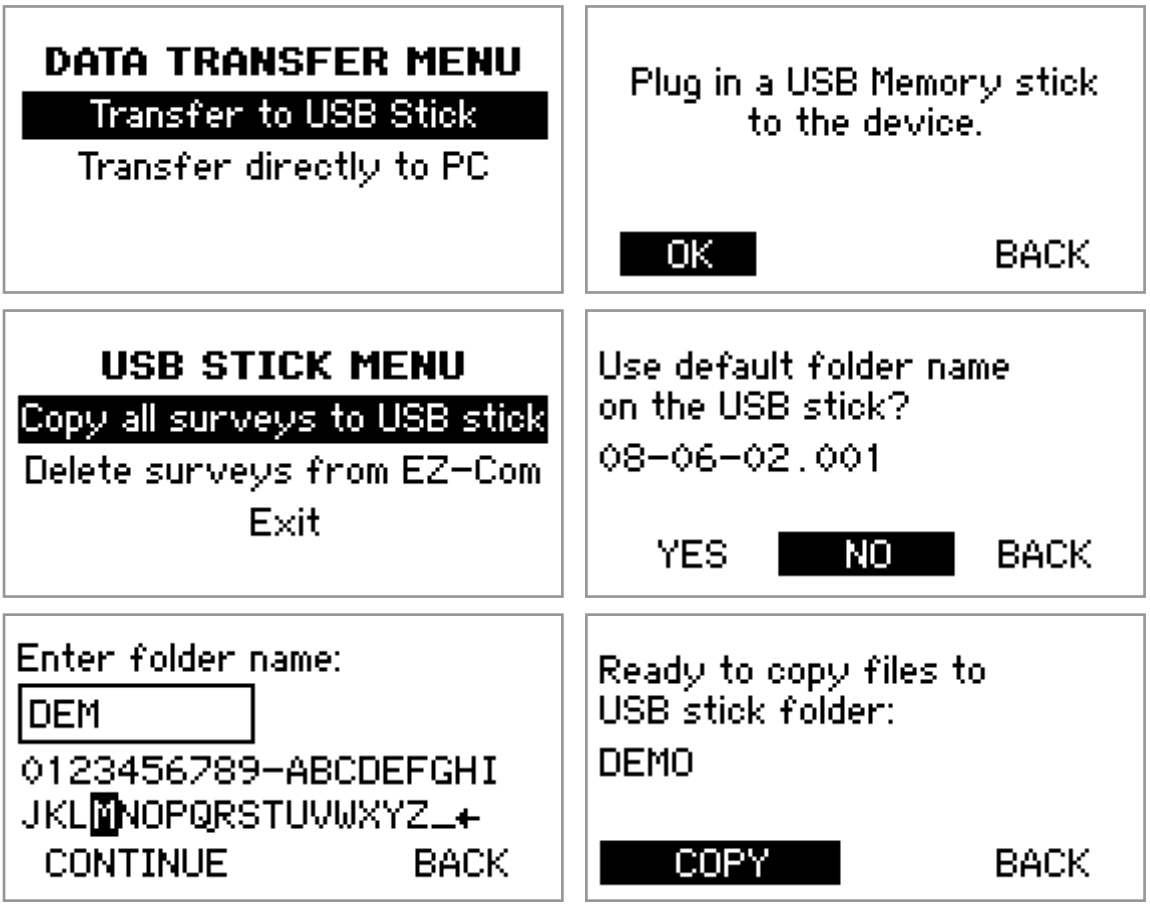
- connect a USB Memory stick to the unit and copy all files to the memory stick
- connect the unit directly to a PC with a USB cable and copy all files directly to the file system of the PC
- connect the unit directly to a PC with a USB cable and import selected Single Shot and Multi Shot surveys via **REFLEX™ SProcess** (version 2.0).

12.3.1 *Transfer files to USB Memory stick*

A standard USB Memory stick, connected to the USB port of the **REFLEX™ EZ-COM** unit, is needed.

All surveys in the **REFLEX™ EZ-COM** unit will be copied to a folder that is created on the USB Memory stick. The default name of that folder is YY-MM-DD.nnn (for example 08-06-02.001) where ‘nnn’ is a serial number. As an alternative, a folder name can be entered, as described in the instructions below.

Figure 102 Copy files to USB stick



Copy files to USB Memory stick

1. From the MAIN menu, select **Data Transfer**.
2. From the DATA TRANSFER menu, select **Transfer to USB Stick**.
3. Connect the USB Memory stick into the USB port of the **REFLEX™ EZ-COM** device and select **OK**.
4. From the USB MEMORY STICK menu, select **Copy all surveys to USB stick**.
5. To use the default folder name, select **YES**. Continue to step 8 below.
6. To enter a folder name, select **NO**.
7. Use the navigation keys to enter the folder name. Select **Continue** when finished.
8. Select **Copy** to start the copying of the survey files.
9. Do not remove the USB Memory stick while '*Copying*' is displayed.
10. When all files have been copied, select **OK** to continue.
11. If you want to delete all surveys in the **REFLEX™ EZ-COM** unit, continue to the section *Delete survey files* below.

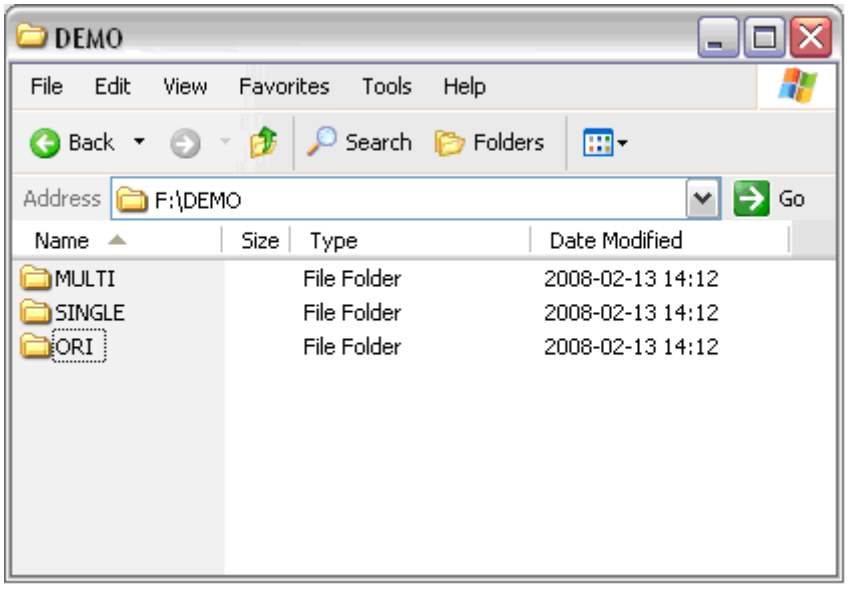
12. If you don't want to delete surveys in the **REFLEX™ EZ-COM** unit, select **EXIT** to return to the MAIN menu. Remove the USB Memory stick and store it in a safe place.

All survey files in the **REFLEX™ EZ-COM** unit are now copied to a folder on the USB Memory stick. The name of the folder is either the default name or the name entered by the user.

In the survey files folder on the USB Memory stick, there are three sub-folders:

- SINGLE; where all Single Shot surveys are stored, including Single Shot surveys with added single shot measurements
- MULTI; where Multi Shot surveys are stored
- ORI; where Orientation surveys are stored

Figure 103 USB Memory stick folders



The figure above shows the file structure on the USB Memory stick when connected to a PC.

Note, when copying survey files from the USB Memory stick to a PC, both the .MLH and the corresponding .MLR files have to be included.

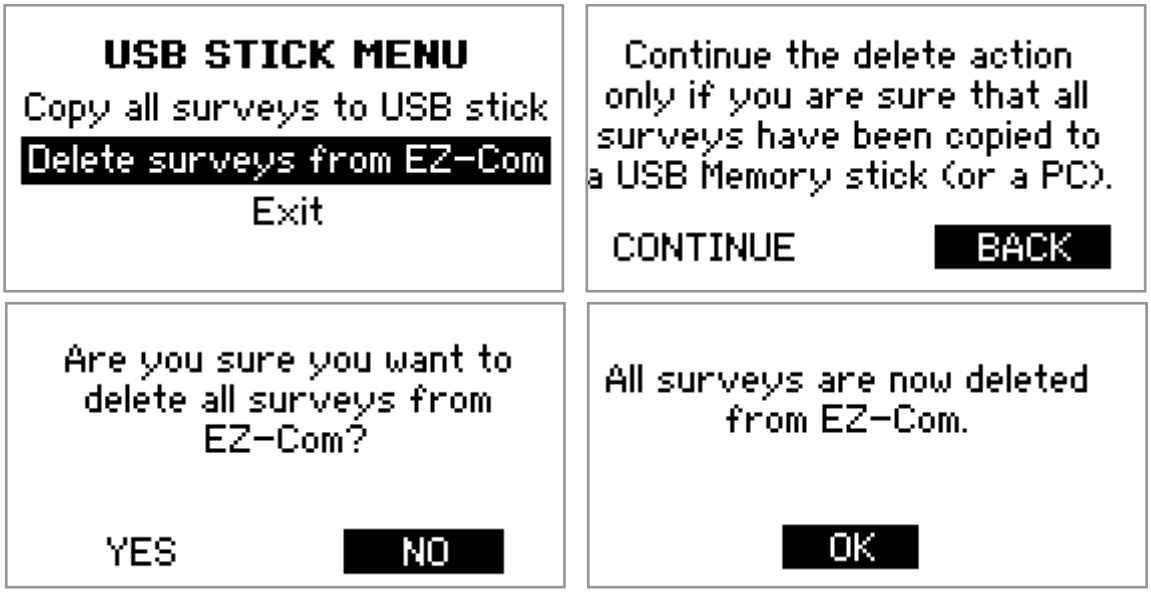
12.3.1.1 Delete survey files

When the survey files have been copied to the USB Memory stick, the files should be deleted from the **REFLEX™ EZ-COM** unit to free memory space.

Note, with the procedure described in this section, *all* survey files are deleted from the **REFLEX™ EZ-COM** unit. As an alternative, the unit can be connected directly to a PC, which allows deletion of selected files only. Please refer to the section *Transfer files directly to PC* below.

Note, be careful not to delete survey files that have not been stored on the USB Memory stick or elsewhere.

Figure 104 Delete survey files



Delete survey files

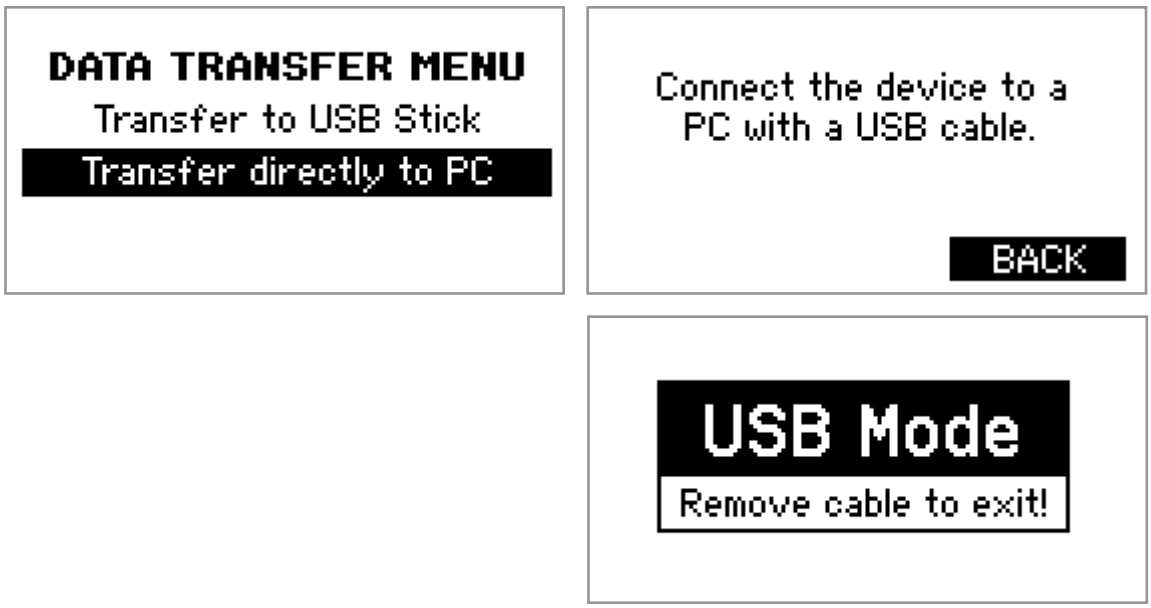
1. From the USB MEMORY STICK menu, select **Delete surveys from EZ-Com**.
2. If you are sure that the survey files have been safely stored in another location, for example on the USB Memory stick, select **Continue** to confirm. If not, select **BACK** to return to the USB MEMORY STICK menu.
3. If you are sure that you want to delete *all* surveys on the **REFLEX™ EZ-COM** unit, select **YES** to confirm. If not, select **NO** to return to the USB MEMORY STICK menu.
4. When all surveys have been deleted, select **OK** to return to the USB MEMORY STICK menu.
5. From the USB MEMORY STICK menu, select **EXIT** to return to the MAIN menu.
6. Remove the USB Memory stick and store it in a safe place.

12.3.2 *Transfer files directly to PC*

A USB cable, Type A-A, is needed to connect the **REFLEX™ EZ-COM** unit to the PC.

When the **REFLEX™ EZ-COM** unit is connected to the PC, it is possible to access all the survey files stored on the unit from the PC.

Figure 105 Transfer files directly to PC

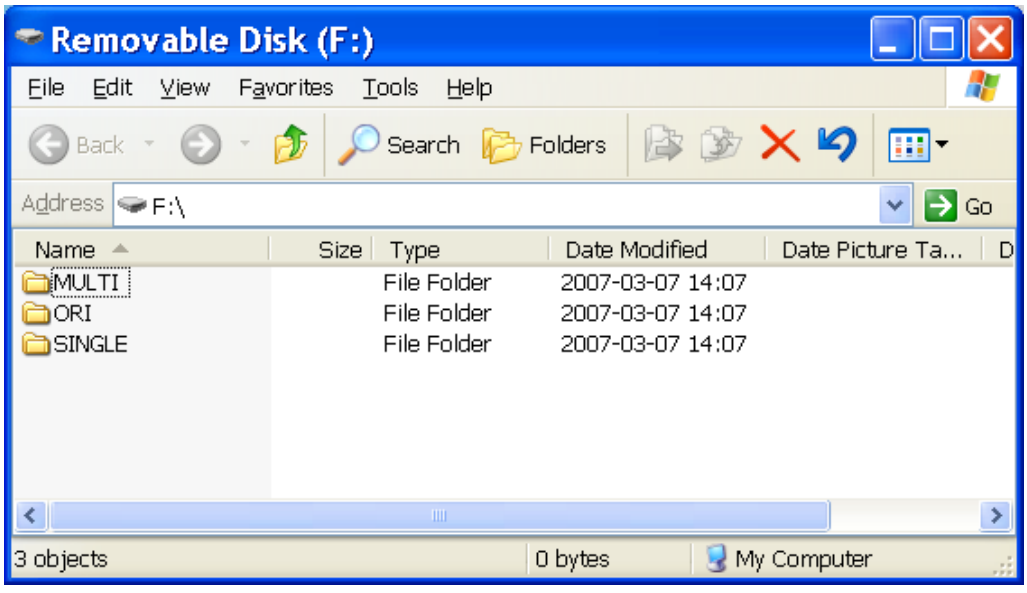


Transfer files directly to PC

1. From the MAIN menu, select **Data Transfer**.
2. From the DATA TRANSFER menu, select **Transfer directly to PC**.
3. Connect the **REFLEX™ EZ-COM** unit to a PC, using a Type A-A USB cable.
4. The *USB Mode* message will be displayed on the **REFLEX™ EZ-COM** unit.

When the **REFLEX™ EZ-COM** unit is connected to the PC, a *Windows Explorer* window is normally automatically displayed on the PC.

Figure 106 Survey file folders



Single Shot surveys are stored in the folder SINGLE.
Multi Shot surveys are stored in the folder MULTI.
Orientation surveys are stored in the folder ORI.

Copy files directly to PC

1. The *Removable Disk* window will appear on the screen. You may have to select 'Open folder to view files' before the survey file folders are displayed. If the *Removable Disk* window does not appear, start *Windows Explorer* and select **My Computer** and open the **Removable Disk** from there.
2. Start another *Windows Explorer* in the PC and open the folder where the survey files are to be stored, for example C:\Program Files\REFLEX\SProcess\Survey Files.
3. In the *Removable Disk* window, open the SINGLE or MULTI folder and mark the files to transfer. Note, both the .MLH and the corresponding .MLR files have to be copied. Press the keys **Ctrl** and **C** simultaneously to copy the file.
4. Place the marker in the *\Survey Files* window. Press the keys **Ctrl** and **V** simultaneously to paste the survey. The survey files are now copied to the PC folder.
5. Disconnect the USB cable.

Survey files could also be copied from the PC to the **REFLEX™ EZ-COM** unit.

*Do not copy files with names longer than eight characters to the **REFLEX™ EZ-COM** unit. That may cause problems and incorrect survey data may be displayed.*

12.3.2.1 Delete survey files

When the survey files have been stored safely on the PC, the files should be deleted from the **REFLEX™ EZ-COM** unit to free memory space.

Note, be careful not to delete survey files that have not been stored on the PC or elsewhere.

Delete survey files

1. Connect the **REFLEX™ EZ-COM** unit to the PC with a USB cable.
2. The *Removable Disk* window will appear on the screen. You may have to select 'Open folder to view files' before the survey file folders are displayed. If the *Removable Disk* window does not appear, start *Windows Explorer* and select **My Computer** and open the **Removable Disk** from there.
3. Open the folder with the files to delete and mark the files.
4. Press the **Delete** key on the PC keyboard.
5. Disconnect the USB cable.

12.3.3 *Import surveys via **REFLEX™ SProcess***

REFLEX™ SProcess version 2.0 or later has to be installed on the PC.

When the **REFLEX™ EZ-COM** unit is connected to the PC, it is possible to access all the Single Shot and Multi Shot survey files stored on the unit from **REFLEX™ SProcess**. (Orientation survey files are not recognized by **REFLEX™ SProcess**.)

It is possible to select which surveys to import to the PC and which surveys to delete from the **REFLEX™ EZ-COM** unit.

Survey files that are imported via **REFLEX™ SProcess** are automatically renamed to the Survey Name stored in the header file.

12.3.3.1 Prepare unit for import

REFLEX™ SProcess uses the **REFLEX™ EZ-COM** serial number to record the history of survey files from specific units. By that, it is possible to import only surveys that have not previously been transferred to the PC from that particular unit.

Display serial number

1. From the MAIN menu, select **Settings**.
2. From the SETTINGS menu, select **Device**.
3. From the DEVICE menu, select **License Key**.
4. The serial number of the unit is displayed to the right.
5. Select **CANCEL** to return to the DEVICE menu.
6. Use the LEFT key to return to the MAIN menu.

A USB cable, Type A-A, is needed to connect the **REFLEX™ EZ-COM** unit to the PC.

Connect REFLEX™ EZ-COM to PC

1. From the MAIN menu, select **Data Transfer**.
2. From the DATA TRANSFER menu, select **Transfer directly to PC**.
3. Connect the **REFLEX™ EZ-COM** unit to a PC, using a Type A-A USB cable.
4. The *USB Mode* message will be displayed on the **REFLEX™ EZ-COM** unit.

For detailed instructions on the import procedure in **REFLEX™ SProcess**, please refer to the on-line Help document.

13 Maintenance

This chapter describes how to maintain **REFLEX EZ-TRAC™** to ensure long service.

13.1 Introduction

REFLEX EZ-TRAC™ is a robust instrument that will take rough treatment in harsh environments. However, it is also a precision instrument and has to be treated accordingly.

***REFLEX EZ-TRAC™** is an advanced instrument. Never open the instrument probe yourself - the calibration of the instrument will be destroyed.*

In the unlikely event of the need to change any of the components of the instrument, please contact **REFLEX™** or your authorized **REFLEX™** distributor.

13.2 Regular maintenance

Regular maintenance extends the service life of your surveying instrument. Make it a habit to always take care of **REFLEX EZ-TRAC™** before and after every survey.

13.2.1 Before every survey

Before threading parts together, check sealing rings and threads. Only use sealing rings that have been provided by **REFLEX™**. Use Molykote to lubricate the sealing rings. Always handle the precision-machined threads with care.

Inspect the nylon landing sub for wear on a regular basis. This can make the difference between the landing sub stopping or passing right through the bit.

If the sealing rings and threads are not handled properly, water or other fluids may enter into the instrument probe and damage the electronics when the instrument is exposed to pressure downhole.

Sealing rings

1. Check that all sealing rings are undamaged.
2. Replace any sealing rings that show signs of wear and tear.
3. Lubricate all sealing rings with a sufficient, but not excessive, amount of silicon grease.

Threads

1. Check that all treads, both external and internal, are clean and undamaged.
2. Keep parts absolutely in line with each other when threading together.

13.2.2 *After every survey*

After a survey, check sealing rings and threads, and clean and dry the equipment.

Sealing rings

1. Dissemble all running gear.
2. Check that all sealing rings are undamaged.
3. Remove any particles that are stuck to the sealing rings.
4. Replace any sealing rings that show signs of wear and tear.

Threads

1. Check that all treads, both external and internal, are clean and undamaged.

Clean equipment

1. Clean all equipment on the outside with a damp rag.
2. Wipe the equipment dry and clean.
3. Put the equipment in the transport cases.

13.3 Battery replacement

Both **REFLEX EZ-TRAC™** and **REFLEX™ EZ-COM** are equipped with non-rechargeable lithium batteries. As the batteries are designed to give several years of life under normal conditions, the need for battery replacement seldom arises.

For instructions on how to replace the battery, please refer to the chapter *Battery Replacement.*

13.4 Service

Normally, the only service needed for **REFLEX EZ-TRAC™** is calibration, which has to be performed by **REFLEX™** personnel.

13.4.1 *Calibration*

Calibration is recommended once a year. The calibration has to be performed by **REFLEX™** personnel. Preventive maintenance of the instrument is performed at the same time.

13.4.2 *Service return*

For service or if any malfunction should occur, please contact **REFLEX™** or your authorized **REFLEX™** distributor for instructions. For contact information, refer to www.reflexinstruments.com.

Please use original transport cases for return shipment. Do not ship until you receive shipping instructions.

14 Battery replacement

This chapter describes how to replace the battery of the **REFLEX EZ-TRAC™** instrument and the **REFLEX™ EZ-COM** unit.

14.1 REFLEX EZ-TRAC™

REFLEX EZ-TRAC™ has a non-rechargeable lithium battery pack, which is designed to give several years of life under normal conditions.

Note, replacement of the battery must be performed in a dry and clean environment.

Disconnect old battery

1. Using two open end wrenches across the flats, unscrew the battery housing from the end of the tool.
2. With the tool held vertically, lift the housing clear of the battery.
3. The ‘O’ ring will either be left inside the housing or on the end of the battery section, retain it for reuse.
4. Gently pull the battery clear to expose the connector.
5. Release the latch and disconnect the battery from the tool.

Figure 107 Unscrew the battery housing

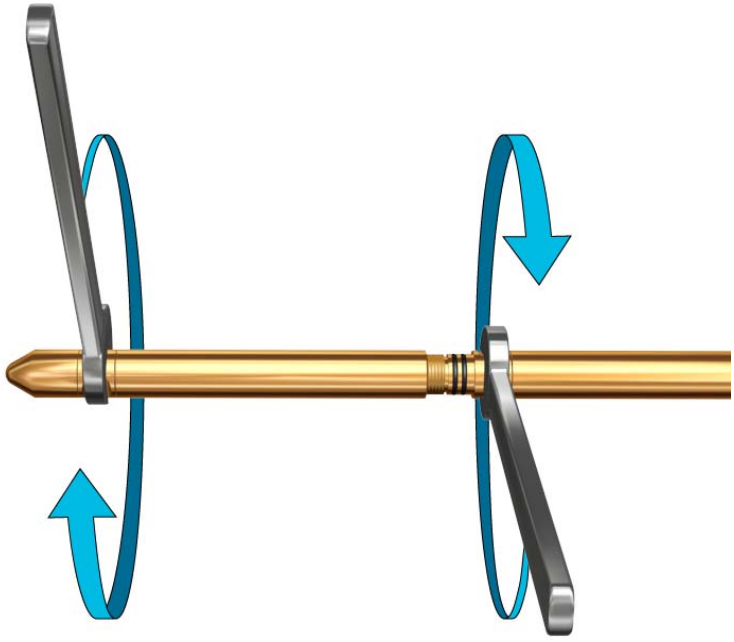
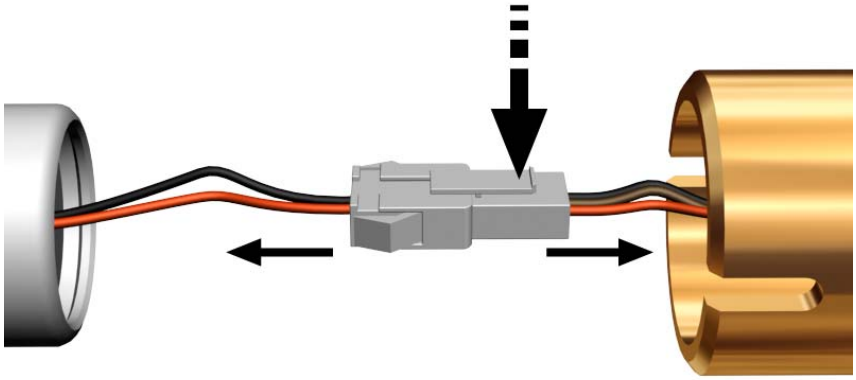


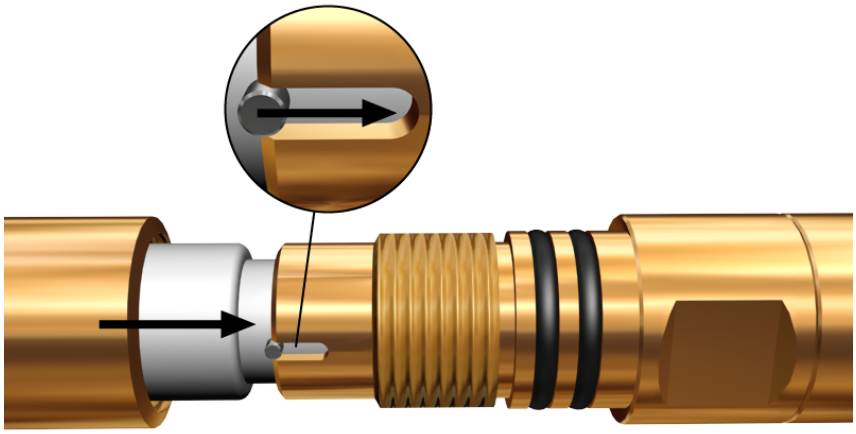
Figure 108 Release the latch



Connect new battery

1. Connect the new battery.
2. Press the connector down inside the tool.
3. Locate the battery casing in the slots.
4. Drop the ‘O’ ring down inside the battery housing.
5. Refit the housing over the new battery.
6. Screw it fully home and tighten with open end wrenches.

Figure 109 Locate the battery casing in the slots



14.2 REFLEX™ EZ-COM

The **REFLEX™ EZ-COM** unit has a non-rechargeable lithium battery pack, which is designed to give several years of life under normal conditions.

Note, replacement of the battery must be performed in a dry and clean environment.

A Torx driver (size T10) is needed to open the **REFLEX™ EZ-COM** unit.

Replace battery

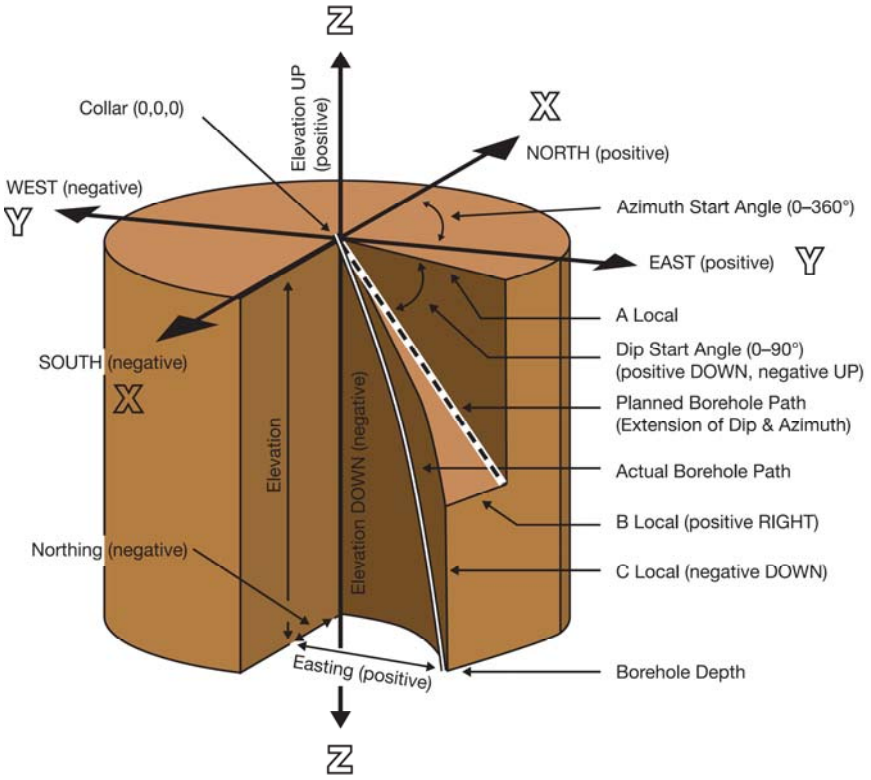
1. Power off the **REFLEX™ EZ-COM** unit.
2. Unscrew the back cover using a Torx driver (size T10).
3. Hold all four wires near the battery connector and gently pull out the connector.
4. Replace with a new battery and reconnect within 10 minutes to preserve the Date and Time settings.
5. Before re-assembling the back cover, ensure that the wires are not caught between the edges of the battery compartment and the back cover.
6. Tighten the screws (torque max 1 Nm).

15 Terminology

The terminology within the drilling industry is not uniform. This chapter provides explanations to the terminology used by **REFLEX™**.

Concepts and terms used in this manual are illustrated in the figure below.

Figure 110 Reflex terminology



X-axis

The x-axis represents the north-south direction in an optional geographical coordinate system. The starting x-point may be set to zero, or to the local north/south coordinate as measured with e.g. a theodolite. North is normally the positive direction.

Y-axis

The y-axis represents the east-west direction in an optional geographical coordinate system. The starting y-point may be set to zero, or to the local east/west coordinate as measured with e.g. a theodolite. East is normally the positive direction.

Elevation UP/DOWN

The z-axis represents the elevation in an optional geographical coordinate system. The starting elevation may be set to zero, or to the local elevation as measured with e.g. a theodolite. In the **REFLEX™ EZ-COM** unit, the elevation convention is positive upwards. The elevation convention (positive upwards or downwards) can be changed in **REFLEX™ SProcess**.

Azimuth

Azimuth is the borehole direction measured from north against east, expressed as an angular distance. The azimuth angle range is 0-360°.

Dip	Dip is the inclination measured from the horizontal plane. The dip angle range is –90° to +90 degrees. A hole in the horizontal plane has a zero dip angle. In the **REFLEX™ EZ-COM** unit, the dip convention is positive upwards. The dip convention (positive upwards or downwards) can be changed in **REFLEX™ SProcess**.
Planned path	The planned borehole path is a line from the planned start coordinates, pointing in the direction determined by the planned start dip and azimuth.
Actual path	The actual borehole path is the path as measured and calculated by the surveying instrument.
Easting	Easting is the position of the borehole in the east-west direction. An Easting value higher than the starting point represents an Eastern position, whereas a lower value represents a Western position.
Northing	Northing is the position of the borehole in the north-south direction. A Northing value higher than the starting point represents a Northern position, whereas a lower value represents a Southern position.
Elevation	Elevation is the depth of the borehole perpendicular to the horizontal plane.
Collar coordinates	The collar coordinates are the actual or planned coordinates of the starting position.
Local coordinates	The local coordinates describe the deviation of the borehole relative to the projection of the actual first station *or* relative to the projection of the planned start.
Local A	Local A is the horizontal projection of the borehole along the starting azimuth direction.
Local B	Local B is the right/left deviation of the borehole, relative to the projection of the Actual first station *or* relative to the projection of the Planned start. Right is positive, left is negative.
Local C	Local C is the up/down deviation of the borehole, relative to the projection of the Actual first station *or* relative to the projection of the Planned start. Up is positive, down is negative.

REFLEX™ EZ-COM License Key

The Multi Shot functionality in **REFLEX™ EZ-COM** is available as a license key enabled option.

License Key

The license key is assigned to the serial number of each individual **REFLEX™ EZ-COM** unit.

Serial Number	
License Key	

Multi Shot enabling instructions

In order to enable the Multi Shot functionality, you need the license key which is assigned to your particular **REFLEX™ EZ-COM** unit.

Example: In the figure below, the serial number is 0004.

Enable Multi Shot

1. From the MAIN menu, select **Settings**.
2. From the SETTINGS menu, select **Device**.
3. From the DEVICE menu, select **License Key**.
4. Ensure that the displayed serial number of the unit is the same as in the table above.
5. Enter the license key from the table above, by using the LEFT/RIGHT keys to navigate to the desired character. The OK key is used to select the active character.
6. If you made a mistake, select the arrow to the right in the line of characters and press the OK key to delete the last character.
7. When the license key is entered, use the DOWN key to go to **OK** on the display.
8. Use the OK key to select **OK** on the display.
9. Use the LEFT key to return to the MAIN menu.
10. Multi Shot should now be available in both the SURVEY and RESULTS menus.