

# How it works

## MI-3 Digital Borehole Survey Tools

### What must a survey tool do?

Borehole survey tools determine the orientation (in three-dimensional space) of a drillhole by means of a series of measurement stations, or "shots". The orientation is usually represented by the measured dip and azimuth readings. Various interpolation schemes can then be used to transform these data into a trajectory in map coordinates.

### The old and the new... New means efficiency, speed, and digital accuracy

The old photographic tools determined dip and azimuth using photographs of the graticule on a floating compass ball; the old mechanical tools used angular scales on a locking gimbaled compass. These old instruments represent the state-of-the-art of 50 years ago. Both are subject to reading errors, a variety of mechanical problems, fussing with chemicals and stopwatches, and limitations on the dip range. They are time-consuming to use since they are capable of recording only a small number of shots (often just one) in a given run.

The MI-3 tools use digitized signals from state-of-the-art electronic sensors to determine dip and azimuth. Data are delivered directly to the operator in numerical form. MI-3 tools are capable of taking thousands of shots in any orientation — this boosts efficiency and permits entirely new ways of using the tools.

### What is inside the probe? Intelligent design!

The MI-3 survey tools contain three major components: a three-component accelerometer, a three-component fluxgate magnetometer, and a computer.

Data from the accelerometer are used to determine the dip or inclination of the tool with respect to vertical. Data from the magnetometer are used to determine the azimuth of the tool with respect to local magnetic north. Additional parameters such as toolface, magnetic field strength, and magnetic dip are also computed (see "Magnetic diagnostics" below). The computer performs a number of functions: power management, time-keeping, data digitizing, data storage, and communication.

### How to use the MI-3 tool? Simplicity!

Most people use MI-3 survey tools in multishot mode. The tool is first connected to a control computer (either a Dos/Windows™ or PalmPilot™ computer) which synchronizes the clocks and starts the survey. Since the tool can store thousands of shots, the shot interval is usually set to 10 or 15 seconds — consequently, the operator never has to wait more than a few seconds for a shot to be taken. After disconnecting from the computer, the MI-3 tool is lowered or pumped into the hole. For coring operations, the tool is attached 7.5–10m (20'–30') in front of the bit on non-magnetic extension rods. The other end of the extension rods is in turn attached to the inner tube or a landing nut.

When a shot is desired, the operator enters the depth in the control computer. The control computer indicates when the next shot will be taken and when the operator can proceed with the survey. Once the tool is recovered, it is plugged into the control computer and the data are downloaded. The control computer picks out the shots for which a depth was entered and displays the survey results immediately.

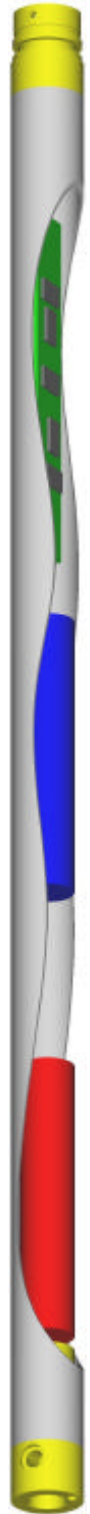
The easiest and most efficient way to run the MI-3 tool is to pump the tool in once a hole is finished. A detailed survey can be taken as the rods are pulled. Since the MI-3 is taking shots every 10 seconds or so, there is usually enough time to take a shot in the time it takes the drillers to break the rod. If the control computer is in the hands of the rig operator, a detailed survey with shots at every joint can be taken with almost no time cost!

With a wireline interface, the same MI-3 tools can also be used in real-time steering or orientation applications by connecting it to a single-conductor wireline. Toolface, dip, and azimuth can then be observed on the control computer at 5 second intervals. The tool will operate over a 10km wireline.

### Diagnostics: Means confidence!

One of the great advantages of the MI-3 tools over the old photo/mechanical tools is that magnetic diagnostics are provided. No longer must you trust that an azimuth is correct. MI-3 tools provide readings of magnetic field strength and magnetic field dip, both of which should be constant for a given geographical location. Deviation in one or both of these parameters can be used to detect azimuth interference from ore bodies and drilling equipment. These diagnostics parameters can also aid the geologist in defining the geological setting and locating contacts.

Acceleration is also computed so that you can be sure that the tool was stable when the shot was taken.



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