GeoInfo

Why probe calibration is so vital and how Robertson Geo maintains a framework for conformance unparalleled in the slim borehole logging industry.

Calibration COUNTS

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From its inception in 1979 the goal of Robertson Geo has been to develop its reputation as a world leading manufacturer and service provider for slimline geophysical probes and associated systems. To achieve this, the need for a comprehensive conformance system for all probes and associated equipment was essential to provide qualitative log data that is traceable to known industry references.

In order to satisfy this, a test borehole facility was established at the Deganwy manufacturing site with the drilling and casing of a 100m borehole. This facility remains an integral part of the system to ensure conformance of all probes that are sold, rented or used by Robertson Geo Service logging teams.

The logs from many thousands of probes in this borehole all contribute toward guaranteeing the accuracy and repeatability of Robertson Geo data.

Compliance is the key to success

Robertson Geo's tool calibration and ISO 9001-2015 procedures provide reassurance that data acquisition complies with the various mandatory requirements for the classification of Mineral Exploration Results, Mineral Resources and Ore Reserves. This level of confidence is critical in defining geological knowledge and technical/economic parameters for use in Public Reports, including the JORC, CIM, UNFC, CRIRSCO, PERC, SAMREC, SME and MRC International standards. Robertson Geo is licensed to factory test and calibrate its nuclear tools with corresponding radioactive sources prior to shipping. ***Unless this is achieved, logging results cannot meet the necessary compliance standards and log data cannot be used for qualitative measurement or calculations.***

Definition of Calibration

Calibration in its strictest form means "comparison to known standards". In practical terms this needs to be extended to cover "measurement uncertainty" and "traceability". Metrology is the science of measurement. The fundamental objective of metrology is to ensure traceability as an essential precondition for the comparison of measurement results.

Conformance Framework and ISO 9001

Robertson Geo is the only slimline probe manufacturer/logging services provider with a QMS certified to ISO 9001:2015. This system dictates that the calibration/conformance process must be formalised, periodic and documented.

A fundamental requirement of the design process for all new probes is that they hold calibration over a period within tolerance. To maintain this throughout the product lifecycle involves control of supply chain conformance, manufacturing processes, testing, repairs and a feedback system to identify problems and modification requirements.

Geophysical logging is essentially a data business. The aim of the calibration/conformance system is to "maintain quality of measurement" for all users of Robertson Geo equipment, including ourselves. In industrial sectors where compliance and traceability are fundamental, all probes come with a certificate of conformity (*see Fig. 1*), and a probe maintenance service is available to verify functionality and calibration.

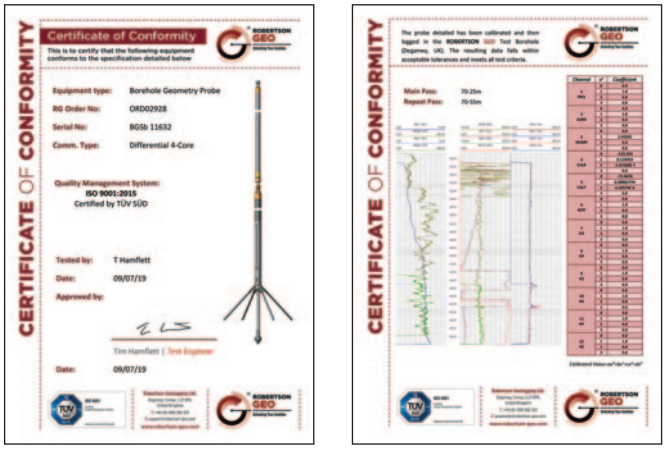

Fig. 1 - Example Conformance Certificate.

Risk Mitigation

The management of risk is an essential component for all civil engineering projects and the responsible engineers need to have confidence in the ground investigation (GI) data they are provided with. Budget constraints can mean that the GI scope is limited and therefore maximum value needs to be extracted

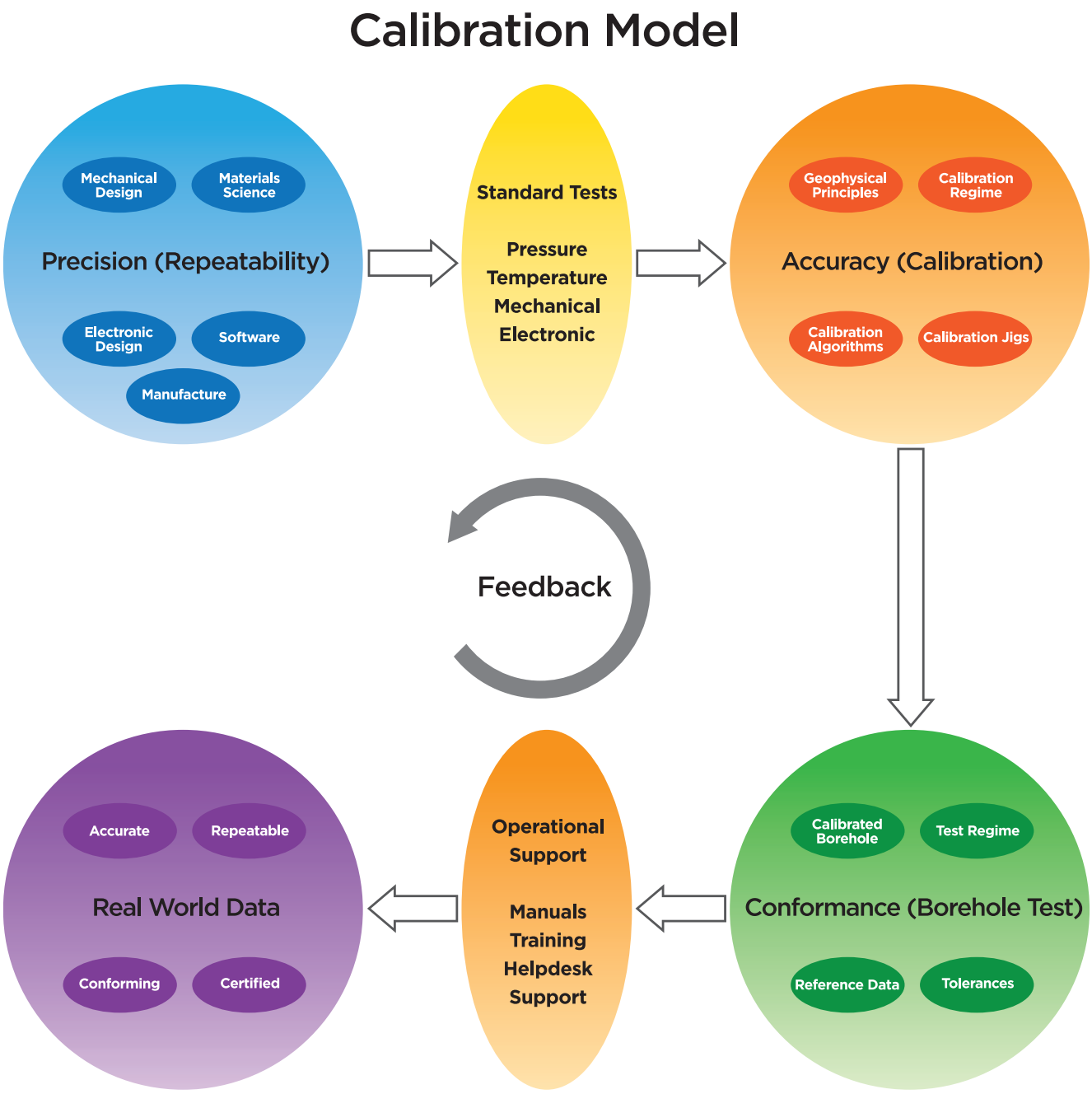

Fig. 2 – Robertson Geo Calibration Model.

from what data is gathered. Geophysical logging produces in-situ data throughout the extent of drilled boreholes, filling in potential gaps due to, for example; poor core recovery or CPT refusal. The risks associated with the ground and the groundwater can be unique to a site, especially in the UK where the diversity of geological conditions is high and accurate data is vital to mitigate these risks.

The implications of inadequate site investigation can be increased costs and delays, over-engineered designs, or in the worst cases - disasters such as structural failures. The financial and possibly legal penalties from post project forensics on failed projects means that all GI providers need to remove as much uncertainty as possible in the quality of data. This article will demonstrate how committed Robertson Geo are about providing accurate, repeatable data from all their probes, thereby increasing confidence in data quality.

It is vital to understand the subsurface characteristics for geotechnical applications and civil engineering projects. Robertson Geo is a specialist and a very experienced international provider of wireline logging data acquisition and interpretation for these industries, with its technologies in worldwide use every day.

The Calibration Model (*See Fig. 2*)

As designers and manufactures of all equipment supplied, the design of appropriate calibration regimes remains our responsibility. The underlying tenet we use is that all theoretical calibration models must also pass scrutiny in our test borehole.

This means that accuracy and repeatability in a real-world situation are a prerequisite. An adjunct to this is to provide training ensuring that the operators of the equipment are also fully competent.

The route to fully calibrated data in the real world starts with the design of the probes. To develop probes capable of high precision/repeatability the appropriate design of sensors, mechanical components, electronic systems, materials and software is necessary. Once the design is established the manufacturing process must also be fully controlled. This involves control of build processes, suppliers, components, batch testing, responding to feedback and implementing change requests. Traceability is also key and, at Robertson Geo, conformance to ISO 9001:2015 is maintained throughout.

Whether at the design stage or in the production stage the probes need to be capable of holding their precision throughout the most extreme conditions dictated by the probe specification. This testing includes electronic systems, mechanical components and the application of cycles of temperature and pressure on the complete probe up to the specification limits. The latter cycles are achieved using sophisticated, calibrated pressure/temperature vessels based at Deganwy.

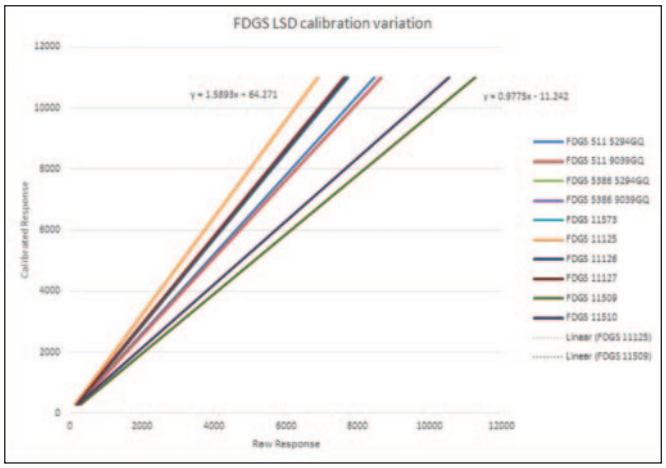

Fig.3 - Calibration curve variation from same spec. probes and sources showing importance of "matched pair" calibrations.

Once a probe is designed and manufactured to be capable of the requisite precision it now must have a suitable calibration applied to it. Based on an understanding of the underlying geophysical principles a calibration regime is designed. In most cases this involves the application of fixed points and a best fit polynomial curve between the points. For two fixed points the curve is linear, for three points quadratic and four is cubic. The fixed points need to be established, often in calibration jigs (which are themselves calibrated to known industry references such as the Adelaide DWLBC calibration pits or ELGI, Hungary) or as easily obtainable standards such as free air or water. Counts from the probe are then taken for each fixed point and a best fit curve applied. The resulting coefficients are placed in a standard calibration file which the software can subsequently utilise. Often there will also be constraints that need to be observed during the calibration process such as separation from ferro-magnetic materials or temperature stabilisation time. For probes detecting radioactivity, a random process, an understanding of the statistical nature of the system and the effect of low count rates must also be considered. For density and neutron probes which require an attached radioactive source, the calibration coefficients obtained are only applicable for the specific match of probe and source (*See Fig. 3*).

To ensure that the calibration regime is appropriate and accurate, all probes are subject to a borehole test. This is undertaken for all new or repaired probes and also for our in-house logging services teams at regular intervals. Calibrated records for the test borehole have been determined using established industry references at ELGI Hungary and the DWLBC calibration pits (API) in Adelaide, Australia to provide the reference models. Characteristic log curves for all probes have been built up from thousands of logs taken over more than 40 years. When the calibrated probe under test has produced its specific curves, they are laid over the reference logs to ensure that they are within acceptable tolerance. Any non-conforming probe will be rejected and subjected to remedial action and then re-tested.

To complete the overall process, Robertson Geo make every effort to ensure that the probe is used appropriately in the field. Manuals are provided with all probes and are available on the company website. A helpdesk facility is also provided whereby customer problems and data can be analysed when queries arise. Comprehensive training is available on all probes for our in-house staff, rental customers and sales customers alike.

Conclusion

It is imperative that any logging system that acquires geophysical log data which will be used for quantitative purposes, whether that be for mining resource estimation or civil engineering design, is supported by a traceable and verifiable calibration regime.

Robertson Geo comprehensively calibrates all its logging systems and uniquely uses an on-site borehole for verifying performance at its Deganwy test well and calibration facility, inspiring confidence that all data acquired is calibrated, traceable and verified to known industry standards.

Only when log data can be demonstrated as conforming to an established calibration regime can it be relied upon for design and engineering purposes. Furthermore, the use of traceable log data significantly reduces the project risk for the end user of such information and provides it with a reliable geology model that informs the project design and decision-making processes.