Slim Hole Induction

User Guide

Primary Calibration of The Tool

The calibration loop supplied for use with the Slim Hole Induction, is a single position coil to represent 685/690 mmho/m (as marked). Also, a "Free Air" position is used for the Zero calibration value.

The standard calibration points and response limits are the following:

Primary Calibration	Standard	Response Range
Natural Gamma	0 api units 200 api units	0 cps 180 - 215 CPS
AP Conductivity	0 mmho/m - mmho/m	* cps * cps
Temperature	- deg F - deg F	25,000 - 27,000 cps 30,000 - 35,000 cps
A and B Values (Temperature Correction Constants) A B	As supplied from Century	
* Induction CPS values may vary greatly depending on tool set-up. Please refer to initial log for normal range.		

Default Calibrations

The following parameters are sensors and responses are set-up to electronic bench testing specifications. Therefore, these "default" calibration numbers are normally used to log the tool. The sensors are the following:

Natural Gamma

In the calibration file, if the default values of 0 cps equals 0 engineering units are not changed, the tool will then automatically use the default values in the tool module for that tool.

Detailed Calibration Procedures

The calibration of the tool has initially been done at the Tulsa facility. Values obtained should serve as an initial reference for subsequent calibrations. CPS values should be within 10 % of these first calibrations, unless the tool has been subsequently set-up.

The following steps are used to calibrate the induction tool.

1. Enter calibration program and enter A and B temperature correction constants. These values are used to temperature correct the conductivity values. Once this has been done (or if it has previously been done), escape out of the calibration program and the calibration file will update.
2. Determine the proper location of the loop if it has not been located already by placing it on the tool and positioning it until the maximum CPS values are observed. This point should be about 87.63 cm (34.5 in.) from the bottom of the stainless steel bottom sub. Next, apply several layers of

tape to the mandrel to support the calibration loop when holding the tool in the vertical position. (Note: if running centralizer, the bottom centralizer will need to be removed first.)

3. Using the "Calibration Capture" feature of the calibration program, obtain the CPS values for air and the calibration ring. Enter these numbers into the appropriate positions. The tool may be held vertically overhead with the calibration loop on the tool and with the loop off for the free air value. Be sure to stand at least 3.05 m (10 ft.) from any metal objects when calibrating.
4. Exit the calibration routine and proceed into logging. Perform a short time drive log with free air and the calibration loop in place. Remember to observe the "Apparent Conductivity" values and not the Conductivity. The values should be within +/- 2 mmho/m for free air (0) and the 685/690 (as marked) loop values.

Note: during calibration, the curve to watch is the AP Cond, as this is the temperature corrected curve. The Cond curve has the additional correction of skin effect applied.

Detailed Logging Instructions

1. For logging greater than 10.16 cm (4 in.) holes, place the centralizers on top and bottom of the probe.
2. Turn tool on for a minimum of five minutes allowing the tool to temperature stabilizes.
3. Using the "Calibration Capture" feature in the calibration menu, recalibrate the "free air" zero calibration point. You do not need to recalibrate the loop.
4. Exit calibration, and perform a short time drive of free air. Hold the tool as high as possible, away from any metal objects (3.05 m (10 ft.) minimum).
5. Plot or Print the "Pre-log" calibration and confirm the conductivity within +/- 2 mmho/m. If the log is outside the tolerance, return to step 3; otherwise place the tool in the hole and begin logging.
6. The tool is corrected for temperature drift; however, temperature shock will cause momentary drift.

It is recommended that you do not start recording a log for 15 minutes, once you have placed the tool in the hole. This will eliminate any temperature shock that may have been caused by a borehole temperature that is significantly higher or lower than the air temperature.

Notes On Logging The 9510/9511 Tool

Test results were performed in Century's test hole and simulated PVC models at the Tulsa facility. Results showed that readings produced were nearly the same as produced by the 9041, 40.64 cm (16 in.) normal resistivity, but the 9510/9511 has better vertical resolution for thin bed response. Also, centralization of the tool in holes greater than four inches is necessary. Other factors measured included the following response characteristics:

- **Signal Radial Response:**
  Distances from tool:
  7.62 cm (3 in.) = 1% of measurement
  45.72 cm (18 in.) = 50% of measurement
  127 cm (50 in.) = 90% of measurement
- **Induction Repeatability:**
  + or - 2 mmho/m.
- **Induction Accuracy:**
  5% @ 30 mmho/m.

- **Natural Gamma Accuracy:**
  2%.
- **Borehole Correction:**
  Not necessary for less than 15.24 cm (6 in.) holes.
- **Temperature Drift:**
  0.3 mmho/m per 1 Degree F; temperature corrected to less than 0.1 mmho/m per 1 Degree F.
- **Induction Calibration Values:**
  0 and 685/690 mmho/m (as marked).
- **Range of Operation:**
  0 to 1000 mmho/m, (500 ohm-m to 1 ohm-m).

Note: Induction Resistivity values greater than 100 Ohm-meters (less than 10 mmho/m) may be speculative due to the small changes in conductivity.

The logging display consists of the following curves and their definitions:

- **Natural Gamma** - in calibrated API units or raw CPS values.
- **Conductivity (**mmho/m**)-** calibrated units, corrected for skin effect (more prevalent at higher conductivities) and temperature corrected.
- **Res (Ohm-M)** - converted conductivity where R = 1000/C.
- **Temperature (Deg F)** - calibrated temperature of the mandrel.
- **AP Cond (**mmho/m**)** - temperature corrected conductivity units.
- **Temperature (CPS)** - raw temperature CPS values.
- **AP Cond (CPS)** - raw CPS conductivity units with temperature correction.

The Temperature Log is the Mandrel Temperature, which is not intended to be a temperature log, but could be used to indicate gross bottom hole temperature.

The following borehole conditions affect the resistivity measurements:

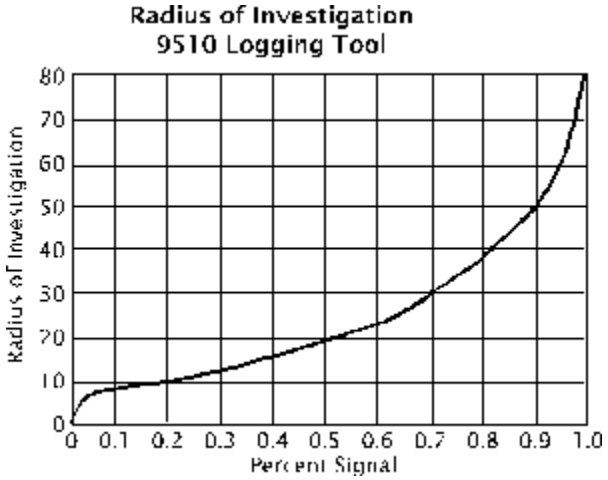
- Borehole Size
- Wash-Outs
- Metallic Minerals

Skin Effect On Conductivity

Two conductivity curves are recorded using the 9510/9511 tool. The Apparent Conductivity curve is compensated for temperature variation of the mandrel. The Conductivity curve would be the true formation conductivity with skin effect applied. The resistivity is then calculated from the conductivity curve. At greater conductivities, skin effect has significant contributions to the actual verses the desired response.

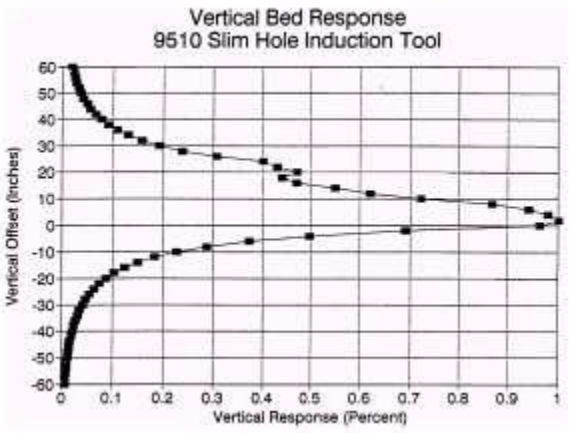
The following laboratory and field tests were performed to test the tool. The tests and the results are as follows:

RADIUS RESPONSE
The depth of investigation plot shows the response at the various depths. At 50% of the signal, a distance of 45.72 cm (18 in.) is observed.



VERTICAL OFFSET

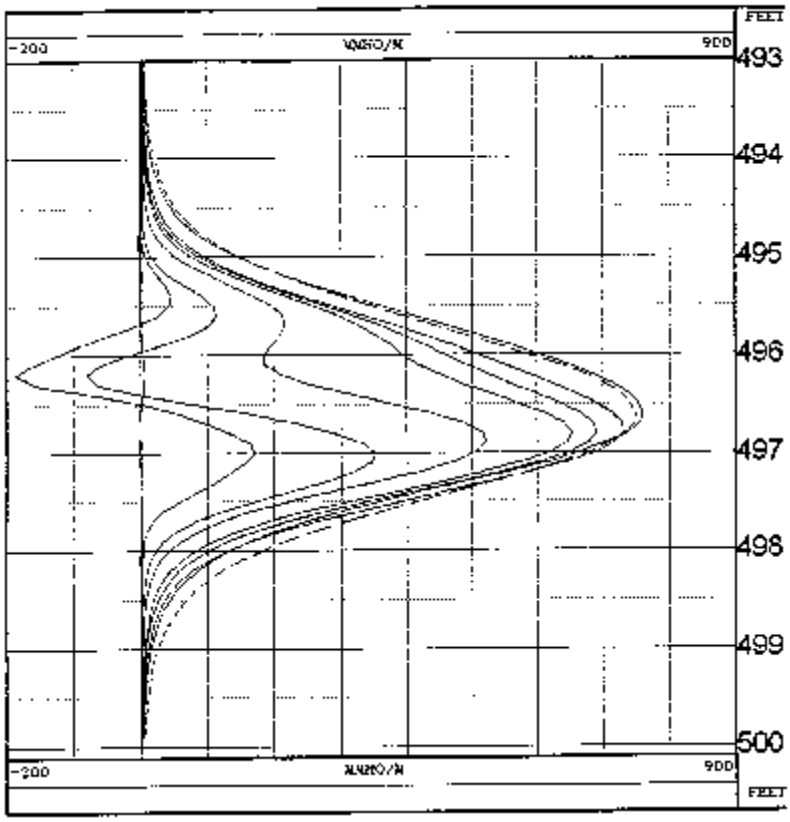
The vertical offset shows the response due to formation thickness. For a zone to be 100% resolved, the formation must be approximately 152.4 cm (60 in.)



FAMILY OF RINGS

The following family of rings plot depicts the response of the tool at 15.25 to 76.2 cm (6 to 30 in.) At the six inch range, the response is "nulled out".

Family of Rings (6 to 30 inches)



LAKE TEST

The induction tools were tested in a lake near Tulsa to determine the accuracy of the calibration and tool stability. The log values obtained in the lake (111 - 113 mmho/m) compare within 1% of the measure lake value obtained with a fluid resistivity measurement.

BOREHOLE EFFECTS

The induction tool was designed to minimize the effects of boreholes up to 15.24 cm (6 in.) in diameter. One test performed at the lake was a time drive log made while moving the tool from the lake to a 15.24 cm (6 in.) PVC pipe which had been lowered into the lake (112 mmho/m) and filled with 0.42 ohm meter (2381 mmho/m) water. The logs show a minimal difference of 1.3% when in the salt water filled PVC pipe.

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