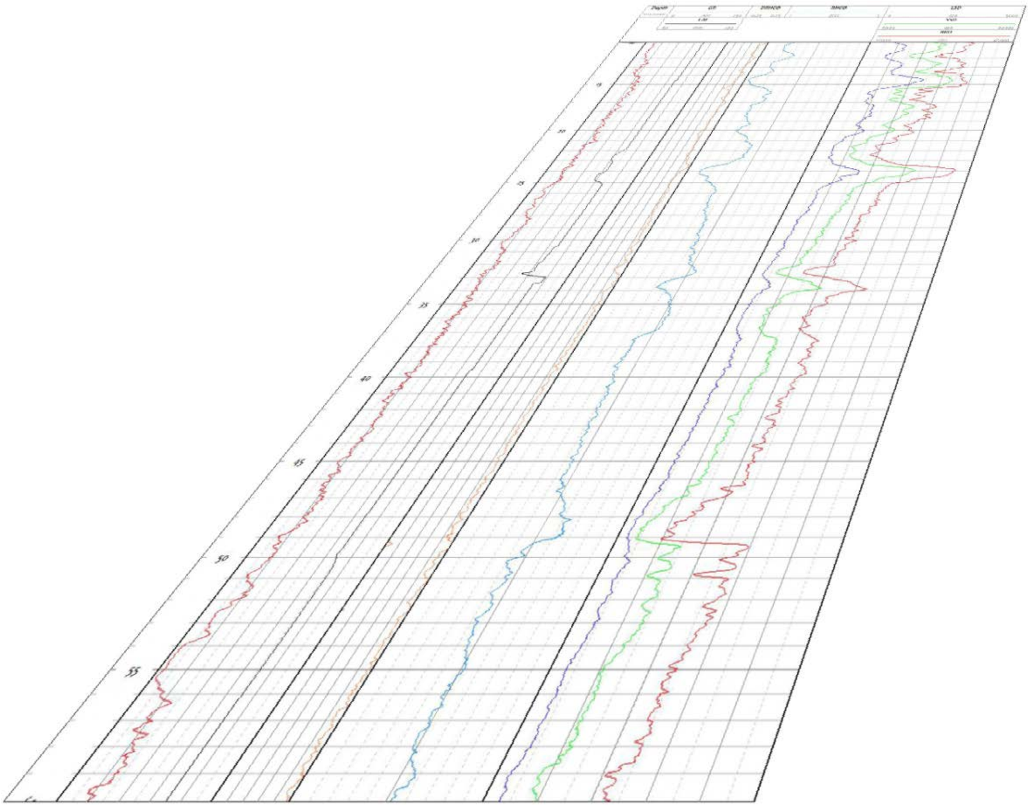

User Guide

QL40 DEN – Compensated Dual Density

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Table of Contents

1 General Information

The QL40-DEN Compensated Dual Density bottom sub is a versatile wireline tool that can be used in a wide variety of logging applications. Measurements include SSD (short-spaced raw cps and g/cc density), LSD (long-spaced raw cps and g/cc density), Compensated density (dual density), and Caliper. Since the tool is part of the Quick Link family of probes, it can be stacked with any QL inline sub. In this manner, additional measurements (such as natural gamma, deviation, or resistivity) can be added to the tool stack. The tool section is designed for operation in $2^{1/2}$ to $11^{1/2}$ inch (6.3 – 29.2 cm) boreholes.

QL40 Stackable Logging Tool Overview

QL stands for Quick Link and describes the latest line of stackable logging tools. This development is a joint venture of Mount Sopris Instruments (MSI) and Advanced Logic Technology (ALT). Innovative connections between tool elements (subs) allow users to build their own tool strings in the field. The Tool Stack Factory – a sophisticated extension of the acquisition software – provides a convenient way to configure tool strings for operation. For more information about the Tool Stack Factory, see LoggerSuite Manual.

Each sub has a Telemetry and Power supply element, TelePSU, allowing stand-alone operation. A GenCPU card in each sub handles Analog to Digital conversion and/or counting of the measurement signal and formatting data for transmission up hole.

The QL40-DEN bottom sub can be operated as a stand-alone probe or can be stacked below other subs. The stack is completed by adding a Tool Top sub. Varied tool top subs are available. Top subs include an MSI single conductor, GO4 conductor, GOI Single conductor and GO7 conductor. Consult the factory for additional options. The number 40 indicates a nominal OD of 40mm. Over coating and special measurements may make some subs larger in diameter. See their particular specifications.

1.1 Dimensions

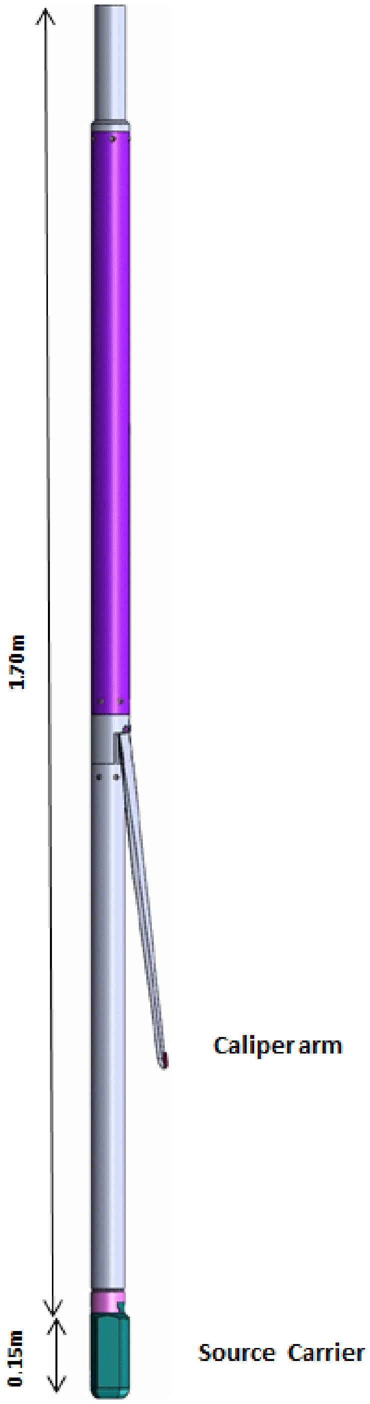


Figure 1-1 *Tool general arrangement*

1.2 QL40-DEN Technical Specifications

Tool:

Diameter:	50.8 mm (2”)
Length:	1.85 m (73”)
Weight:	19.2 kg (42 lbs)
Max. Temperature:	85 °C (185 F)
Max. Pressure:	206 bar (3000 PSI)
Short spaced source – detector (SSD):	20 cm (7.87”)
Long spaced source – detector (LSD):	35 cm (13.77”)

Cable:

Cable type:	Mono, Coaxial, 4 or 7 conductor
Digital data transmission:	Up to 500 Kbits per second depending on wireline
Compatibility:	ALTlogger – BBOX – Matrix

Measurement:

Caliper Max.	29.2 cm ($11^{1/2}$”)
Caliper Accuracy:	2.54 mm (0.1”)
Caliper Resolution:	0.64 mm (0.025”)
Density Range:	1 – 4 g/cc (depends on source)
Source:	100 – 250 mCurie (Cs-137 or Co-60)
Density Accuracy:	0.1 g/cc (100 mC Cs-137)
Density Resolution:	0.05 g/cc (100 mC Cs-137)

Power:

DC voltage at probe top:	Min 80 VDC Max 160 VDC Nominal 120 VDC
Current:	Nominal 25mA

2 Measurement Principle

2.1 Density

The compensated density measurement is accomplished using a radioactive source and two radiation detectors. The detectors are designed for use with a Cs137 source (emits 662 keV gamma particles). They are set to respond to gamma particles having energies of 200 keV or higher (the Compton energy band). Radiation detectors are comprised of two CsI(Th) scintillator crystals coupled to two photomultiplier tubes. The near detector scintillator is 0.5 inches (1.27 cm) long and 0.5 inches (1.27 cm) in diameter; the far scintillator is 1.5 inches long and 0.5 inches in diameter. The detectors are shielded so that they only respond to gamma radiation from the same side of the tool that source energy radiates from. Radiation emanating from the source travels into the formation (into the side of the borehole opposite the caliper), and is backscattered by Compton scattering. The detectors sense this backscattered radiation. Compton scattering results from gamma radiation interacting with the electrons in the formation, so total electron density is measured rather than bulk density.

The detector response is a function of density and the detector offset from the source. As shown in Figure 2, for low densities (typically less than 1 g/cc) and close offsets (typically less than 8 cm for 137Cs), the detector response increases with increasing density. The intuitive explanation of this phenomenon is that when density and spacing are small, more electrons cause more backscattering and more radiation at the detectors. As density and detector offset continue to increase, more of the radiation is absorbed and the response decreases with increasing density and spacing. The detector response at 4 cm from the source is on the positive slope of the curve below; that is, the response increases with increasing density. The response for detectors at 11cm or more from the source has a negative slope. The detector response decreases with increasing density for these offsets.

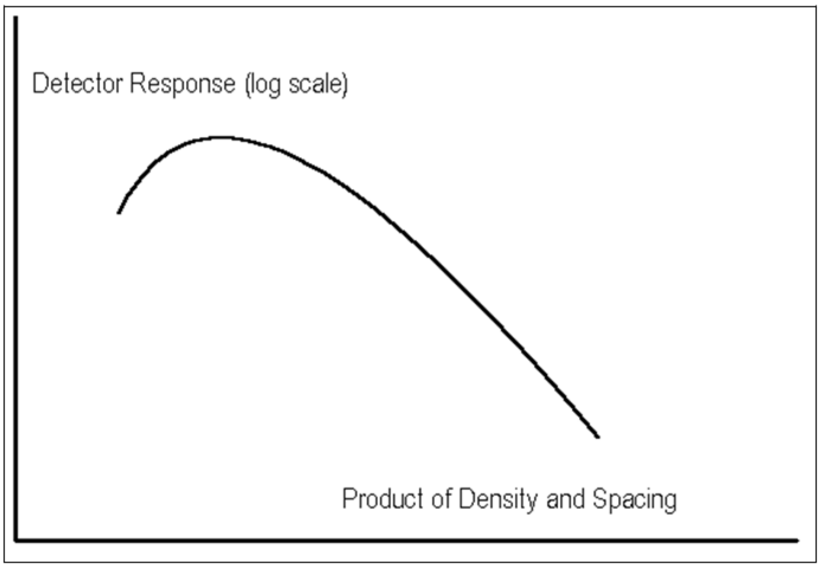


Figure 2-1: *Generalized density detector response*

The volume of investigation for the long offset and short offset density measurements is different. The combination of these two measurements, together with a typical spine and rib chart shown in Figure 3, are used to determine compensated electron density. This method compensates for rugosity and fractures in the borehole wall and any distance the tool may standoff from the borehole wall. The compensation assumes that the borehole is filled with water. The correction is different for air or mud filled holes. Calibration and compensation curves for each QL40-DEN are supplied in a Technical Addendum to this documentation (coming soon). The information presented in the Technical Addendum are obtained by performing a 4th or 5th order multivariate regression on density survey data from the Q40-DEN at the Department of Energy (DOE) pits in Grand Junction, Colorado. During characterization, data are collected at various densities, borehole diameters, and tool standoffs.

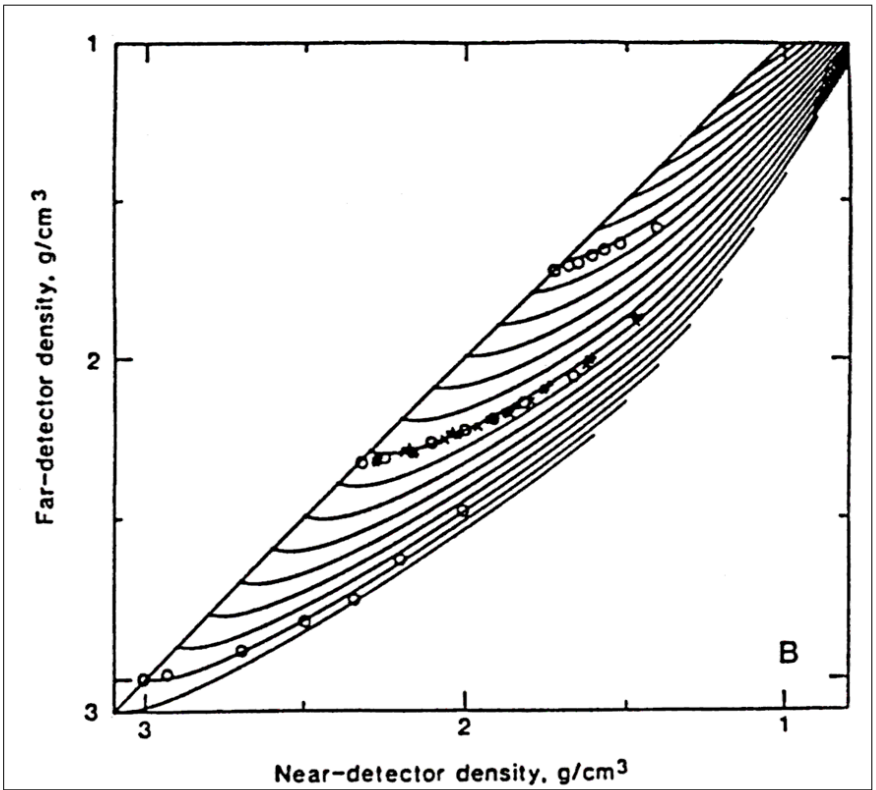


Figure 2-2 *Typical density compensation*

2.2 Caliper

The caliper measurement is straightforward. The arm is actuated by a compressed spring. A position sensor (a linear potentiometer) connected to the caliper arm drive piston measures the actual arm position. The DC output voltage from the wiper of the potentiometer is converted to a frequency linearly related to the borehole diameter. Calibration constants and linearization are stored in the tool specific sub file so that initial user calibration is not normally necessary. Depending on borehole conditions, the wear button on the arm will eventually change size, and re-calibration can be made using the MChNum calibration function and known calibration rings or calibration jig.

3 QL40 DEN assembly and set up

QL stands for **Q**uick **L**ink and describes an innovative connection between logging tools (subs) allowing to build custom tool stacks. QL40 describes a specific family of logging tools. Each sub is equipped with its own Telemetry board, Power supply element and A/D converter allowing an operation as stand-alone tool or as a stack in combination with other subs of the QL product family.
The QL40 probe line deals with two types of subs - Bottom Subs and Mid Subs.

Bottom Sub
A bottom sub is a tool that must have one or more sensors located at the bottom. It can be operated in combination with other QL subs connected to the top but it is not possible to connect another sub below. When used in stand-alone mode the bottom sub only needs a QL40 tool top adaptor, which fits the cable head.

Mid Sub
A mid sub is a tool that can be integrated anywhere within a stack of tools. When used at the bottom of a tool string a QL40 bottom plug must be used to terminate the string. If the mid sub is used as a stand-alone tool it needs a QL40 bottom plug at the lower end and a QL40 tool top adaptor at the top.

3.1 QL40 Tool Stack Assembly

A QL40 tool stack may be terminated by either a QL40 bottom sub or a QL40 bottom plug. At the top of the stack a QL40 tool top is required to connect the tool string to the cable head. Several tool tops are already available; special ones can be made on request.

To assemble and disassemble the subs the C-spanner delivered with the tool must be used (Figure 3-1). It is recommended that before each assembly the integrity of the O-rings (AS216 Viton shore 75) is verified. Prime the O-rings with the silicon grease that was supplied with the subs.

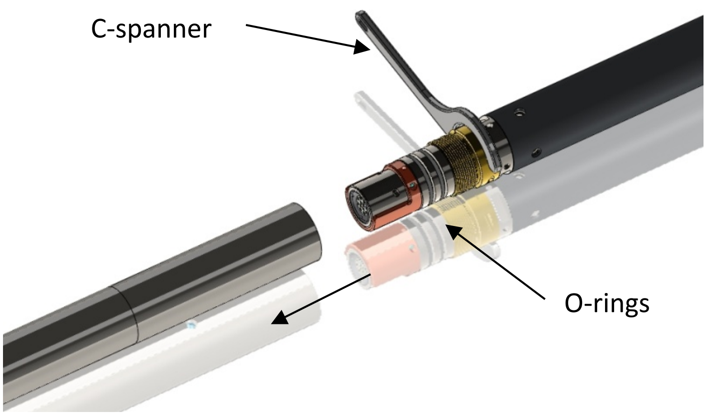


Figure 3-1 *C-spanner and O-rings of QL connection*

The following example of a QL40-ABI, QL40-GAM and QL40-GO4 (Figure 3-2) describes how to replace the QL40-ABI with a QL40-Plug in order to run the QL40-GAM sub stand-alone.

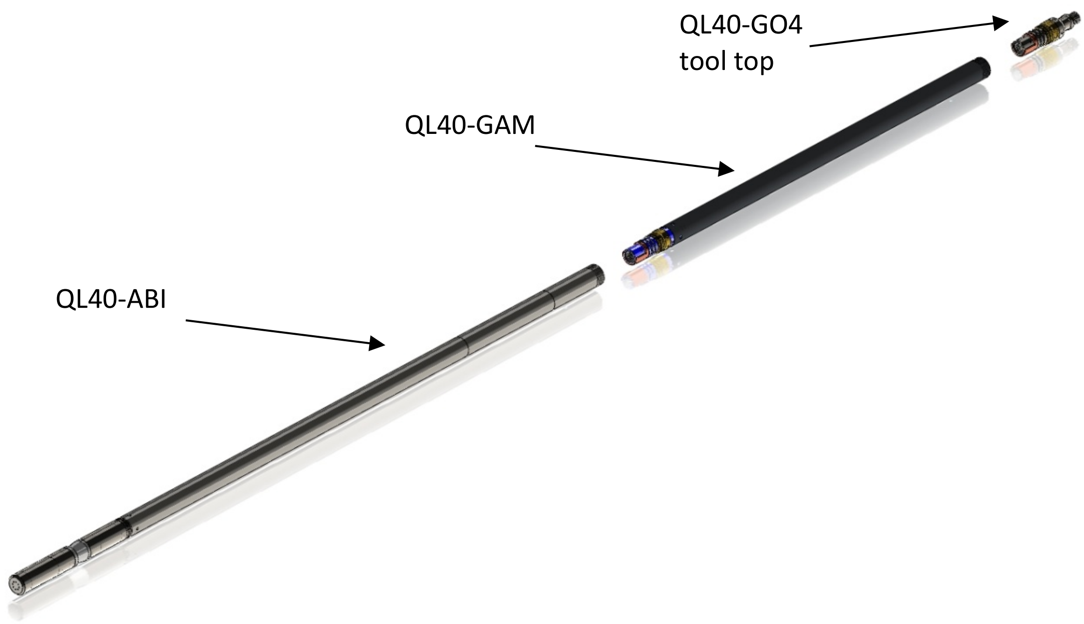


Figure 3-2 *Tool stack example*

To remove the QL40-ABI bottom sub attach the C-spanner to the thread ring as shown in Figure 3-3, unscrew the threaded ring, (anticlockwise about the tool axis when looking towards the bottom of the tool), and remove the QL40-ABI bottom sub.

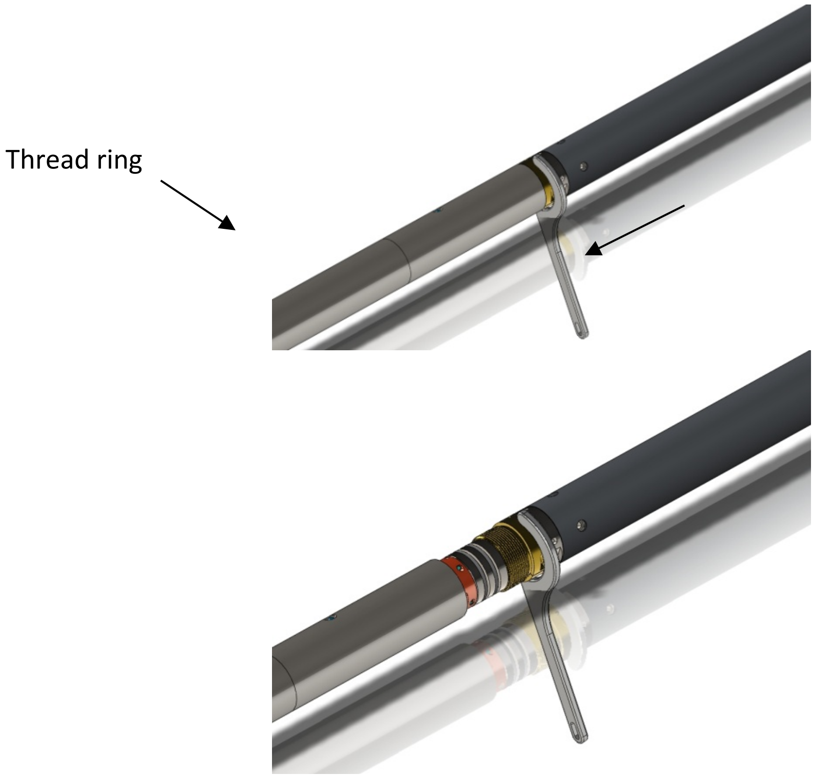


Figure 3-3 *Unscrewing the thread ring and removing the bottom sub*

After checking the O-ring integrity, align and slip the QL40-Plug over the exposed QL connector (Figure 3-4), attach the C-spanner and screw the threaded ring until the plug draws up tight to the ring.

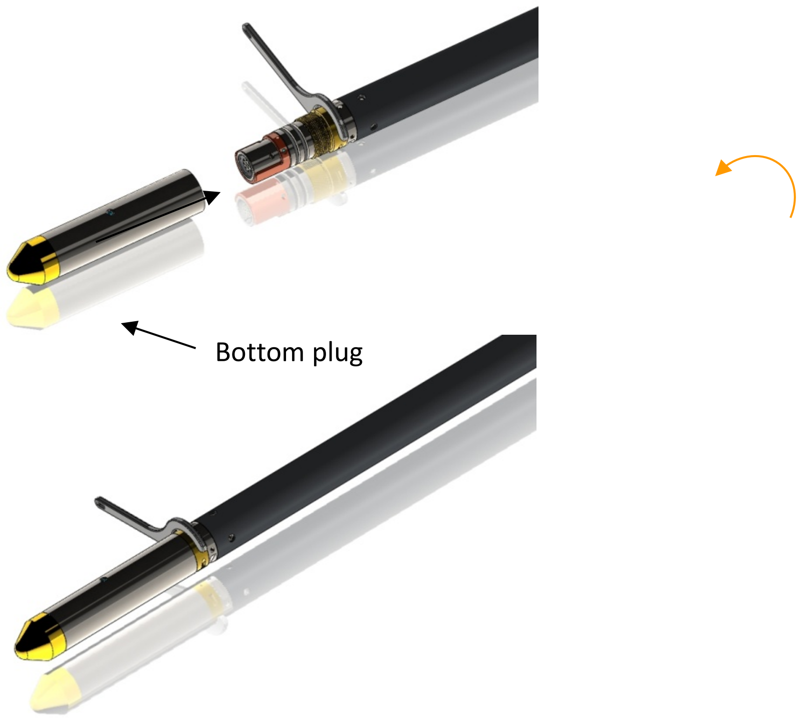


Figure 3-4 *Attaching the QL40-Plug*

The QL40-GAM can now be run stand-alone (Figure 3-5).

Figure 3-5 *QL40-GAM mid sub with tool top and bottom plug*

3.2 Radioactive source installation

If the radioactive source has not been installed in the source carrier, it should be done using the following procedure. Handling of radioactive materials is normally only allowed by persons trained and authorized by government license. It is assumed that this task, and insertion and removal of the source holder from the QL40-DEN probe will be handled by such qualified personnel.

Locate the necessary components before attempting to install the source. Items needed include a portable radiation counter to monitor source activity, a *medium strength*, thread locking compound (such as “blue LocTite”), tongs, dovetail mount tungsten source carrier, source installation tool, source handling tool, long handled screwdriver, the source retainer screw, the source shield, and the radioactive source in its transport container.

Place all components on a solid table, in an area where unauthorized personnel cannot enter. The standard practice of minimizing time and maximizing distance from the source should be followed. All unnecessary personnel should be asked to leave the area.

The source is machined with an 8/32 thread, which will be mated to a matching 8/32 set screw that is installed in the source retainer screw. Normally, the set-screw is pre-installed in the source retainer screw, leaving about 4-5 threads exposed for connection to the source. The photograph at right shows the source retainer screw with set-screw exposed. Ensure the O’Ring is in place on the retainer screw. The radioactive source capsule is threaded onto the set-screw (after first applying a small amount of Blue Loctite to the set screw on the Source Retainer screw).
Prepare the source retainer screw and set screw first.

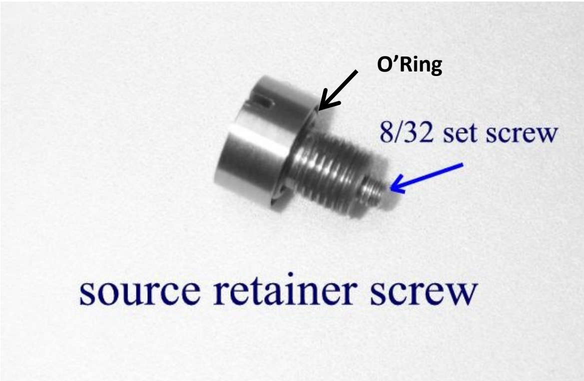


Figure 3-6 *Source retainer screw*

Figure 3-7 *Tong with source*

Figure 3-8 *Detail of source in tongs*

Then, the source should be loaded in the tongs with the 8/32 threaded hole up. The person loading the source then screws the source retainer screw on to the source, using the source installation tool shown below:

Figure 3-9 *Source Holder, Source Installation Tool, and Retainer Screw*

Figure 3-10 *Screw with Source Screwed On*

After the source is screwed on to the source retainer screw, the retainer screw is then screwed in to the source carrier, as shown below. Ensure O-ring is on Retainer Screw.

Figure 3-11 *Retainer Screw with Source being screwed into Source Carrier*

Figure 3-12 *Source carrier with Source Installed*

The Source Carrier is then loaded into the source shield with the source handling tool, where it is stored when not in use.

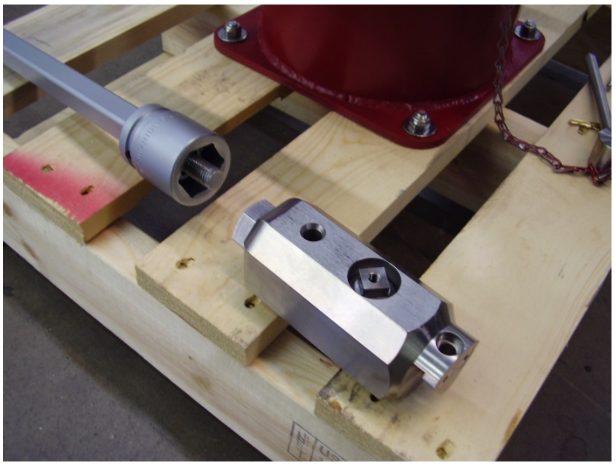


Figure 3-13 *Source Carrier and Source Handling Tool*

Figure 3-14 *Shield with source and source carrier installed*

3.3 Installation of Source Carrier onto QL40-DEN Probe

To load the source from the shield into the probe, the following procedure should be followed:

1. Clear the area of all non-essential personnel.

2. Connect the probe to the cable head, leaving plenty of slack cable to handle the probe.

3. Place the source shield near the probe. **Make sure the borehole is covered!**

4. Lay out the required handling tools (source handling tool, long handled screwdriver).

5. Remove the source holder screw from the dovetail mount at the bottom of the QL40-DEN probe.

6. Insert the source handling tool onto the source carrier within the shield. Rotate source handling tool onto the carrier until it is locked into place. Unlock the shield and remove the source carrier.

7. Insert the source carrier into the mating tapered dovetail mount on the bottom of the QL40-DEN.

Figure 3-15 *Installing Source Carrier onto probe with Source Handling Tool*

8. Next, insert the locking screw using the long-handled screwdriver, and snug up the screw into the far side of the dovetail mount. Do not over tighten, but make sure the bottom of the screw comes to the outside of the dovetail mount. Remove the screwdriver from the lock screw. Remove the source handling tool from the end of the source carrier.

Figure 3-16 *Inserting locking screw into the Source Carrier*

9. Remove the long-handled screwdriver and then lift the probe from the caliper area, keeping the source carrier at least 3 feet (1 meter) away from you. Carefully lower the probe into the borehole. It is best if two people perform this operation, but one person can do this if they plan their movements in advance.

10. To remove the source carrier after logging, clean the bottom section off to remove any mud or debris from the lock screw and dovetail mount area.

11. Lay the probe on a firm surface. Cover the borehole!

12. With the probe caliper facing up, attach the source handling tool to the bottom of the source carrier and twist the handle clockwise to lock the carrier to the handling tool.

13. Remove the source locking screw with the long handled screwdriver.

14. Slide the source carrier out of the dovetail mount with the handling tool and return it to the shield.

15. Lock the source in the shield.

16. Remove the handling tool by unscrewing it counter clockwise.

17. Clean the bottom of the QL40-DEN dovetail mount area, so it will be ready for the next job.

3.4 Estimated Exposure during Source Installation and Use

The 100 mCi ^{137}Cs source used with the Mount Sopris QL40-DEN emits gamma radiation. The user of this probe should be trained in the recommended safe practices for handling radioactive material during a well logging operation. Licensing authorities normally require users to maintain and follow a standard procedure. Contact Mount Sopris or ALT if you need any additional information on this subject.

The source capsule will only be handled during initial installation in the source carrier. From that time forward, it should not be necessary to directly handle the source capsule. When performing wipe tests, it may be necessary to remove the source holder screw, but this process should normally not provide any more exposure than a normal logging operation.

For a normal logging operation, the source handling tool will be used to move the source carrier from the lead shield to the probe source mount. When in the lead shield, the radiation exposure at the sides and bottom surface is ~ 0.2 mRem/hr. At the source spacer end it is ~ 1 mRem/hr.

During source transfer, the thickest shielding of the source carrier is on the side of the carrier where the source retainer screw is located. The strongest radiation field is on the opposite side of this screw. When handling the source, try to keep the source retainer screw up so the strong field is pointed toward the ground. This means the probe will be positioned so that the caliper arm side of the probe is pointing up.

When the source carrier is out of the lead shield, the exposure rate at one meter is about 44 mRem/hr. Using 30 seconds to transfer the source to the probe and lower it into the borehole to a safe distance (a meter or so), the transfer exposure rate would be 1/120 = 0.367 mRem. For one complete logging operation (2 transfers), the exposure would be 0.733 mRem. Using this rate, an operator could perform nearly 7000 logging operations per year before exceeding the recommended maximum annual exposure of 5 Rem.

4 Operating Procedure

Note: Parts of the topics discussed in these sections below assume that the user is familiar with the **LoggerSuite** acquisition software. Refer to the corresponding operator manuals for more details. Information about assembly and configuration of tool stacks can be found in the same manuals.

4.1 Quick Start

1. Insure that the caliper section is properly cleaned and greased. See the maintenance section for more information. Refer to the following section on **Radioactive Source Installation** to install source.

2. Connect toolstack to cablehead and lower into the borehole. Start LoggerSuite acquisition software

3. Select the relevant QL40-DEN tool from the drop down list (***Figure 4-1***) in the software's **Tool** panel (if your tool is not listed check that your tool configuration file is stored in the designated folder on your computer).

Figure 4-1 *Tool panel*

4. In the **Tool** panel switch on the tool (click **On** button) and verify that the power indicator shows a valid (green) level. The system goes through a short initialization sequence which sets the default parameters and communication settings held in the tool configuration file. The configuration returned by the tool is also checked during this procedure. (Setup tool communication as explained in chapter **4.4** if error message is displayed.)

5. Click the extend icon  in the **Depth** panel and press **Zero Tool**

6. Lower the QL40-DEN to the bottom of the borehole. Open the Caliper arm using the **Settings/Commands** button. Do **NOT** open the caliper while running downhole, as damage to mechanical and electrical parts may result.

7. In the **Acquisition** panel (***Figure 4-2***) select the sampling mode (Depth Up). Click on **Settings** and specify the corresponding sampling interval. Switch on the sampling (click the **ON** button).

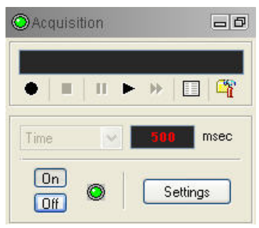


Figure 4-2 Acquisition panel

8. Press the **Record** button in the **Acquisition** panel (***Figure 4-2***), specify a file name and start the logging.

During logging observe the controls in the **Telemetry** panel ***(Figure* 4-3)**:

- Status must be valid (green light);
- Bandwidth usage in green range;
- Memory buffer should be 0%;

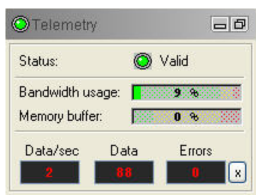


Figure 4-3 *Telemetry panel*

- Number of **Data** increases and number of **Error**s negligible.

9. To end the logging procedure press the **Stop** button in the **Acquisition** panel

10. Turn off the “Depth” sampling mode (click **OFF** button). Select the “Time” sampling mode and turn it on (click **ON** button) to control the closing caliper operation

11. In the **Tool** panel close the caliper arm using the **Settings/Commands** button

12. Turn off the “Time” sampling mode and turn off the tool power

13. Place the tool on the ground or a cleaning stand so that the caliper arm is up and the radiation is exiting the source holder down towards the ground. Rinse off the source section quickly and remove the source, following the procedure in **Radioactive Source Installation**.

4.2 Tool Communication with ALT Logger

The telemetry provided through the ALTLogger is self-tuning**.** In case communication status is not valid the user can manually adjust the settings. In the **Telemetry** panel of the dashboard click on  to display the **Configure Tool Telemetry** dialog box ***(Figure 4-4)***.
A procedure to achieve valid communication is given below:

- Change the **Baudrate** to 41666 kbps.
- Verify that the **Downhole Pulse width** knob is set on 20 (default value). This value is the preferred one and is suitable for a wide range of wirelines. For long wireline (over 2000m), increasing the pulse width could help to stabilize the communication. The reverse is true for short wireline (less than 500m).
- Set the **Uphole** discriminators in the middle of the range for which the communication status stays valid.
- Increase the **Baudrate** to the desired value and observe that the communication status stays valid and the **Bandwidth usage** (in **Telemetry** panel of the dashboard) is below the critical level.
- When **Uphole** discriminators are properly set, store the new configuration as default. The tool should go through the initialisation sequence successfully the next time it is turned on.

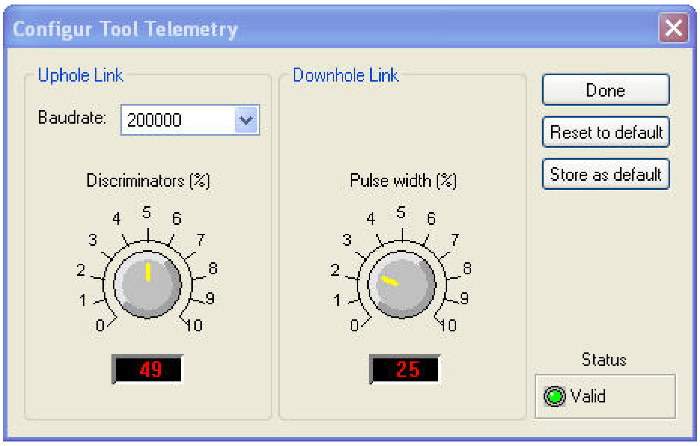


Figure 4-4 *Tool communication settings*

4.3 Tool Communication with MATRIX

The tool telemetry can be configured through the **Telemetry** panel of the Matrix dashboard. By clicking on , the operator has access to the **Configure ALT Telemetry** dialog box (***Figure 4-5***) providing various controls to adjust the telemetry settings and monitor its current status.

The **Analysis View** displays the current discriminator levels (vertical yellow lines) and a histogram of the up-hole data signal. The scales of the **Analysis View** can be adjusted using the **Vertical Scale** and **Horizontal Scale** knobs and the **lin**ear / **log**arithmic scale buttons.

The status of the configuration should be flagged as Valid (indicated by the LED being green). In any other case (LED red) the telemetry should be adjusted (we assume a pulse signal is displayed in the analysis view). Click on the **Advanced** button to display additional controls to tune the telemetry.

The Automatic settings option is the preferred mode and should allow the telemetry to be configured for a wide range of wirelines without operator input. For wirelines with a more limited bandwidth, the operator might need to turn off the automatic mode and adjust the telemetry settings manually. In general, the gain setting should not be left in the automatic mode once a valid setting has been determined. Uncheck the box to disable automatic gain. For each wireline configuration, the discriminators (vertical yellow lines) for the **positive** and **negative** pulses must be adjusted in order to obtain a valid communication status (see ***Figure 4-5*** for an example of a suitable discriminator position). There is also the option to alter the **baudrate** in order to optimize the logging speed. The input **gain** can be increased (long wirelines) or decreased (short wirelines) in order to set up the discriminator levels correctly.

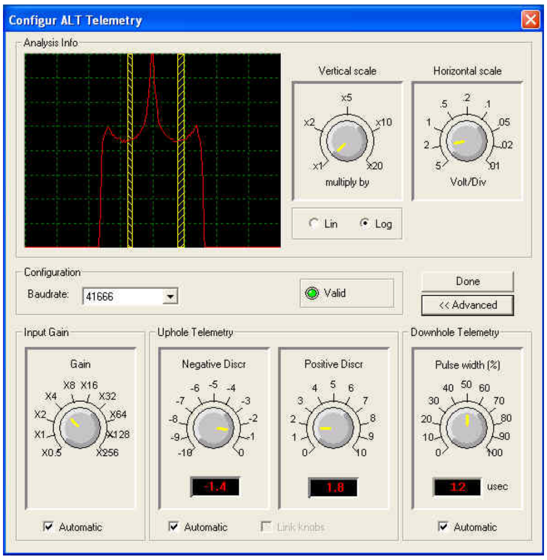


Figure 4-5 *Matrix telemetry settings*

Once the telemetry is correctly set, store the new settings as default. The tool should go through the initialization sequence in "Valid" status the next time the power is turned on.

4.4 Recorded Parameters, Processors and Browsers

4.4.1 Recorded parameters

The following channels are recorded by the QL40-DEN tool:

RHOB	**Compensated Density calculated from short and long detectors - g/cc**
DRHO	**Compensated Density minus Long Spaced Density (RHOB-RHOLSD) - g/cc**
CAL	**Caliper - cm**
RHOSSD	Short Spaced Density - g/cc
RHOLSD	Long Spaced Density - g/cc
Time	Sampling Time - sec
TCPU	Temperature (recorded on CPU board) - ºC
MOT	Caliper Motor Status - Opening/Closing/Idle
HV	High Voltage monitor
SSDCNT	Short spacing Density Counts
LSDCNT	Long spacing Density Counts
CALCNT	Caliper Counts
SSDCPS	Short spacing Density - counts per second
LSDCPS	Long spacing Density - counts per second
CALCPS	Caliper - counts per second

***Table 1** QL40-DEN recorded channels*

4.4.2 MChNum Browser

The **Figure 4-6** shows a typical example of the numerical values displayed in the MChNum browser window during operation.

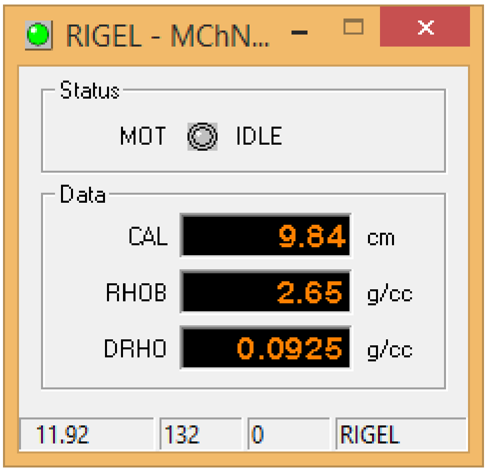


***Figure 4-6** MChNum browser window*

MOT	Caliper Motor Status
CAL	Borehole diameter (in centimeters)
RHOB	Compensated Density (in g/cc)
DRHO	Compensated Density minus Long Spaced Density (in g/cc)

The other parameters listed in **Table 1** can be displayed in real time if required. Right click on MChNum browser and click on "**Display options**" from the menu.

Select in the "Display options properties" dialog box and add the additional channels to display.
It is possible to change the format of decimal digits displayed for a channel. Select the channel and click on "Settings" to configure the number of digits after the period.

4.4.3 MChCurve Browser

The MChCurve browser ***(Figure 4-7)*** displays the recorded parameters by means of curves in real time.

The user is allowed to modify the curve presentation by double clicking on the log title (colors, column position, scale, filter, grids, etc.).

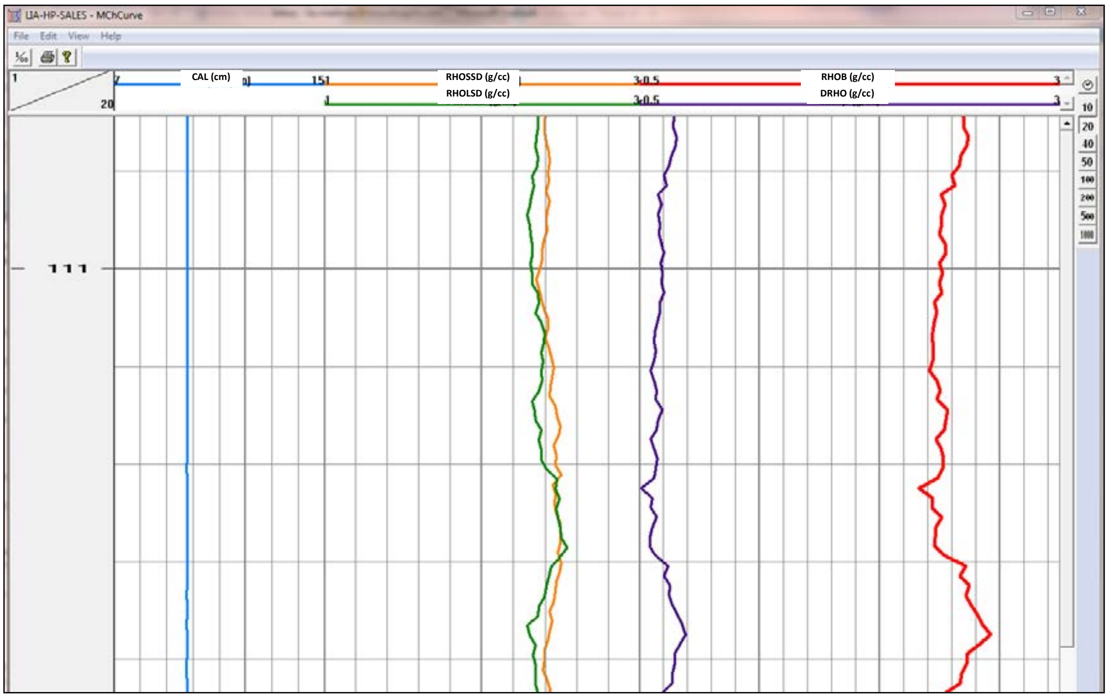


***Figure 4-7** QL40-DEN MChCurve browser*

Figure -8Figure -9Figure -10

5 Performance Check & Calibration

5.1 Density

Good practice requires regular validation of the measurements. This is can be achieved by comparison of tool readings and blocks of known density. Calibration of the **density** measurement is not complicated, but requires two calibration standards. Nylon (Density 1.26 g/cc) and Aluminum (Density 2.60 g/cc) are optionally available from Mount Sopris Instruments or ALT (p/n Q40DEN-1800 and Q40DEN-1700). Follow the steps below:

1. Connect the QL40-DEN probe to the cable head, and power up the tool as outlined the above operating procedure.

2. Grasp the tool near the probe top (to minimize radiation exposure) and place it on the **nylon** density calibration block. A long table or probe stands will be needed to allow the probe to rest horizontally in the calibration blocks with no stress on the probe housings. Lay out the aluminum and nylon blocks so that the probe can be easily moved between the two blocks and adjusted to rest horizontally in either block. See below:

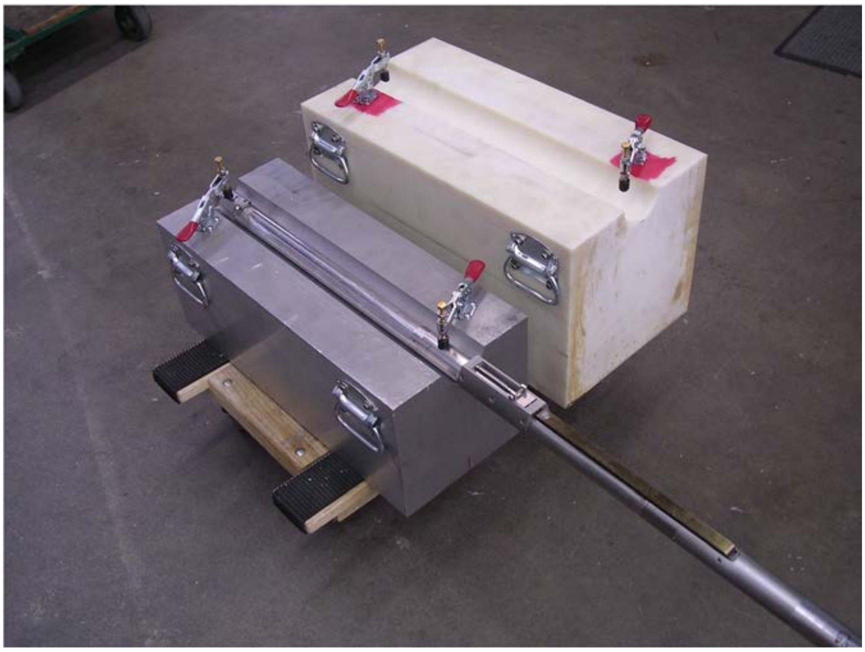


Figure 5-1 *QL40-DEN resting on its calibration block*

3. Slide the bottom of the probe out the end of the block and place the source shield near the end of the probe. Install the source as per the **Source Installation Procedures** section.

4. Insert the probe into the calibration block with the caliper pointing straight up. It is not necessary to open the caliper for calibration. Make sure that the probe rests perfectly flat in the grooved radius in the block.

5. Use the clamps to secure the probe to the calibration block. They can be adjusted by turning the hex nuts to allow a secure lock when the handles are pressed down. See detail in the next figure.

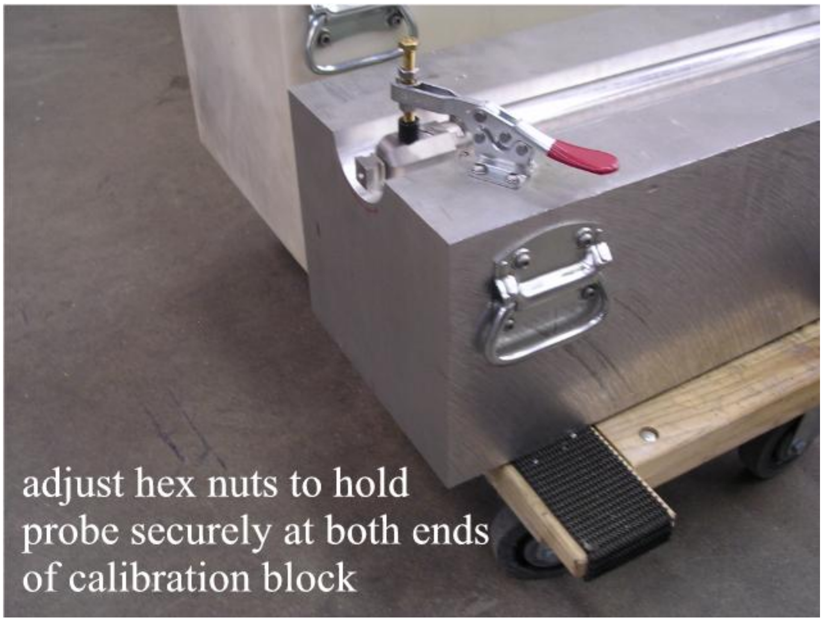


Figure 5-2 *Probe secured on the calibration block*

IMPORTANT: The probe <u>MUST</u> be supported at the probe top end with a suitable probe stand so that there is no stress on the probe housings and joints. This allows the density detector section to rest completely flat in the calibration groove, and minimizes strain on the caliper and modem sections of this probe.

6. Right click the Green LED o the MCHNum Browser window or right click the top pane to display the MCHNum context menu.

7. Select **Calibration Settings**. The calibration window will pop up.

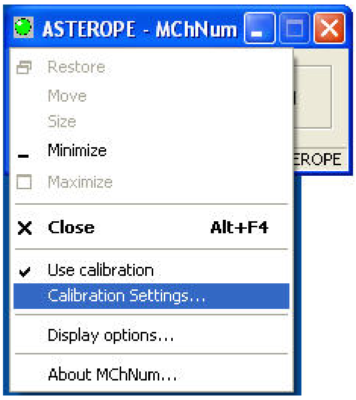


Figure 5-3 *MChNum – access to the calibration settings*

8. Set the time sampling interval, and then set the sampling mode to 'Time'. The time digitize interval may need to be increased until the RHOSSD and RHOLSD repeat within 1 or 2 percent. A value of 1000ms for the sampling rate and 100 samples should be sufficient to compute the average RHOSSD & RHOLSD counts in cps. The

number of samples can be edited by clicking on "options" in the calibration page – refer to Figure 5-4).

9. On the calibration window, click on the '**RHOSSD**' tab. Type '**1.26**' into the Reference edit box for the First Point. Click the **Sample** button for the first calibration point and wait until the sampling is completed (sampling time will be function of the number of samples and sampling rate defined by the user). This will cause the natural logarithm of the counts to be entered into the first point value edit box.

   Click on the '**RHOLSD**' tab and repeat. For the far detector, the natural logarithm of the far counts is entered into the edit box.

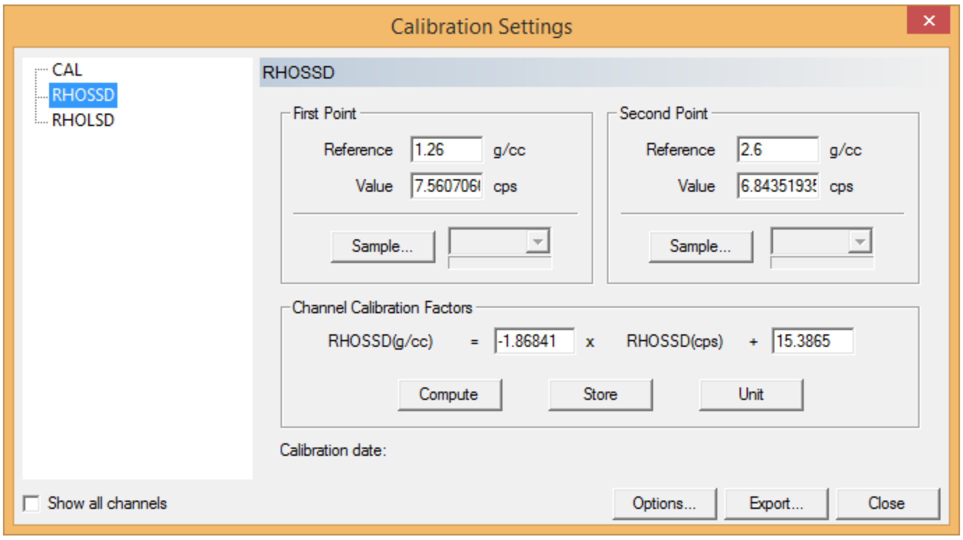


Figure 5-4 *calibration example*

10. Place the tool on the **aluminum** calibration block, again grasping the tool near the cable head to minimize exposure to radiation.

11. Click on the '**RHOSSD**' tab. Type '**2.60**' into the Reference edit box for the Second Point. Click the **Sample** button for the Second Point and wait until the sampling is completed (sampling time will be function of the number of samples and sampling rate defined by the user). This will cause the natural logarithm of the counts to be entered into the second point value edit box. Click on the '**RHOLSD**' tab and repeat. For the far detector, the natural logarithm of the far counts is entered into the edit box.

12. Click '**Compute**' and then click '**Store**' for each tab, 'RHOLSD' and 'RHOSSD'.

13. On the Logger Dashboard, click the '**Close All**' button on the 'Browsers & Processors' panel. Next, restart all processors and browsers by clicking on the **'Start All**' button. This will implement the new calibrations.

5.2 Caliper

Calibration of the **caliper** measurement generally is not necessary. The caliper has been calibrated at the factory and the calibration numbers are electronically stored in the sub file. If small adjustments need to be made to the caliper calibration, follow the steps below.

1. Connect the probe to the cable head, and power up the tool as outlined in the above operating procedure.

2. Place the probe on a table or stand that will allow the caliper arm to open fully without any external resistance.

3. Use **Settings/Commands** to open the caliper arm. This will take ~60 seconds.

4. Right click on the MChNum window and then click on **Calibration Settings**. The calibration window will open.

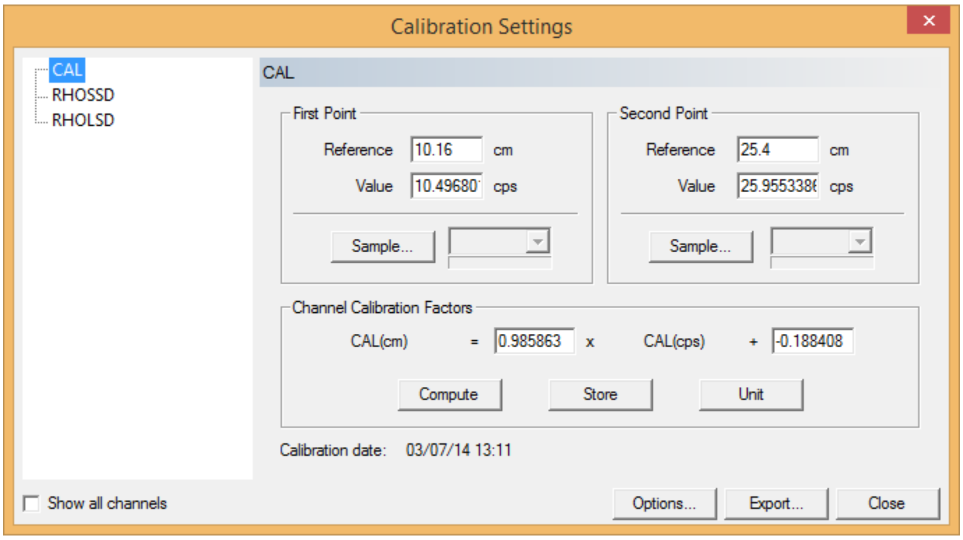


Figure 5-5 *Caliper calibration page*

5. Set the time sampling interval (set to 500 ms), then set the sampling mode to 'Time'.

6. Place the caliper calibrator around the tool and slide it along the tool until the calibrator can engage the caliper arm. Set the caliper arm to the **four inch** position on the calibrator.

7. On the calibration window, click on the '**CAL**' tab. If calibrating in inches, type **'4.00'** (or '10.16' cm) into the reference edit box for the First Point. Click the First Point **Sample** button and wait until the system has returned a value.

8. Next, set the caliper arm to the **ten** inch position on the calibrator. If calibrating in inches, type **'10.00'** into the reference edit box for the Second Point, otherwise type '25.4' (cm) into the reference edit box. Click the Second Point **Sample** button and wait until the system has returned a value.

9. Press the **Compute** and then **Store**.

10. On the **Browsers & Processors** panel click **Close All** then **Start All** to refresh the other Browsers and Processors. This must be done as they only read the calibration constants from the configuration file when they start.

11. Check the calibration by setting the caliper arm to the **six** inch position and verifying the result indicated by MChNum's Caliper field is **6.00 inches +/- 0.1 inches** (15.24 cm +/- 0.254 cm).

5.3 Density Compensation Notes

Density for the near and far detectors (RHOSSD, RHOLSD) is calculated as the log of the raw detector counts. Compensated Density (RHOB) is then calculated by the formula:

(2.975327597445237 x RHOLSD) - (1.971171233098749 x RHOSSD) - 0.014985496037274

This channel is calculated at a depth offset of 0.1575 meters from the bottom of the tool.

The Compensation channel displayed in MChNum, labeled as DRHO, uses the same depth offset as the RHOB channel. The formula for it is: (RHOB – RHOLSD)

6 Maintenance

Warning: Removing the electronic chassis from pressure housing without prior consultation with ALT/MSI will void the tool warranty.

6.1 General maintenance

The QL40 series tools require periodic maintenance. Make sure the threads on the brass nut on the sub bottom are free of sand, mud or other dirt. A thin layer of anti-seize is recommended. When disassembling the sub string, dry the joint as it is separated to prevent fluid from entering the sub top and getting into the electrical connector inside.
After replacing top and bottom protectors it is good to wash the probe off after each use. ***Never take the probe apart. This probe is very difficult to disassemble and requires special steps to be taken in order to gain access to the inside of the probe without damaging the electronics. If you have read this after attempting to disassemble the probe chances are the probe has experienced damage and will need to be sent to the factory to be repaired.*** Inspect o-rings occasionally and keep the threads on both ends of the probe clean, to minimize problems in the future.

Remember that the **gamma detectors are fragile**. Use care when placing the tool in the borehole and when traveling down into the borehole. Also, store the tool in a secure place, preferably in a shock resistant container. During transport, logging tools typically endure more shock than when in the borehole.

Keep the caliper mechanism filled with grease at all times. By pumping more grease into the caliper, old dirty grease is flushed out. Continued use of a dirty caliper mechanism may cause the tool to leak. Before and after each usage of the probe, using a standard automotive grease, apply grease to the two grease ports. These are located immediately above and below the arm pivot point. Close the arm to apply grease to the upper fitting and open the arm to apply grease to the lower fitting. After each log, when possible, clean and flush mud and or contaminants out of the caliper arm assembly.

6.2 Locking Ring Assembly Maintenance

Tools required:
1.5mm Allen wrench
2 ea 40-42mm spanner wrench
Paper towels or clean rags

Replacement Parts:
ALT26005, Large Threaded Ring, Qty 2
28-174-995 M2x8 SHCS, Qty 2

Disassembly:
Unscrew and remove the two M2x8 socket head cap screws and separate the two halves. Four guide pins align the two ring halves and tend to hold them together after the screws are removed.
To pry the halves apart you can use a pair of spanner wrenches inserted into the wrench holes on opposite sides of the ring mating surfaces to pull them apart slightly.
Do this carefully to prevent bending the guide pins.

Figure 6-1 *Disassembly of the treaded ring*

Place something small in the opening and move the spanners to the other side and pry it open slightly.
This should be enough to release the two rings as below.

Figure 6-2 *Halves rings when pulled apart*

Clean inside surfaces thoroughly and reassemble, coating the inside with a very light film of anti-seize compound. Nickel based compounds are best, to prevent any sticking between the brass and steel surfaces.

6.3 Upgrading firmware

In accordance with the ALT policy of continuous development the tool has been designed to allow firmware upgrades.

Firmware upgrade procedure is as follows:
1. Confirm that the communication is valid.
2. Upgrade firmware

6.3.1 Checking the communication
1. Connect the tool to your acquisition system.
2. Start ALTLog/Matrix software.
3. In the **Tool** panel select the appropriate tool and turn on the power.
4. In the **Communication** panel, select **Settings**. Check **baud rate** is set to **41666** and **communication status** is **valid** (Figure 6-1 or Figure 6-2).

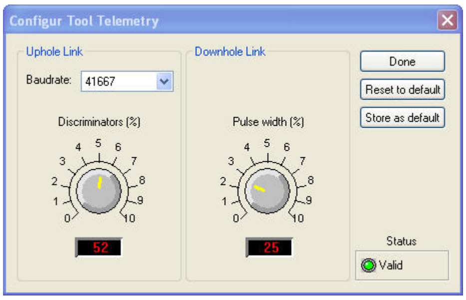


Figure 6-3*Tool communication settings - ALTLog*

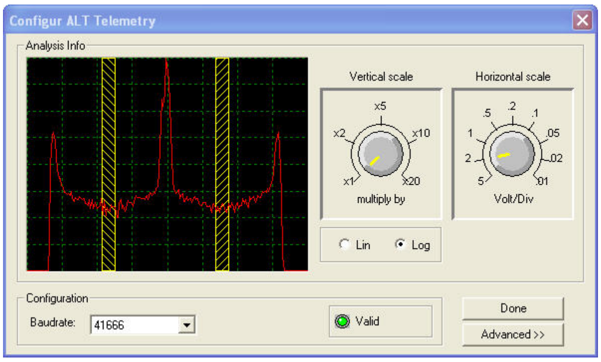
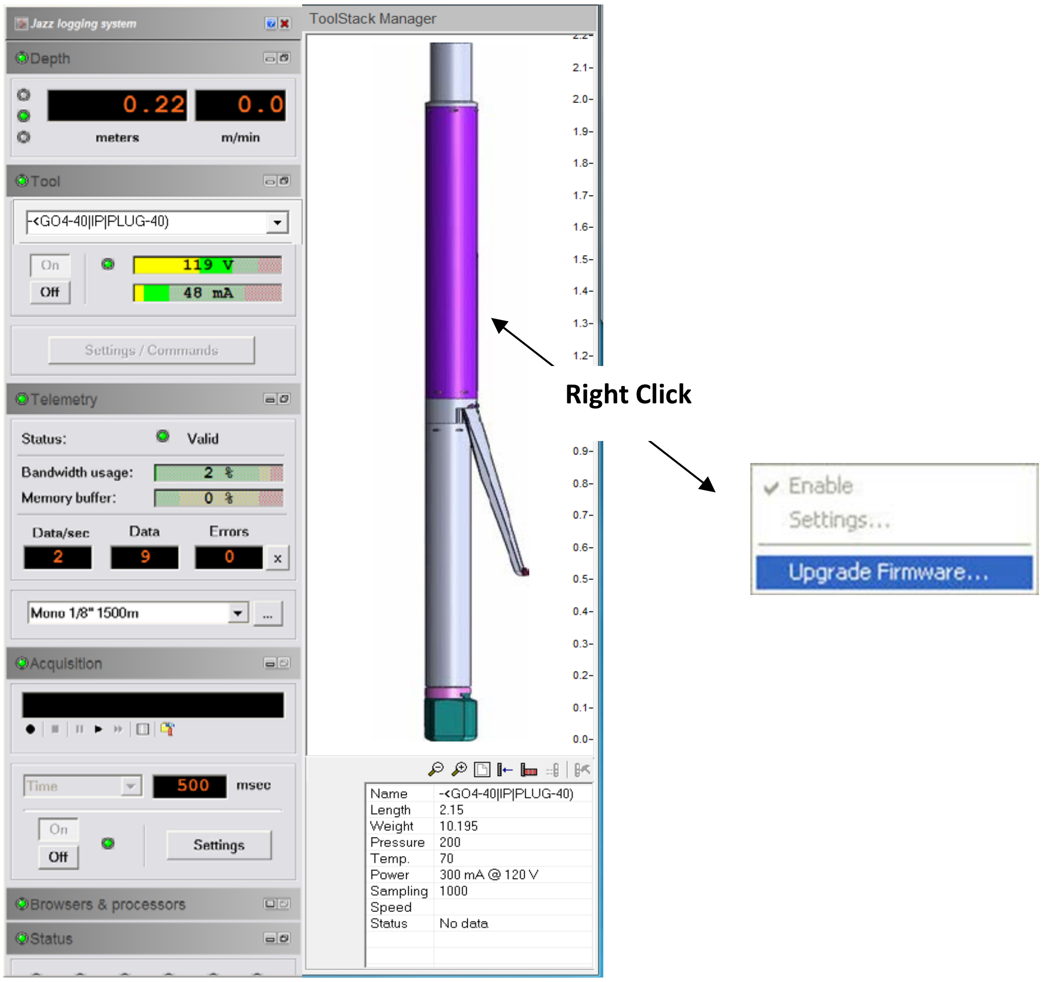


Figure 6-4 *Tool communication settings - Matrix*

Warning: Telemetry must be tuned properly. Bad communication may abort the upgrade of the firmware!

6.3.2 Upgrading the firmware

1. **Right Click** on the tool preview in the **ToolStack Manager** view and select **Upgrade Firmware** from the context menu.



2. The following message will appear (Figure 6-5). Click **Yes** to validate your choice.

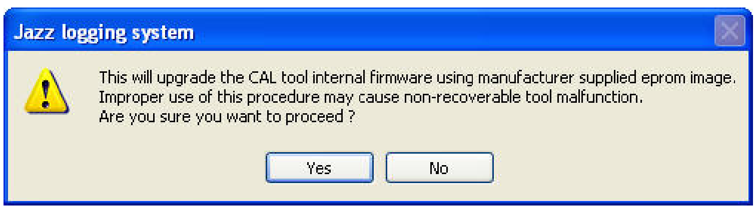


Figure 6-5 *Warning Message during firmware upload*

3. Select and open the appropriate **.hex** file provided. The upgrade will start.
4. During the upgrade procedure, the following message is displayed:

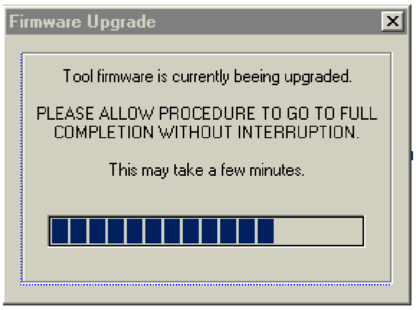


Figure 6-6 *Firmware upgrade progress window*

5. Once the upgrade has been successfully completed (Figure 6-7), click on **OK** to turn off the tool.

Figure 6-7 *Successful upgrade*

6. Power on the tool to start the upgraded firmware.

Note that the following error message (Figure 6-8) will appear at the end of the procedure when the tool firmware upgrade has failed or has been aborted. Verify the tool communication settings in this case.

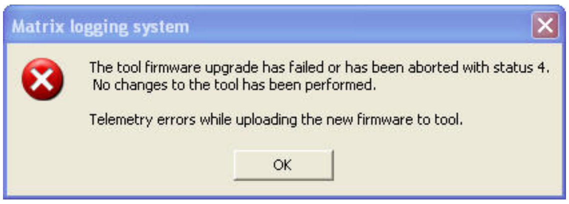


Figure 6-8 *Error message*

7 Troubleshooting

In the event the tool develops a problem, follow the troubleshooting procedure listed below.
WARNING: ***NEVER DIS-ASSEMBLE THE PROBE WITHOUT KNOWLEDGE OF PROCEDURE***

Observation	To Do
Tool not listed in Tool panel drop down list.	- Do you have a configuration file? - Has the configuration file been installed with the LoggerSettings application (refer to LoggerSettings and LoggerSuite manuals for more information)
Tool configuration error message when powering on the tool.	- Check all connections. - Adjust the telemetry settings for your wireline configuration (see chapter 3.2 or 3.3) and store the new settings as default. Apply the appropriate tool settings for your logging run (see chapter 3.4).
Tool panel - No current.	- Verify that the wireline armour is connected to the logging system. Test your interface cable between winch and data acquisition system. - Verify cable head integrity. - Verify voltage output at the cable head (it should be 120V).
Tool panel - Too much current (red area).	**! Immediately switch off the tool !** **-**Possible shortcut (voltage low, current high): Check for water ingress and cable head integrity - wireline continuity. - Verify the interface cable between winch slip ring and data acquisition system is not loose at the connectors. Check for possible source of the short circuit. - If the above shows no issues, use test cable provided by ALT to verify tool functionality. - If the problem still occurs, please contact service centre.
Telemetry panel - status shows red.	- Verify the telemetry settings for your wireline configuration (see chapter 3.2 or 3.3). - If problem cannot be resolved contact support@alt.lu or tech.support@mountsopris.com
Telemetry panel - memory buffer shows 100%.	- Indicates that the systems internal memory buffer is full. PC can’t receive incoming data streams fast enough. Ensure your PC has enough resources available.
Telemetry panel – bandwidth usage shows 100%. *(Overrun error message.)*	- Set the baudrate to highest value allowed by your wireline configuration. - Reduce logging speed or increase vertical sample step.
Telemetry panel - large number of errors.	- Verify the telemetry settings for your wireline configuration (see chapter 3.2 or 3.3). - Check bandwidth usage and telemetry error status.

8 Appendix

8.1 Replacement Parts

Item No.	Qty	MSI Part No.	Description
1	1	Q40DEN-0560	Caliper Wear Button
2	1	16-201-007	Silicone Lubricant Cartridge 14.1 oz.
3	1	2GDA-1400	Caliper Calibrator
4	1	28-175-627	Retainer Screw
5	1	54-203-216	Grease Gun #4BY69 for 14.1 oz.
6	1	54-101-921	C-Spanner Wrench
7	1	ALT26306	Q40 Plastic Male Lid

8.2 Other Parts

Item No.	MSI Part No.	ALT Part No.	Description
1	17-202-092	ALT 26312-A	QL40-Go1 tool top
2	Q40GO4-1000	ALT 26074-A	QL40-Go4 tool top
3	17-202-079	ALT 26310-A	QL40-Go7 tool top
4	Q40MS1-1000	ALT 26084	QL40-MSI tool top
5	Q40DEN-1700	-	Aluminum Calibration Block
6	Q40DEN-1800	-	Nylon Calibration Block

9 Probe tops - standard configurations

9.1 QL40-GO4 four conductor tool top

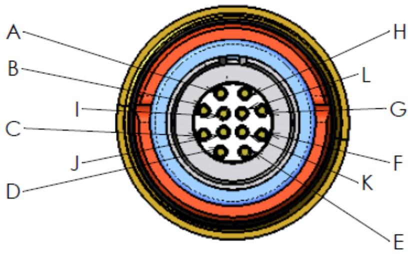


Figure 9-1 *Bottom connection to tool*

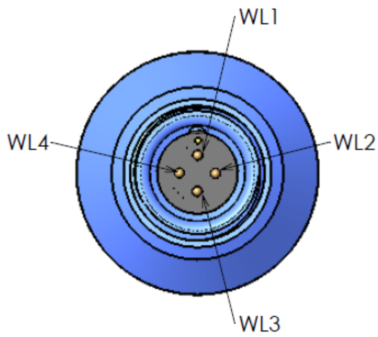
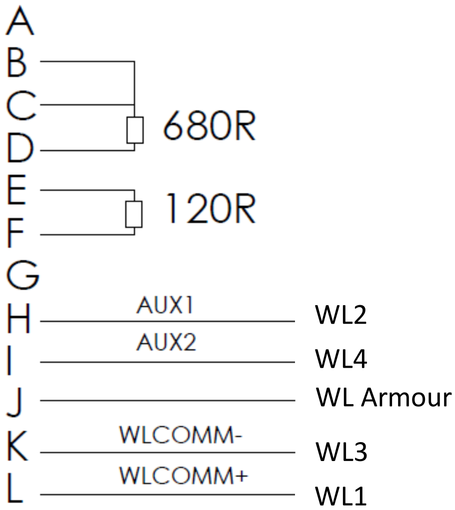


Figure 9-2 *Top connection to cable head*



9.2 QL40-MSI and QL40-GO1 single conductor tool tops

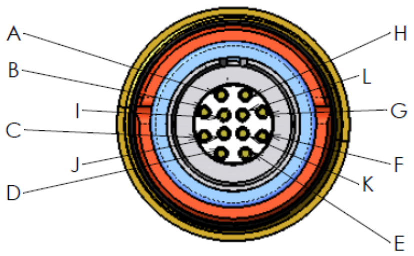


Figure 9-3 *MS1 and GO1 bottom connection to tool*

Figure 9-4 *MS1 top connection to cable head*

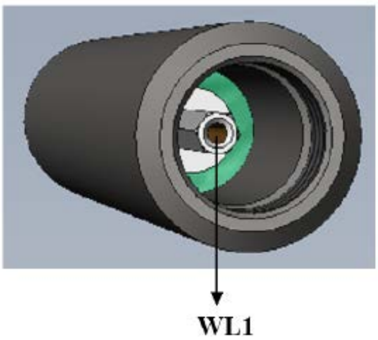


Figure 9-5 *GO1 top connection to cable head*