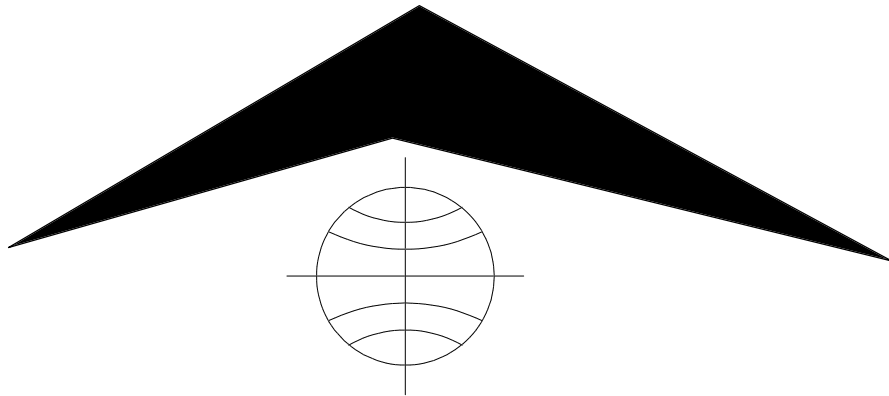


# 2SNA-1000-S

## DX Series Spectral Gamma Probe



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## General Information

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### Overview

The 2SNA-1000-S DX series spectral gamma probe section is a versatile tool that can be used in a wide variety of logging applications. The tool section measures natural gamma spectra, single point resistance, and spontaneous potential. Since the tool is part of the DX family of probes, it can be operated with any DX probe section. In this manner, additional measurements (such as density) can be added to the tool string.

Users can select from three operational modes (256, 512, or 1024 channel) based on their survey needs. The tool section is offered with several different options. The standard 2SNA-1000-S uses a 0.875 by 3 inch NaI(Tl) scintillator. The probe section is available with a BGO scintillator (2SNA-1000-SB) for more efficient detection of high energy gamma particles (and poorer energy resolution and accuracy).

The 2SNA-1000-S provides real time temperature compensation. The response from conventional tools drifts as temperature changes. This drift is extreme when using a BGO scintillator. The 2SNA-1000-S has been calibrated at the factory using several different sources and a swept temperature bath. Calibration coefficients resulting from these tests are stored inside the tool so that real time temperature compensation can be performed.

### Controls, Connectors, and Layout

The 2SNA-1000-S probe section must be connected to a 2SMA-1000 modem section to make up the minimal tool string. Additional sections (such as a 2GDA-1000 density section) may be inserted in the tool string.

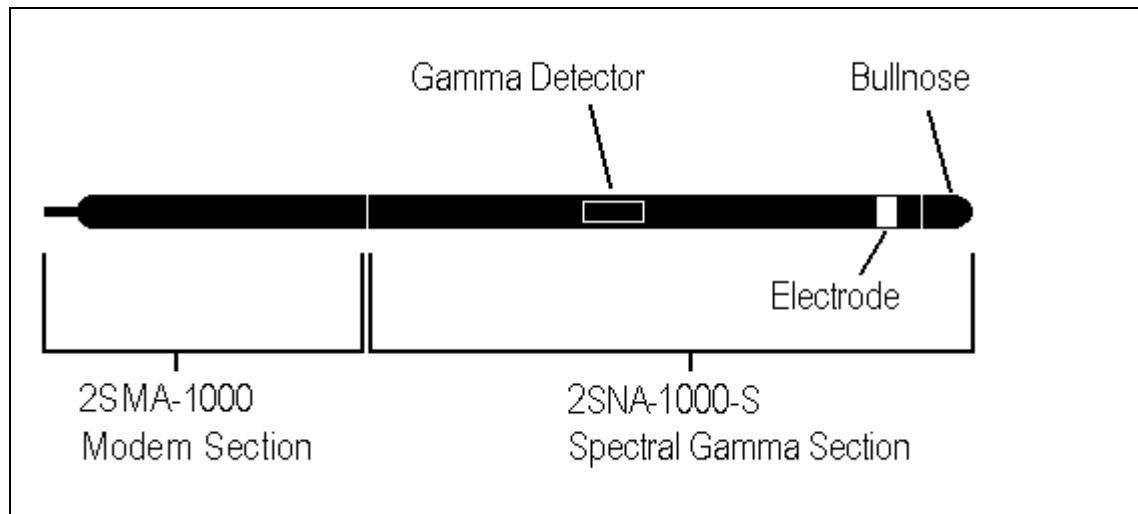


Figure 1: Diagram of the 2SNA-1000-S probe.

The DX series probe sections utilize keyed 10 pin connections. For example, to connect the 2SMA-1000 and the 2SNA-1000-S sections, insert the male end (lower end) of the 2SMA-1000 into the female end (upper end) of the 2SNA-1000-S. Rotate one of the sections until the alignment pin engages. Carefully press the two sections completely together. There may be some resistance when joining the sections together due to the O-ring seals in the connection. After the connection is fully seated, anchor the joint with the three hex head screws.

## Theory of Operation

Naturally occurring radioisotopes emit many types of subatomic particles. Alpha, beta, and gamma particles are among the most common types of radiation and are seemingly well understood. When gamma particles travel through matter, they can interact with matter in one of three types of reactions: photoelectric, Compton scattering, and pair production. If a photon (gamma particle) survives one of these reactions, then its energy will be less than its pre-reaction energy. Figure 2 shows the resultant spectrum from a standard  $^{137}\text{Cs}$  source which emits 662 KeV photons. The sharp peak that appears at 662 KeV is called the photopeak. The gamma rays that produced this peak did not react with matter as they traveled from the source to the detector, and they were totally absorbed by the gamma detector. The two smaller peaks to the left of the main peak are referred to as the Compton edge and the backscatter peak respectively. Gamma rays producing this part of the spectrum have been involved in Compton scattering reactions. Some of these reactions may have caused the particle to not be totally absorbed by the detector (scintillator crystal). The point that this simple example illustrates is that oftentimes, the particles from natural emitters will likely be involved in one or many reactions that complicate the resulting spectrum. This topic can be quite complex; and the reader can learn more from the many available textbooks on modern physics or particle physics.

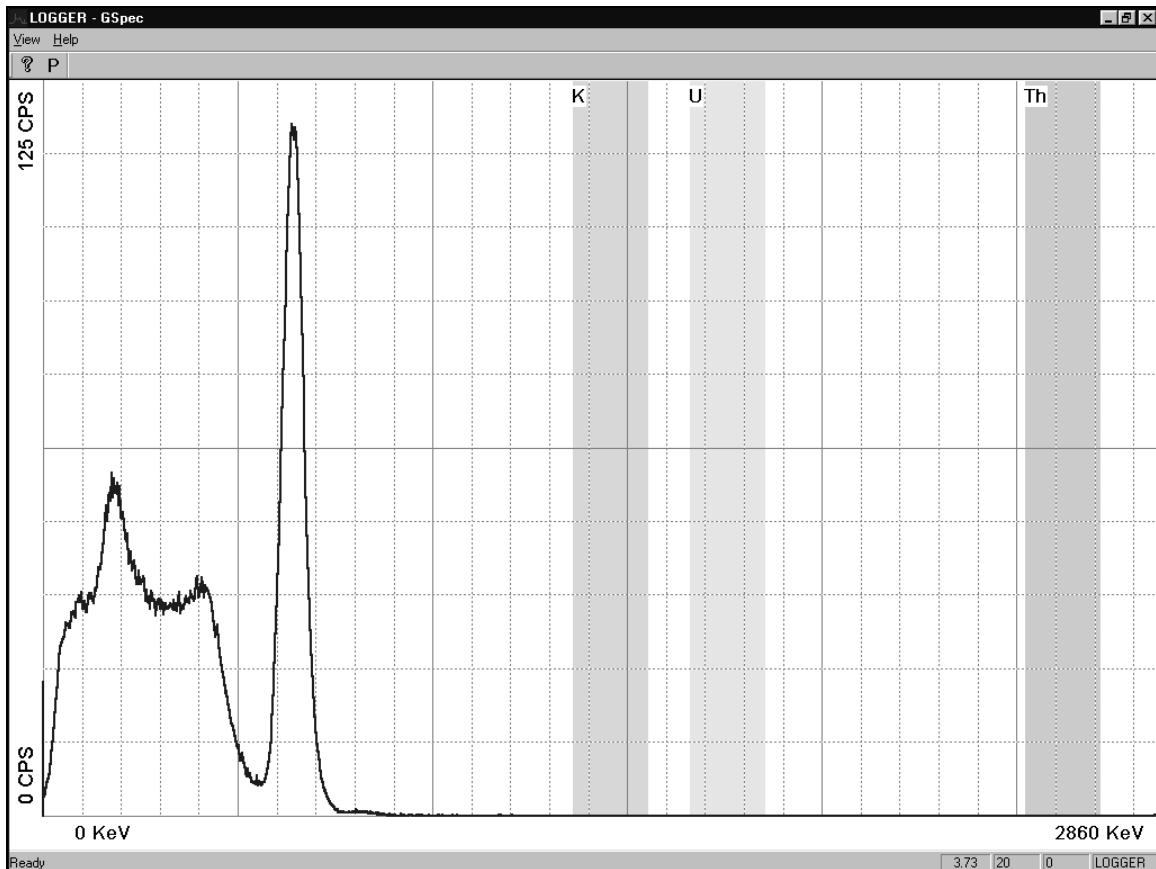


Figure 2: A typical spectrum from  $^{137}\text{Cs}$  standard source showing a peak at 662 KeV.

The radius of investigation for the gamma detector is a function of the energy of the natural gamma radiation and the density of the surrounding medium. Higher energy particles tend to travel further before being completely absorbed through various reactions. A more dense formation will cause the natural radiation to be attenuated more quickly. Generally speaking, the radius of investigation is on the order of one to two feet (30-60 cm).

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The gamma detector is made from a scintillator crystal and a photomultiplier tube. When a gamma particle is absorbed by the scintillator, the scintillator emits a small flash of light. The intensity of the light flash is proportional to the amount of energy absorbed by the scintillator. The light pulse is converted into an electric current and amplified by the photomultiplier tube. The amplitude of the electric current resulting from the incident photon is measured. A spectrum is built using the measured amplitude from many incident gamma particles. This spectrum is sent to the surface when the current time or depth digitize interval set by the operator has elapsed.

The 2SNA-1000-S performs real time temperature compensation. This is necessary because the amount of light produced by the scintillator varies with temperature. In fact, the temperature output from a BGO crystal varies by over 50% over the operating temperature range. Temperature compensation is based on calibration data stored inside the probe. The calibration data are determined at the factory by cycling the temperature over the operating range using several different radioactive standards.

Single point resistance is simply the resistance between the electrode at the bottom of the probe (the survey current source), and a fixed survey current return. The survey current return is usually either a fixed electrode on the surface (the surface electrode or mudplug), or the logging cable armor. The 2SNA-1000-S uses the logging cable armor. Since the survey current returns on a large area of the armor, the current density is low at the return and essentially all of the change in response comes from different resistances near the source electrode on the tool. The survey current is an AC current to prevent electrolysis of the survey electrodes. The radius of investigation for the single point resistance electrode is approximately 6-8 inches (15-20 cm).

Spontaneous potential is the DC potential between the probe electrode and a reference electrode located an infinite distance from the probe electrode. Since it is impossible to place an electrode at an infinite distance from the probe electrode, the reference electrode is often placed on the surface to reference the formation potential. The SP measurement then measures the potential difference between the borehole fluid and the non-invaded formation. The potential difference is, from a simplistic view, due to salinity differences between the borehole fluid and the non-invaded formation fluid. Most textbooks on geophysical logging contain a thorough review the causes of excursions on SP logs. The 2SNA-1000-S uses the armor as the reference electrode. Due to the long length of the armor, the potential on the armor is the average potential presented by the formation over the long length of exposed armor. Using the armor as the reference may change the offset value for the SP log, but not the amplitude of the individual excursions in the log.

## 2SNA-1000-S DX Series Spectral Gamma Probe

### Specifications

Maximum pressure .....	3000 PSI
Operation temperature range .....	0 to 60 degrees C
Storage temperature .....	-40 to 70 degrees C
Natural gamma energy range .....	0 - 3 MeV
Natural gamma energy accuracy .....	2% of full scale
Natural gamma energy resolution .....	10% full width half maximum
Sensor location (from bottom of probe).....	22.83 inches (58 cm)
Single point resistance range.....	0-1000 ohms
Single point resistance accuracy.....	1% of full scale
Single point resistance resolution.....	0.5 ohm
Sensor location (from bottom of probe).....	5.11 inches (13 cm)
Spontaneous potential range .....	-2000-2000 mV
Spontaneous potential accuracy .....	1% of full scale
Spontaneous potential resolution.....	0.5 mV
Sensor location (from bottom of probe).....	5.11 inches (13 cm)
Length (assembled) .....	46.61 inches (118.4 cm)
Diameter .....	1.5 inches (3.81 cm)
Weight.....	11 lbs (4.99 kg)
Length (when connected to a 2SMA-1000) .....	71.26 inches (181 cm)
Diameter .....	1.5 inches (3.81 cm)
Weight.....	17 lbs (7.71 kg)

## **Installation**

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### **Installing the 2SNA-1000-S**

The DX series probe sections must use MSLog as the data acquisition program. If you do not have the MSLog acquisition software, contact Mount Sopris Instruments. After MSLog is installed on the acquisition PC, and configured for your winch and logging cable, the 2SNA-1000-S probe drivers need to be installed. Use the MSLConfig utility to install the necessary probe drivers. Note that there will be different probe drivers for each specific 2SNA-1000-S model, and also the probe sections that will be connected to the 2SNA-1000-S.

The MGX II logger must have either the 5PMA-1000 or 5TMA-1000 modem installed. These modems are only available on the 5MCA-1000 consoles. Units with the modems installed will have the extension /TMA or /PMA appended to the model number. The model number is shown on the logger nameplate located near the power connector. If you don't have the proper modem installed, contact Mount Sopris Instruments.

### **Setting up Isolation for the Resistance and Self Potential Measurements**

In order for the resistance and self potential measurements to function properly, the part of the tool and logging cable above the electrode (near the bottom of the 2SNA-1000-S section) must be electrically isolated. The 2SMA-1000 is wrapped in a neoprene sleeve. Before logging, make sure that any metal exposed above the electrode is well covered with several layers of PVC electrical tape. Cover any exposed metal from the electrode to the probe top. Remember that the tool may be rubbing against the side of the borehole, so make the isolation robust. If there is any break in this insulation, the resistance and spontaneous potential measurements may not record accurate, calibrated data.

## Operating Procedure

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### Operation

The outline shown below describes the procedure that should be used for most logging operations. For a more detailed description of software operation, consult the MSLog user manual. This manual is available as 'help' in MSLog. To access the MSLog 'help', right click on the MSLog dashboard and select Help Index.

1. Connect the logging cable head to the 2SMA-1000 modem and the rest of the probe string. For the Mount Sopris single conductor cable head, rotate the probe instead of the cable head to make the connection. Inspect the cable head O-ring before making the connection. Make sure that it is not worn, nicked or cut. Apply silicon grease to the o-ring surface. Insure that the mating parts of the cable head and the probe top are clean.
2. In order for the resistance and self potential measurements to function properly, the part of the tool and logging cable above the electrode (near the bottom of the 2SNA-1000-S section) must be electrically isolated. The 2SMA-1000 is wrapped in a neoprene sleeve. Before logging, make sure that any metal exposed above the electrode is well covered with several layers of PVC electrical tape. Cover any exposed metal from the electrode to the probe top. Remember that the tool may be rubbing against the side of the borehole, so make the isolation robust. If there is any break in this insulation, the resistance and spontaneous potential measurements may not record accurate, calibrated data.
3. Start the acquisition software (MSLog), select the proper probe driver, and power up the tool. Usually the tool calibrations will be verified at this point. This is outlined in the next section.
4. Place the tool in the borehole. Zero the tool at the zero depth reference. Lower the tool until it is submerged. Wait for the tool to thermally equilibrate to the borehole fluid temperature. It is important to allow the tool to thermally equilibrate so that the real time calibrations are accurate. Allow 15-20 minutes for the tool to equilibrate.
5. Using MSLog, set the desired depth digitize interval, set the digitizing mode to 'depth up', 'depth down', or 'time' and start recording a data file. Log the borehole as desired. You may wish to log the entire borehole slowly. Alternatively, you may want to log in 'time' mode at a fixed depth for a particular zone of interest. As a rule, the logging speed should be fairly slow (~3 ft./min or ~1 m./min.) for reasonable statistics and repeatability of the recorded spectra. Slower logging be necessary to improve the resolution and repeatability of the data
6. When finished logging, power down the tool, and remove it from the borehole. Place the tool on the ground or a cleaning stand. Wash the probe with water (a portable sprayer works well), making sure that all mud and solids are rinsed away. Inspect the insulating tape for wear. Replace worn insulating tape as necessary.

### Performance Checks and Calibrations

Calibration of the **spectral gamma** measurement should not normally be necessary. If calibration is needed, follow the steps below:

1. Connect the probe to the cable head, and power up the tool as outlined the above operating procedure.
2. Place a known gamma reference source as close as possible to the probe at a distance of 22.8 inches (58 cm) from the bottom of the probe.
3. Place the tool and the source in a water bath. Wait 15-20 minutes to allow the tool to thermally equilibrate. If the tool is not submerged, the tool may not warm up evenly, and the resulting calibration may not be valid when the tool is submerged.
4. Set the time digitize interval, then set the sampling mode to 'Time'. The time digitize interval may need to be increased until the spectrum displayed by GSpec is well defined

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- and repeatable. Place the mouse pointer on the photopeak of the spectrum and press the left mouse button. Record the channel number for this peak.
- Place a second known gamma reference source as close as possible to the probe at a distance of 22.8 inches (58 cm) from the bottom of the probe.
  - Set the time digitize interval, then set the sampling mode to 'Time'. The time digitize interval may need to be increased until the spectrum displayed by GSpec is well defined and repeatable. Place the mouse pointer on the photopeak of the spectrum and press the left mouse button. Record the channel number for this peak.

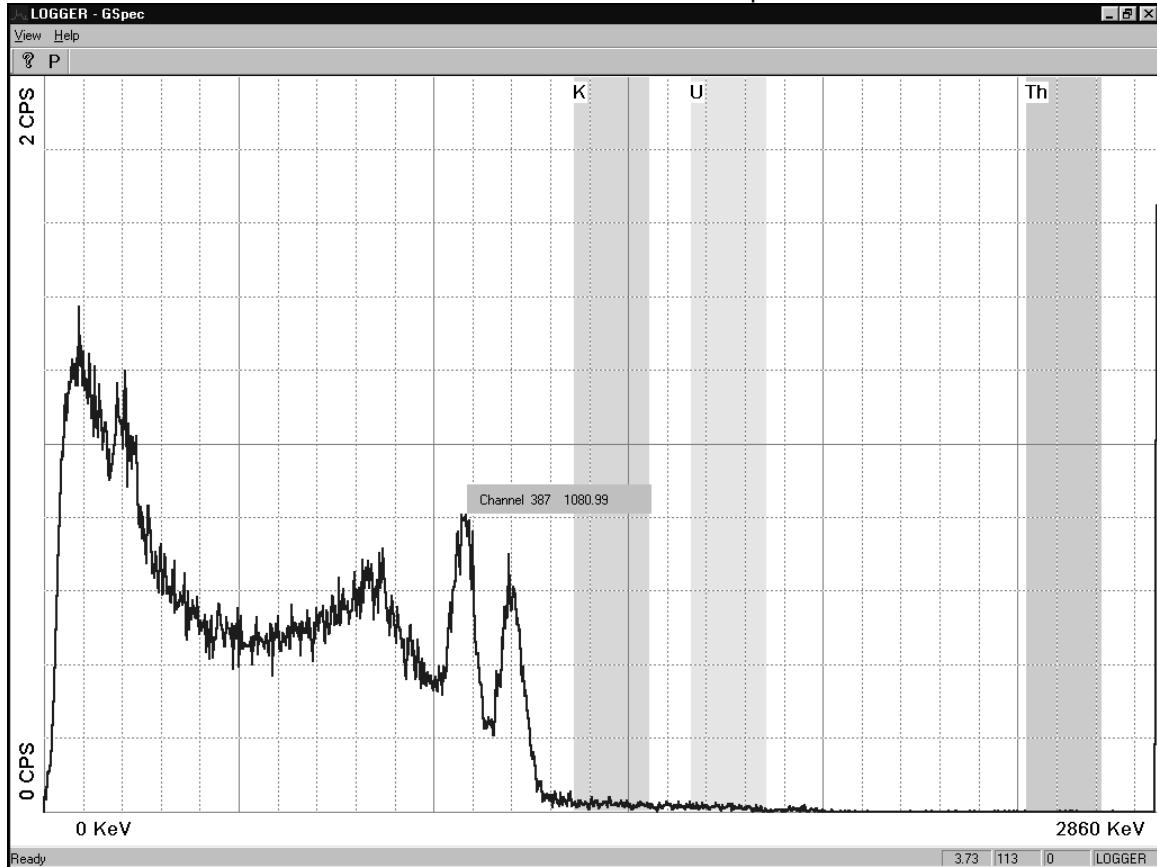


Figure 3: A typical spectrum from  $^{60}\text{Co}$  standard source showing a peak at 1173 and 1333 KeV.

- Click on the SpecProc window. Right click on the 'P' parameter tool bar button. Enter the energy for the first calibration source in the 'First Calibration Point' 'Energy' field (i.e. 662 for  $^{137}\text{Cs}$ ). Enter the window number recorded in step 3 in the 'First Calibration Point' 'Channel' field (i.e. 222 for  $^{137}\text{Cs}$ ). Enter the energy for the second calibration source in the 'Second Calibration Point' 'Energy' field (i.e. 1173 for  $^{60}\text{Co}$ ). Enter the window number recorded in step 5 in the 'First Calibration Point' 'Channel' field (i.e. 387 for  $^{60}\text{Co}$ ). See figure 4.

**Process Parameters**

Spectrum Calibration

	Energy	Channel
First Calibration Point	662	226
Second Calibration Point	1173	401
Multiplier	2.92	
Offset	2.07997	

Apply Calibration Points

Apply Offset and Multiplier

Energy Window Definitions

	Name	Low Energy Cutoff	High Energy Cutoff
Channel	K	1360	1560
Channel	U	1660	1860
Channel	Th	2520	2720
Channel	Ch4	1500	2000
Channel	Ch5	2200	3000

Summing

Depth

Time

Depth: 0.25

Time Interval: 30

OK

Cancel

Figure 4: SpecProc calibration dialog box.

8. On the MSLog panel, click the 'Close All' button on the 'Browsers & Processors' window. Next, restart all processors and browsers by clicking on the name of the browser or processor, and pressing the 'Start' button. Note: LASWriter only needs to be started if an LAS output file is desired.
9. Check the calibration by placing a known gamma reference source as close as possible to the probe at a distance of 22.8 inches (58 cm) from the bottom of the probe. Verify that the photopeak appears at the correct energy.

Calibrating the **resistance** and **spontaneous potential** measurements is not necessary. They have been calibrated at the factory and the calibration numbers are electronically stored inside the probe.

## Preventative Maintenance

Always keep the probe section connector covered when disconnected. This protects the connectors from mechanical abuse and corrosion. Use the probe section protector caps.

Remember that the gamma detector is 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 all thread and O-ring surfaces clean and dry. Re-apply grease or silicone compound (O-rings) on a regular basis. Always clean the tool after each use.

## Troubleshooting

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### Problems with the Probe

If electronic troubleshooting becomes necessary, it should only be performed by qualified persons.

If MSLog reports communications errors (such as parity-framing) and no data can be displayed, make sure that the probe is communicating properly. When the logger and the probe are communicating properly, the 'to probe' and 'from probe' lights should be flashing on the logger.

If communications are not functioning properly, make sure you are using the correct tool driver with MSLog. Also, check the condition of the wireline. The MSLog online help provides detailed instructions on this procedure. When running MSLog, right click on the dashboard and select Help Index. Then choose the Wireline and Cablehead Troubleshooting section.

### Disassembly Instructions

To access the inside of the probe, the probe top can be removed from the main housing. To remove the probe top, first remove the three screws just below the section top. You will have to dig out the sealing compound out of the screw heads. This compound is used to discourage inadvertent disassembly. After removing the three probe top screws, gently pull the probe top out of the housing and disconnect the probe top connector from the upper circuit board. Remove the housing locking screw (located just above the resistivity electrode) using an M3 hex wrench.

Next the housing can be unscrewed from the lower section of the probe. The gamma circuit board is located at the top end of the inner housing with the gamma detector just below the circuit board. Disassembly of the gamma detector is not recommended. The lower most circuit board is for the resistance and spontaneous potential.

Common field correctable electronic problems are a broken or shorted wire. A visual inspection of the wiring should be performed before further testing is done.

If electronic testing is to be done, the user should have detailed electronic schematics before proceeding any further.

**Schematics**

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2SNA-1000-S

Drawing Number

Title

## Appendix

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### Suggested QA Procedure

General notes for Quality Assurance (QA) are presented here for users who need to utilize these techniques when collecting data. These users will need to periodically calibrate their equipment using equipment whose calibration is traceable to an approved standard. Details of these calibrations must be recorded.

When an instrument is calibrated, records need to be kept regarding the calibration standard(s) used and what was changed on the instrument to calibrate it. Typically, the corrections made to the instrument involve changing constants that are used to scale the raw instrument reading so that the proper value is reported. The constants must be recorded during a calibration procedure. Mt. Sopris acquisition programs record the calibration constants that were used to acquire the data. This aids the QA process, but does not replace the need for recording these constants at the time of calibration. The reason for this is that the length of time since the last calibration is unknown with only this information.

The device providing the standard must be traceable to an accepted standard. Examples of organizations providing standards for measuring instrumentation are: The U. S. National Bureau of Standards; The American Petroleum Institute; and the American Society for Testing Materials. For example, if the voltmeter or the density standard used for calibration is not traceable to an approved organization, such as those listed above, the calibration should not be considered valid. Records should be kept indicating the last time that standard being used for calibration was calibrated or checked against an approved standard. The QA procedure necessary for some programs mandate that the calibration standards be periodically checked against a standard approved by a proper agency.

A QA procedure may dictate that data taken from a given locale be associated with records indicating the exact time and location that the data was collected. The data itself may have to be collected in a certain format to meet requirements. Often, QA procedures specify that surveys must be repeated and the data from the successive surveys compared. This technique is used to eliminate poor or invalid data.